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Evidence synthesis

Scoping review of children's and youth's outdoor play publications in Canada

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This article has been peer reviewed.

Abstract

Introduction: Since 2015, interest in the benefits of outdoor play for physical, emotional, social and environmental health, well-being and development has been growing in Canada and elsewhere.

Methods: This scoping review aims to answer the question, "How, and in what context, is children's and youth's outdoor play being studied in Canada?" Included were studies of any type on outdoor play published after September 2015 in English or French by authors from Canadian institutions or assessing Canadian children and/or youth. Articles retrieved from MEDLINE, CINAHL and Scopus by March 2021 were organized according to eight priority areas: health, well-being and development; outdoor play environments; safety and outdoor play; cross-sectoral connections; equity, diversity and inclusion; professional development; Indigenous Peoples and land-based outdoor play; and COVID-19. Within each priority, study design and measurement method were tallied.

Results: Of the 275 articles included, the most common priority area was health, well-being and development (n = 239). The least common priority areas were COVID-19 (n = 9) and Indigenous Peoples and land-based outdoor play (n = 14). Cross-sectional studies were the most common; the least common were rapid reviews. Sample sizes varied from one parent's reflections to 999 951 data points from health databases. More studies used subjective than objective measurement methods. Across priorities, physical health was the most examined outcome, and mental/emotional development the least.

Conclusion: A wealth of knowledge on outdoor play in Canada has been produced since 2015. Further research is needed on the relationship between outdoor play and mental/emotional development among children and youth.

Keywords: *outcomes research, healthy lifestyle, well-being, child health, priorities*

Highlights

- Since 2015, interest in the benefits of outdoor play for physical, emotional, social and environmental health, well-being and development has been growing in Canada and elsewhere.
- We identified 275 Canadian articles on outdoor play published since 2015.
- The most common focus was on the health, well-being and developmental benefits of outdoor play. The least common focus was on COVID-19 and Indigenous Peoples and land-based outdoor play.
- This scoping review highlights the dramatic expansion of outdoor play research in Canada and proposes areas for future research.

Introduction

The 2015 *Position Statement on Active Outdoor Play*[1,2] (Position Statement) highlighted the unequivocal benefits of outdoor play for children's physical, mental, emotional, social and environmental health, well-being and development.[3,4] Two systematic reviews,[3,4] which collectively identified 49 academic articles related to outdoor play (though these are not exclusive to Canada or Canadian authors), investigated the evidence on the health, well-being and developmental benefits of outdoor play and informed the development of the Position Statement. These reviews, and the Position Statement, were a galvanizing force, bringing the many and diverse members of the outdoor play sector together and inspiring research, practice and policy work in Canada and abroad. For example, the Position Statement has been cited by more than 300 articles, used by local Ontario government to inform health policy efforts[5] and by the District of Saanich in a BC Supreme Court[6] ruling as evidence on the benefits of risk taking, helping the District defend their stance on outdoor play.

Rationale and objectives

The *Outdoor Play in Canada: 2021 State of the Sector Report*[7] ("State of the Sector Report"), released in October 2021, addressed three main questions as a follow-up to the Position Statement: how has the outdoor play sector changed since the publication of the Position Statement; what is the current state of the sector; and what are the

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priorities for the sector over the next 5 years.

Addressing the first two questions involved tracing the evolution of the outdoor play movement in Canada since 2015 through the organization of conferences, launch of funding initiatives and initiation of working groups dedicated to promoting outdoor play and by conducting a scoping review of outdoor play literature published, in part, because of these efforts.

For example, the Position Statement was featured in the 2015 ParticipACTION Report Card on Physical Activity for Children.[8] The Report Card showed that there were little data on the outdoor play habits of Canadian children and youth. More data have since become available, though what these show is of concern: before the COVID-19 pandemic, only 21% of Canadian children and youth regularly played outdoors,[9] but by April 2020, outdoor play had decreased nationally[10] and the levels have been slow to return, even to pre-pandemic levels.[11] This is an alarming trend, but one that would not have been so clearly demonstrated had it not been for those initial 2015 findings and the resultant push to address this knowledge gap.

The primary aim of the scoping review was to document the efforts to build on the foundation of research on outdoor play in Canada since the publication of the Position Statement.[2] The electronic search conducted in spring 2021 and updated in March 2022 identified 447 publications on outdoor play in Canada, where play is defined as "voluntary engagement in activity that is fun and/or rewarding and usually driven by intrinsic motivation" and outdoor play is defined as "a form of play that takes place outdoors," in keeping with the Play, Learn and Teach Outdoors Network (PLaTO-Net) Terminology, Taxonomy, Ontology Global Harmonization Project.[12,13]

Because of the staggering number of publications identified, many of which focus on play among adults, we divided the included articles into two: on children's and youth's outdoor play and on adult-oriented outdoor play. The scoping review presented here encompasses the literature on children's and youth's outdoor play and aims to answer the question, "How, and in what context, is children's and youth's outdoor play being studied in Canada?"

A scoping review that focusses on adult outdoor play will also be prepared.

A secondary aim of this scoping review was to build on the third question in the State of the Sector Report,[7] on the outdoor play sector's priorities for the next 5 years. To address this third question within the Report, a 63-person national cross-sectoral consultation group was brought together to identify major priorities for the outdoor play sector and associated actions via a 4-month consultation process. Common priorities were identified, refined, voted on and subsequently presented to the broader outdoor play sector in Canada for input to ensure representation. Through this process, 302 Canadian stakeholders agreed on nine major priorities. These were subsequently endorsed by 12 reviewers, colleagues who work in international outdoor play sectors.[7] These nine priorities aim to serve as a common vision for the outdoor play sector to thrive and succeed over the next 5 years:

- Promote the health, well-being and developmental benefits of outdoor play;
- Promote, protect, preserve and invest in outdoor play environments;
- Advocate for equity, diversity and inclusion in outdoor play;
- Ensure that outdoor play initiatives are land-based and represent the diverse cultures, languages and perspectives of Indigenous Peoples of North America;
- Research and support data collection on outdoor play;
- Reframe views on safety and outdoor play;
- Leverage engagement opportunities with the outdoors during and after COVID-19;
- Increase and improve professional development opportunities in outdoor play; and
- Expand and enable cross-sectoral connections/collaborations.

Therefore, the secondary aim of the scoping review was to categorize the included articles according to these priorities; provide guiding information on common methods of measurement and evaluation within the priorities; and determine the methodological and knowledge gaps within each priority. By doing so, our aim was to help identify where to focus efforts within each priority, and where there is a wealth of knowledge that researchers, policy makers, educators, practitioners and outdoor play advocates can draw on to promote, protect and preserve access to play in nature and the outdoors for all.

Methods

This scoping review followed the Preferred Reporting Items for Systematic reviews and Meta-Analysis Extension for Scoping Review (PRISMA-ScR) guidelines[14] (checklist available on request from the authors). We also used the Arksey and O'Malley[15] framework, as updated by Levac et al.[16] Accordingly, we completed the following six steps: (1) identification of the research question; (2) identification of relevant studies; (3) selection of eligible studies; (4) charting the data; (5) collating, summarizing and reporting of results; and (6) consulting with relevant stakeholders.

Search strategy

We conducted an electronic search via three academic databases, Ovid MEDLINE, EBSCO Cumulative Index to Nursing & Allied Health Literature (CINAHL) and Scopus in March 2021, using two search concepts, "outdoor play" and "Canada." Other search terms used in conjunction with the two search concepts were "free play," "nature play," "risky play," "active play," "unstructured play," "unsupervised play," "playground," "school ground," "loose parts," "outdoor recreation," "nature-based recreation," "nature experience" and "outdoor activities." These terms were selected based on key outdoor play terms identified in the PLaTO-Net Terminology, Taxonomy, Ontology Global Harmonization Project.[13]

KB conducted the search on 29 March 2021 and updated it on 31 March 2022.

Full search strategies for each database are shown in Supplementary Table 1.

Study inclusion criteria

We used the population, concept and context (PCC) framework[17] to ensure that studies selected for the review aligned with our research questions. Peer-reviewed articles published in English or French by (first or last) authors from Canadian institutions, or works that studied a Canadian population, published between September

2015 and March 2022 were included. No restrictions were placed on the type of study or article (e.g. commentaries and reviews were included). Studies were excluded if they did not measure or describe outdoor play experiences and/or literature.

The PLaTO-Net Terminology, Taxonomy, Ontology Global Harmonization Project[13] does not limit play to children, and our searches had no limits on participant age. However, because of the large number of articles retrieved that met our inclusion criteria (n = 447), we separated the data according to age (e.g. children/youth, < 18 years; adults, ≥18 years; or both).

Study selection

Articles that met the inclusion criteria were downloaded and imported into Covidence (Veritas Health Innovation, Melbourne, AUS) for de-duplication. Two reviewers (LDL and KB), working independently, screened the titles and abstracts of the included articles using the PCC framework.[17] Inclusion depended on consensus between the two reviewers. These two reviewers developed the PCC and, before level 1 screening, engaged in a training session where each reviewer independently evaluated the same 10 articles against the inclusion criteria and met to discuss challenges and questions. During level 1 screening, these two independent reviewers met weekly to discuss conflicts in the screening process and achieve consensus.

For full-text screening (level 2), this process was repeated with a third independent reviewer, so that at least two reviewers (LDL, KB or NS) had to agree on final inclusion, resolving any conflicts through discussion to achieve consensus.

Data extraction

Three reviewers (LDL, KB and NS), working independently, used a data extraction form developed a priori in Covidence and pilot-tested by all three to extract data from full texts. The reviewers met weekly during the extraction phase to discuss any uncertainties in ensuring standardization of the extraction protocol. In some instances, an article was reviewed by two reviewers because both were on Covidence at the same time; this served as a spot-check to ensure consistency in their methods. Consensus was achieved among all reviewers via discussions and items were re-categorized if necessary.

The following data were extracted from each article using Covidence's extraction template: title, country, population (children/youth; < 18 years, adults; ≥18 years, or both), study design, measurement of outdoor play and outcomes associated with outdoor play such as quality of life; physical, mental/emotional health; cognitive, social and environmental health; cognitive, emotional, physical and skill development; and general well-being.

Once data were extracted, the template containing the extracted data was downloaded and expanded upon to synthesize themes related to study design and measurement of outdoor play. We organized study design into the following categories: literature review, systematic review, meta-analysis, scoping review, rapid review, commentary, randomized controlled trial (RCT), non-RCT, longitudinal, cross-sectional or mixed methods.

Measurement of outdoor play was categorized as objective or subjective. Objective measurement included use of a device (e.g. accelerometer, GPS); observations (e.g. system of observing outdoor play); and/or environmental assessment (e.g. examination of neighbourhood correlates of outdoor play). Subjective measurement included proxy report (e.g. parents reporting on their child's behaviour); self report; and/or narrative (e.g. single person retelling of an experience).

If the article was a commentary, we extracted the following themes: outdoor play as a method/facilitator of learning; outdoor play and physical or mental well-being; and/or outdoor play and climate change/ecological impacts.

Finally, we extracted themes on all but one of the nine priorities identified in the State of the Sector Report[7]; the research and data collection priority was not included in this extraction list because all the articles in the scoping review would naturally align with research and data collection.

Data synthesis

We separated extracted data into two groups according to age (i.e. children/youth or adults), with articles referring to both children/youth and adults included in both datasets. We then organized articles according to the priorities identified in the State of the Sector Report,[7] recognizing that many of the included articles align with more than one priority area. We counted the number of articles within each priority and the type of study design and measurement of outdoor play.

Results

Study selection

Our search for articles on outdoor play yielded 4327 articles. After removal of duplicates, 3736 articles underwent level 1 screening. After removal of irrelevant articles (n = 2979), 757 articles underwent level 2 screening. Of these, we excluded 310 because they did not focus on or measure outdoor play (n = 156; 50%); they were published before September 2015 (n = 77; 25%); they were not by a Canadian author or did not study a Canadian population (n = 60; 19%); they were not considered full articles (n = 12; 4%); the full-text of the article could not be located (n = 4; 1%); or they were not published in English or French (n = 1; < 1%). For the full review, 447 articles were deemed relevant; 275 articles focussed on children/youth outdoor play and were included in this scoping review.

See Figure 1 for a visual representation of the screening process.

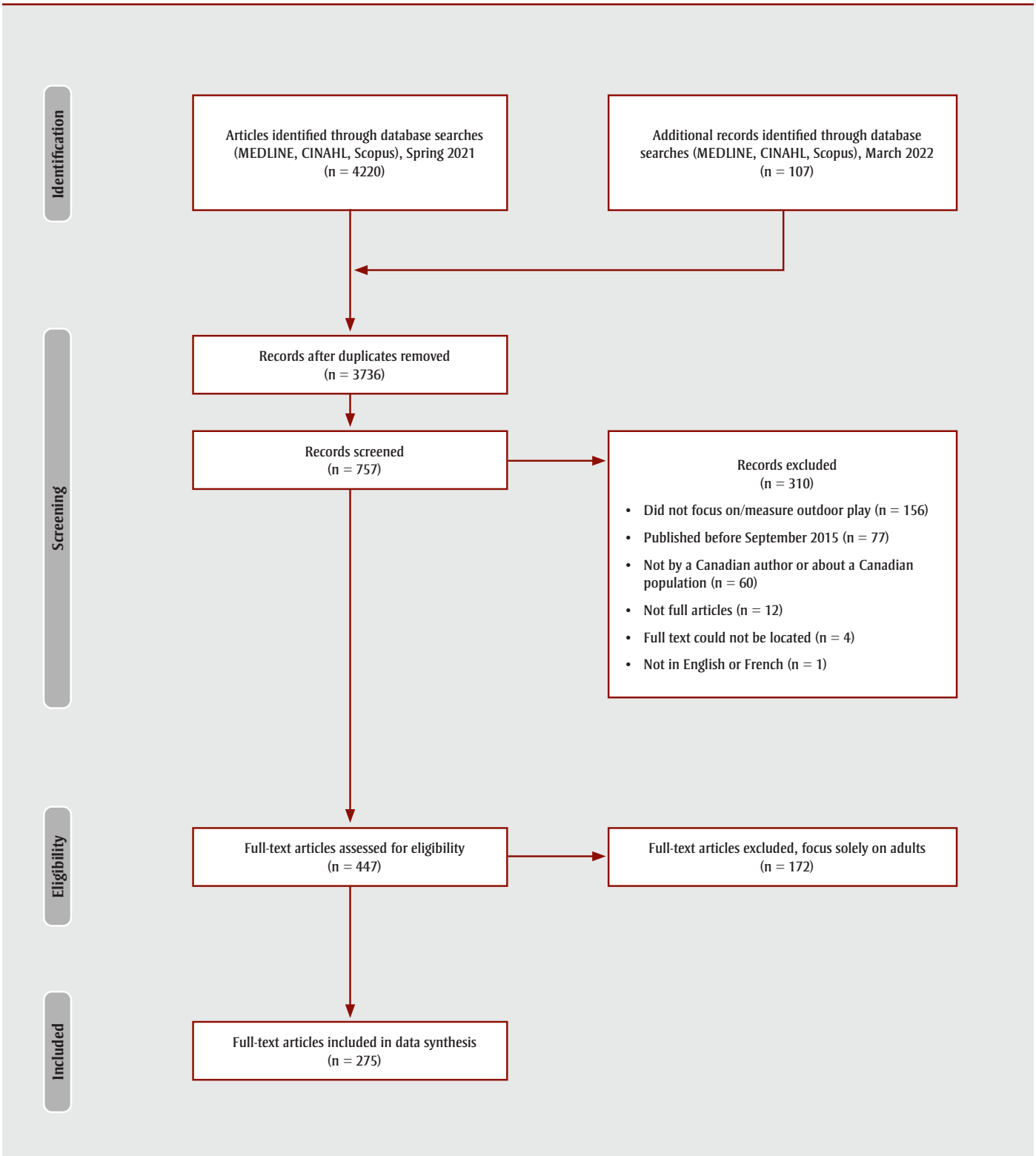
Study characteristics

An overview of the characteristics of each included study is available in Supplementary Table 2. The distribution of included articles by year of publication is shown in Figure 2.

In line with the inclusion criteria, all studies focussed on children and youth younger than 18 years. More articles focussed on children (delineated as 5–11 years old or no age range specified for children; 183/275) than on younger ages (< 5 years; 73/275) and adolescence (12–17 years; 117/275), with considerable overlap (118/275) in the age ranges examined.

Almost three-quarters of the articles (74%; 204/275) examined both males and females, 24% (65/275) did not specify sex/gender and only a fraction looked exclusively at either males (1%; 3/275) or females (1%; 3/275).

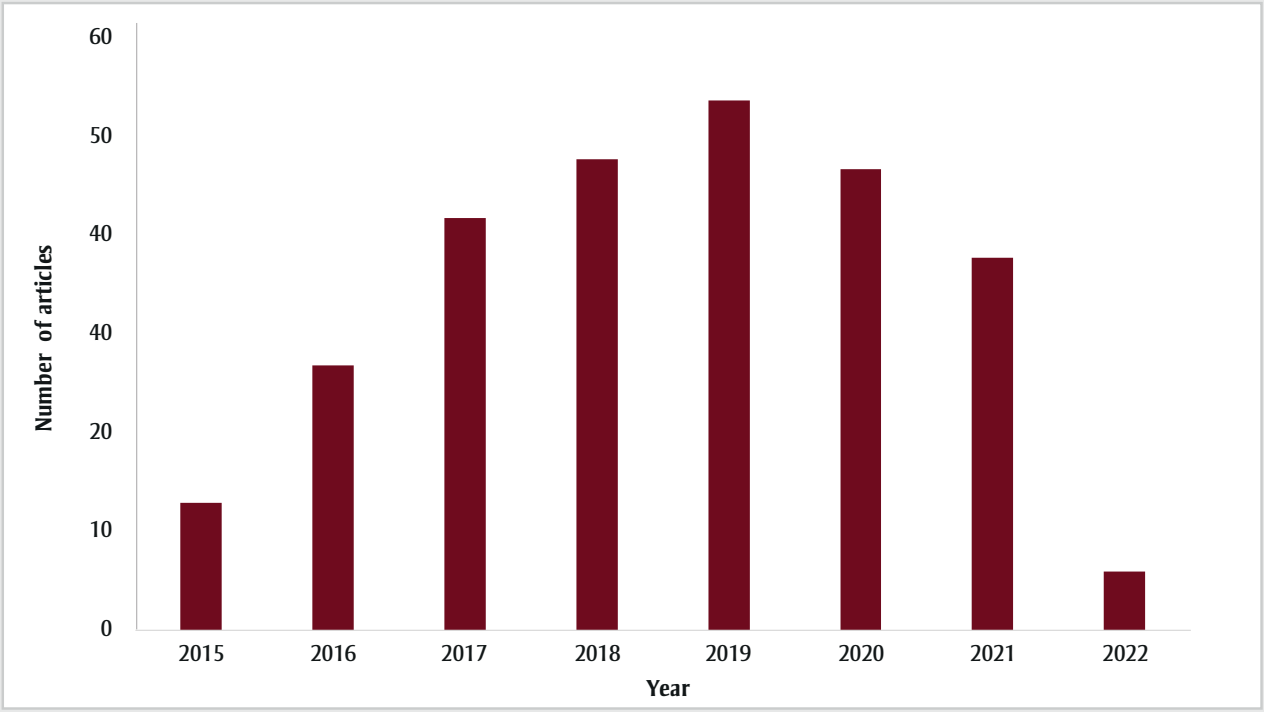
FIGURE 1
PRISMA-ScR flow diagram[a] of the identification, screening, eligibility and inclusion of studies in this scoping review



Abbreviation: PRISMA-ScR, Preferred Reporting Items for Systematic Reviews and Meta-Analysis Extension for Scoping Review.

[a] Based on Moher et al., 2009.[18]

FIGURE 2
Distribution of articles included in the scoping review by year of publication (2015–2022)



Note: Each bar represents the number of included articles in the review according to year of publication. Article counts for 2015 and 2022 are based on partial years; counts in 2015 were from September to December and in 2022 from January to March.

In line with the inclusion criteria, all the articles were written by authors from Canadian institutions or examined a Canadian population. Seven studies covered Canadian and international participants,[19-25] and a Canadian and American research team analyzed data from international participants in one study.[26] Sample sizes varied widely, depending on the study design, from one parent's observations of their son playing outdoors[27] to 999 951 data points on unintentional injuries among children and youth collected from linked health and administrative databases.[28]

Outdoor play themes

We categorized the included articles according to one or more of the State of the Sector Report[7] priorities, in rank order: health, well-being and development (n = 239); outdoor play environments (n = 155); safety and outdoor play (n = 85); cross-sectoral connections (n = 66); equity, diversity and inclusion (n = 48); professional development (n = 41); Indigenous Peoples and land-based outdoor play (n = 14); and COVID-19 (n = 9). Figure 3 shows the distribution of included articles according to these priority themes and year of publication.

Outdoor play study design

Cross-sectional studies were the most common study design across the State of the Sector Report[7] priorities except for studies in the Indigenous Peoples and land-based outdoor play priority, for which the most common study design was mixed methods.

The least common study design was rapid review. Rapid review tied as the least common design in the following priorities: safety and outdoor play (no rapid reviews, meta-analyses or scoping reviews); cross-sectoral connections (no rapid reviews or scoping reviews); equity, diversity and inclusion (no rapid reviews, longitudinal studies or RCTs); professional development (no rapid reviews, meta-analyses or scoping reviews); Indigenous Peoples and land-based outdoor play (no rapid reviews, longitudinal studies, meta-analyses, RCTs or scoping reviews); and COVID-19 (no rapid reviews, literature reviews, longitudinal studies, meta-analyses, mixed methods, non-RCTs, RCTs, scoping reviews or systematic reviews) (see Table 1 and Figure 4).

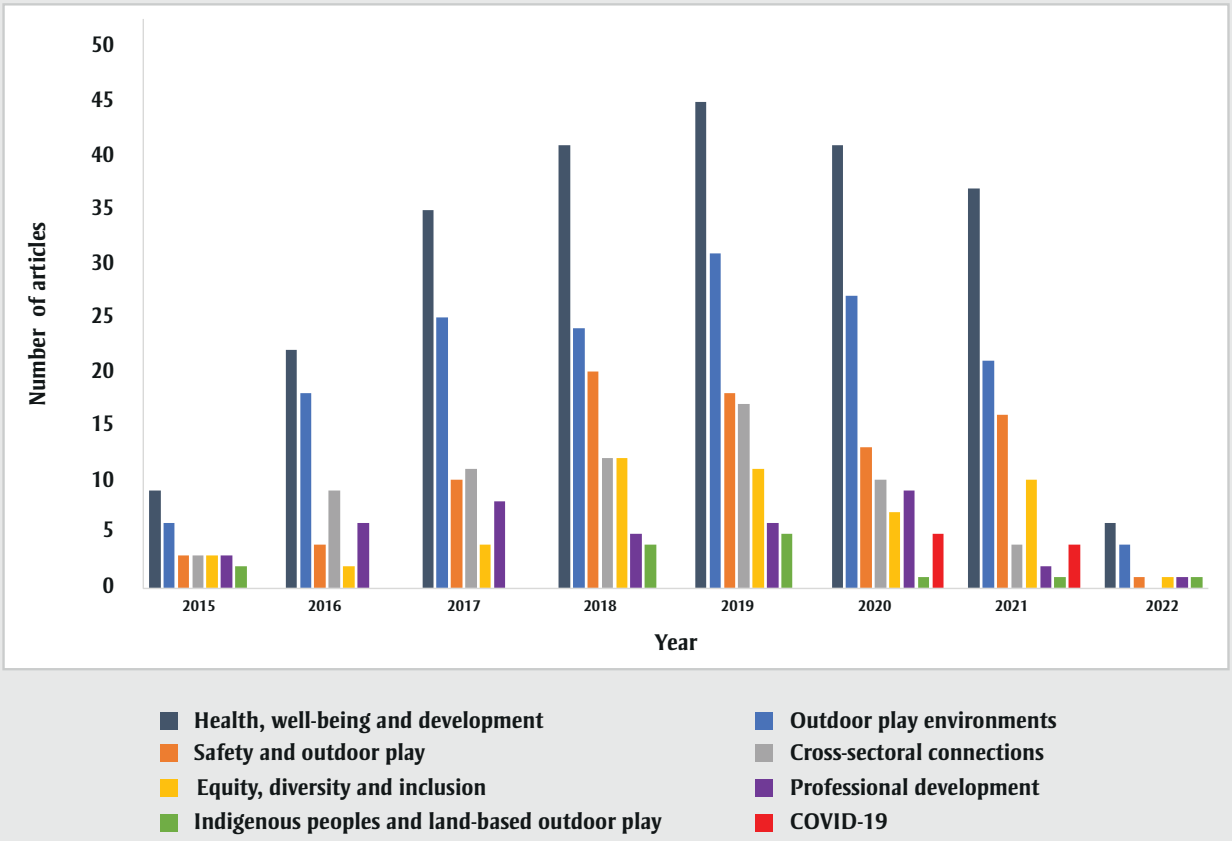
Measurement of outdoor play

Overall, more studies used subjective than objective measures of outdoor play across the State of the Sector Report[7] priorities (see Table 2).

No subjective measure was consistently used more than others across priorities. Narrative measures were used less than others, with several exceptions. For instance, across the cross-sectoral connections and professional development priorities, self report was the least used subjective measure; across the priorities on equity, diversity and inclusion and Indigenous Peoples and land-based outdoor play, proxy report was the least used subjective measure.

The most used objective measure across priorities were device-based measures, with four exceptions. Within the safety and outdoor play priority, environmental assessment was the most used objective method of measurement; within the

FIGURE 3
Distribution of articles in this scoping review aligned with the State of the Sector Report[a] priority themes, by year of publication (2015–2022)



Note: Many articles aligned with more than one priority, and articles published in a given year may count towards more than one bar.

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[7]

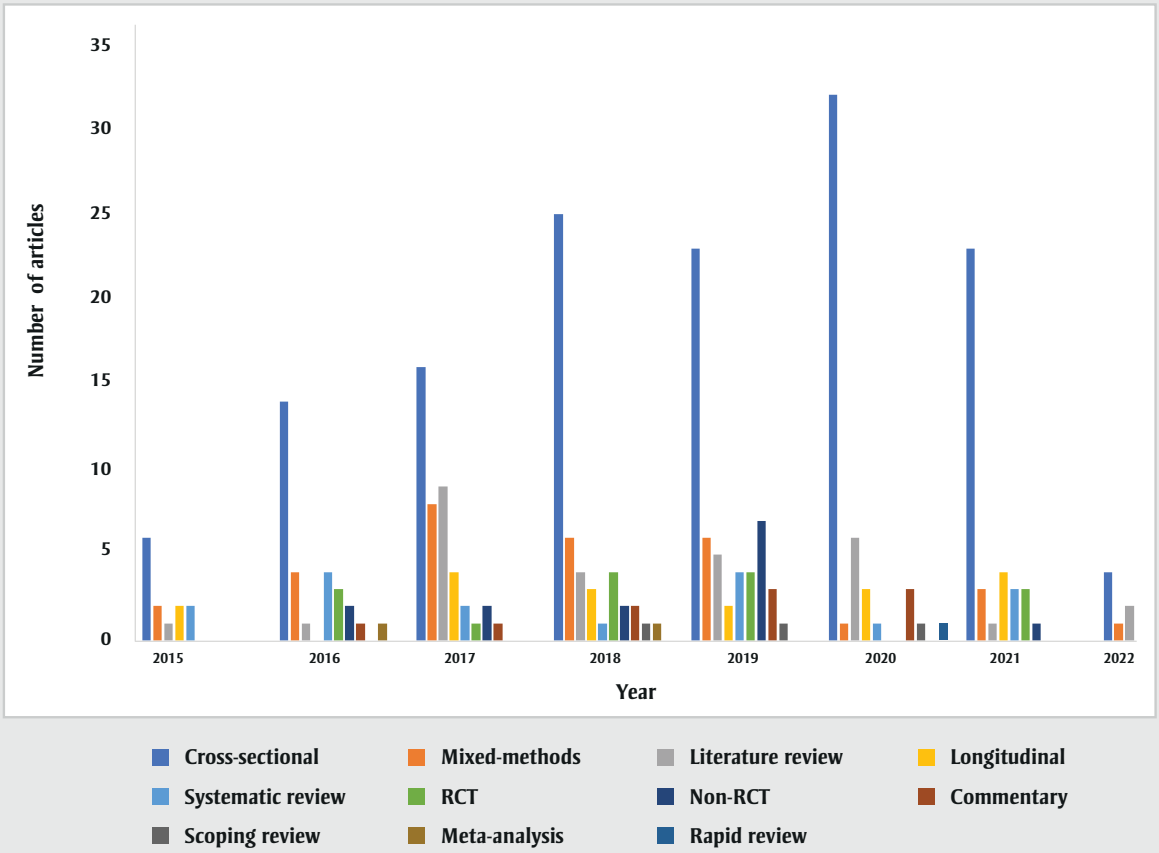
TABLE 1
Articles organized according to the State of the Sector Report[a] priorities, by study design (n = 275)

Study design	Priorities, % (n)							
	Health, well-being and development (n = 239)	Outdoor play environments (n = 155)	Safety and outdoor play (n = 85)	Cross-sectoral connections (n = 66)	Equity, diversity and inclusion (n = 49)	Professional development (n = 41)	Indigenous Peoples and land-based outdoor play (n = 14)	COVID-19 (n = 9)
Commentary	3.3 (8)	3.9 (6)	2.4 (2)	4.5 (3)	2.0 (1)	4.9 (2)	14.3 (2)	11.1 (1)
Cross-sectional study	51.5 (123)	49.0 (76)	60.0 (51)	39.4 (26)	59.2 (29)	34.1 (14)	21.4 (3)	100.0 (9)
Literature review	9.6 (23)	12.3 (19)	9.4 (8)	10.6 (7)	14.3 (7)	9.8 (4)	21.4 (3)	0
Longitudinal study	7.5 (18)	7.7 (12)	5.9 (5)	4.5 (3)	0	4.9 (2)	0	0
Meta-analysis	0.8 (2)	0.6 (1)	0	1.5 (1)	2.0 (1)	0	0	0
Mixed methods	10.9 (26)	13.5 (21)	10.6 (9)	18.2 (12)	10.2 (5)	14.6 (6)	35.7 (5)	0
Non-RCT intervention	5.4 (13)	5.2 (8)	1.2 (1)	10.6 (7)	4.1 (2)	9.8 (4)	7.1 (1)	0
RCT	5.9 (14)	3.9 (6)	4.7 (4)	12.1 (8)	0	17.1 (7)	0	0
Rapid review	0.4 (1)	0	0	0	0	0	0	0
Scoping review	1.7 (4)	0.6 (1)	0	0	4.1 (2)	0	0	0
Systematic review	6.7 (16)	6.5 (10)	5.9 (5)	3.0 (2)	6.1 (3)	7.3 (3)	7.1 (1)	0

Abbreviation: RCT, randomized controlled trial.

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[7]

FIGURE 4
Distribution of articles included in this scoping review aligned with the State of the Sector Report[a] priority themes, categorized by study design and year of publication (2015–2022)



Abbreviation: RCT, randomized controlled trial.

Note: As some articles were categorized according to more than one study design they may count towards more than one bar in a given year.

[a] *Outdoor Play in Canada: 2021 State of the Sector Report*.[7]

TABLE 2
Articles organized according to the State of the Sector Report[a] priorities, by measurement of outdoor play (n = 275)

Measurement of outdoor play	Priorities, % (n)							
	Health, well-being and development (n = 239)	Outdoor play environments (n = 155)	Safety and outdoor play (n=85)	Cross-sectoral connections (n = 66)	Equity, diversity and inclusion (n = 49)	Professional development (n = 41)	Indigenous Peoples and land-based outdoor play (n = 14)	COVID-19 (n = 9)
Objective measures								
Device	17.6 (42)	18.1 (28)	11.8 (10)	16.7 (11)	10.2 (5)	24.4 (10)	0	0
Environmental assessment	5.9 (14)	12.3 (19)	12.9 (11)	6.1 (4)	6.1 (3)	7.3 (3)	7.1 (1)	0
Observation	13.4 (32)	12.3 (19)	5.9 (5)	9.1 (6)	12.2 (6)	7.3 (3)	7.1 (1)	0
Subjective measures								
Narrative	25.5 (61)	27.7 (43)	34.1 (29)	39.4 (26)	32.7 (16)	36.6 (15)	50.0 (7)	22.2 (2)
Proxy report	34.7 (83)	33.5 (52)	48.2 (41)	36.4 (24)	30.6 (15)	43.9 (18)	14.3 (2)	88.9 (8)
Self report	43.1 (103)	40.0 (62)	35.3 (30)	34.8 (23)	53.1 (26)	24.4 (10)	28.6 (4)	44.4 (4)

[a] *Outdoor Play in Canada: 2021 State of the Sector Report*.[7]

equity, diversity and inclusion priority, observation was the most used; within the Indigenous Peoples and land-based outdoor play priority, environmental assessment and observation were the most used; and within the COVID-19 priority, no objective methods of measurement were used.

Environmental assessments were the least used objective method of measurement, though they tied as the least used method with observation within the outdoor play environments, professional development, and Indigenous Peoples and land-based play priorities. Observation was the least used objective method of measurement within the safety and outdoor play priority.

Commentary themes

Across priorities, outdoor play as a method/facilitator of learning, and outdoor play and physical and/or mental well-being were consistently more common than the theme outdoor play and climate change/ecological impact (see Table 3).

Outcomes

Overall, physical health was the most common outcome across the State of the Sector Report[7] priorities, with some exceptions. For the outdoor play environments priority, physical health tied with environmental health as the most common outcome. For the equity, diversity and inclusion and Indigenous Peoples and land-based outdoor play priorities, social health was the most common outcome (see Table 4).

The least common outcome across priorities was mental/emotional development, with some exceptions. For the safety and outdoor play priority, mental/emotional development and quality of life were the least common outcomes. For the cross-sectoral connections and Indigenous Peoples and land-based outdoor play priorities, quality of life was the least common outcome. For the COVID-19 priority, no outcomes were recorded on cognitive development, cognitive health, mental/emotional development, physical development, quality of life and skills development.

Discussion

The number of publications on outdoor play in Canada increased considerably since the publication of the *Position Statement on Active Outdoor Play*[1,2] in 2015. These articles vary widely in terms of type of publication and sample size. Physical health was the most commonly measured outcome of children/youth's outdoor play and mental/emotional development the least. Of the State of the Sector Report[7] priorities, the most common focus was health, well-being and developmental benefits of outdoor play, and Indigenous People and land-based outdoor play was among the least common. These observations are indicative of the efforts and focus of outdoor play research over the past 6 years and show where major gaps remain.

Many of the reviews identified in this scoping review[29-42] focussed primarily on physical health outcomes. Several[30-36,40] also explored the social and environmental health benefits of outdoor play for children and youth; this is encouraging given the importance of building a connection to the land at a young age for fostering lifelong environmental stewardship and promoting action to mitigate climate change.[43,44]

Given the relative novelty of outdoor play research in Canada, it is also not surprising that cross-sectional studies were the most common study design as these studies are a crucial first step in understanding the state of outdoor play across Canada. More than half of the included studies had sample sizes greater than 100 individuals, and of these, more than half had sample sizes greater than 1000 individuals (see Supplementary Table 2). This is encouraging considering criticism that has been levelled at the broader field of outdoor play research that it lacks sufficient sampling.[45]

Another methodological criticism of outdoor play research is the lack of rigorous study design,[45] such as RCTs. Such studies are needed to validate the many correlational observations on outdoor play and health and development. Although this scoping review identified far fewer RCTs than other study designs, we did identify RCTs in most priority areas, which is encouraging. Understandably, there were no RCTs on the priority themes of COVID-19 or equity, diversity and inclusion because of ethical constraints. There were also no RCTs on the priority theme of Indigenous Peoples and land-based outdoor play; here, the most common study design was mixed methods, which is considered to be the most culturally appropriate method for conducting research related

TABLE 3
Articles organized according to the State of the Sector Report[a] priorities, by commentary theme (n = 275)

Commentary themes	Priorities, % (n)							
	Health, well-being and development (n = 239)	Outdoor play environments (n = 155)	Safety and outdoor play (n = 85)	Cross-sectoral connections (n = 66)	Equity, diversity and inclusion (n = 49)	Professional development (n = 41)	Indigenous Peoples and land-based outdoor play (n = 14)	COVID-19 (n = 9)
Outdoor play and climate change/ ecological impacts	1.3 (3)	1.9 (3)	0	1.5 (1)	0	0	0	0
Outdoor play as a method/ facilitator of learning	3.3 (8)	5.2 (8)	4.7 (4)	3.0 (2)	2.0 (1)	2.4 (1)	14.3 (2)	0
Outdoor play and physical and/or mental well-being	5.9 (14)	6.5 (10)	3.5 (3)	4.5 (3)	2.0 (1)	2.4 (1)	7.1 (1)	0

[a] *Outdoor Play in Canada: 2021 State of the Sector Report*.[7]

TABLE 4
Articles organized according to the State of the Sector Report[a] priorities, by outcome (n = 275)

Outcome	Priorities, % (n)							
	Health, well-being and development (n = 239)	Outdoor play environments (n = 155)	Safety and outdoor play (n = 85)	Cross-sectoral connections (n = 66)	Equity, diversity and inclusion (n = 49)	Professional development (n = 41)	Indigenous Peoples and land-based outdoor play (n = 14)	COVID-19 (n = 9)
Cognitive development	13.0 (31)	15.5 (24)	12.9 (11)	16.7 (11)	10.2 (5)	17.1 (7)	21.4 (3)	0
Cognitive health	6.7 (16)	4.5 (7)	4.7 (4)	7.6 (5)	6.1 (3)	7.3 (3)	14.3 (2)	0
Environmental health	29.3 (70)	52.3 (81)	36.5 (31)	30.3 (20)	30.6 (15)	31.7 (13)	35.7 (5)	22.2 (2)
General well-being	15.9 (38)	16.1 (25)	12.9 (11)	24.2 (16)	28.6 (14)	19.5 (8)	35.7 (5)	11.1 (1)
Mental/emotional development	2.9 (7)	1.3 (2)	2.4 (2)	7.6 (5)	2.0 (1)	4.9 (2)	21.4 (3)	0
Mental/emotional health	24.3 (58)	18.7 (29)	9.4 (8)	21.2 (14)	30.6 (15)	9.8 (4)	35.7 (5)	11.1 (1)
Physical development	7.1 (17)	7.7 (12)	9.4 (8)	7.6 (5)	6.1 (3)	14.6 (6)	14.3 (2)	0
Physical health	58.2 (139)	52.3 (81)	68.2 (58)	51.5 (34)	46.9 (23)	41.5 (17)	35.7 (5)	77.8 (7)
Quality of life	3.8 (9)	4.5 (7)	2.4 (2)	6.1 (4)	6.1 (3)	7.3 (3)	7.1 (1)	0
Skills development	13.0 (31)	14.8 (23)	11.8 (10)	19.7 (13)	16.3 (8)	39.0 (16)	21.4 (3)	0
Social health	39.3 (94)	36.1 (56)	35.3 (30)	37.9 (25)	55.1 (27)	19.5 (8)	64.3 (9)	22.2 (2)

[a] *Outdoor Play in Canada: 2021 State of the Sector Report.*[7]

to, and in conjunction with, Indigenous Peoples.[46,47]

The wide variety of tools used to measure outdoor play across studies highlights the complexity of and challenges in measuring outdoor play.[48,49] While device-based measures were the most commonly used objective method of measurement of outdoor play, many studies also used subjective methods.[48,50-69] Combining both objective and subjective methods may allow for capturing more rich data on the multidimensional components of outdoor play, including the experiences, sensations, emotion, context and physicality of outdoor play behaviour.[70] However, the diversity of both objective and subjective methods used in the field poses a challenge when attempting to compare research studies, which highlights the need to establish broad consensus and standardization of measurement using valid and reliable tools—a need that the State of the Sector Report[7] recognized as a central action item for advancing research and data collection in the field.

Strengths and limitations

Major strengths of this scoping review include the robustness of the scoping review process and output and our adherence to PRISMA-ScR guidelines[14] and the Arksey and O'Malley[15] framework.

Although we omitted including any manuscripts not published in English or French, which would be a limitation, only one study was excluded based on this criterion. Given that the intent of this scoping review was to identify articles published by authors from Canadian institutions or works that studied a Canadian population, this does limit the generalizability to other countries.

Another major strength of this review was the direct link to the State of the Sector Report[7] priorities; in linking to the priorities, this review—and more specifically, Supplementary Table 2, which lists the characteristics of each included outdoor play study and their alignment with the State of the Sector priorities—may serve as a practical resource and evidence base for researchers, policy makers, educators, practitioners, outdoor play advocates and others seeking to address the State of the Sector Report[7] priorities and affiliated actions.

Future directions

Our findings highlight several gaps in knowledge in the outdoor play sector that are important areas for future research. Few articles were available on Indigenous Peoples and land-based outdoor play. Supporting knowledge generation with Indigenous Peoples and promoting learning about Indigenous land-based outdoor play may provide an opportunity to build relationships of trust between Indigenous and non-Indigenous peoples in Canada and move towards reconciliation, as outlined in the *Truth and Reconciliation Commission of Canada: Calls to Action*.[71] The State of the Sector Report[7] described this as a major priority, and given the central importance and intertwined nature of land for outdoor play, one that is embedded in all other priority areas.

Another major gap was the lack of outcomes to do with mental and emotional development. Given the concerns about the mental health of children and youth as a result of the COVID-19 pandemic,[72] and the parallel push to encourage children to go outdoors for the physical and mental benefits[73,74] and improved air circulation,[75] investing more resources into understanding and exploring the benefits of outdoor play on mental and emotional developmental is warranted.

Finally, after the launch of the State of the Sector Report[7] at the Breath of Fresh Air Outdoor Play Summit in October 2021,[76] several stakeholders expressed the need to establish a base of knowledge on equity, diversity and inclusion efforts in the field of outdoor play. This scoping review identified 46 articles examining this priority. The articles identified here (see Supplementary Table 2) may serve to inform those seeking best practices as well as information on successful achievements and the remaining hurdles in advancing

equity, diversity and inclusion in this sector.

Conclusion

In this scoping review our aim was to answer the question, "How, and in what context, is children's and youth's outdoor play being studied in Canada?" We identified 275 articles published since 2015, with the methods of measurement varying widely and often involving multiple tools and types. Identified articles spanned all priority areas of the *Outdoor Play in Canada: 2021 State of the Sector Report*,[7] with the greatest research effort on the health, well-being and developmental benefits of outdoor play and the least on COVID-19 (which is unsurprising given the relative recency of the start of the pandemic) and on Indigenous Peoples and land-based outdoor play. This scoping review aimed to highlight the growing foundation of knowledge produced in Canada since the release of the *Position Statement on Outdoor Play in 2015*[1] and proposes several areas where further research is needed.

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Conflict of interest

The authors have no conflicts of interest to report.

Authors' contributions and statement

LDL, KB and MST conceptualized the scoping review. LDL, KB and NS conducted the data curation, formal analysis and investigation. LDL and KB developed the methodology.

LDL wrote the original draft. LDL, KB, NS and MST reviewed and edited the draft.

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References

1. Outdoor Play Canada. Position statement on active outdoor play [Internet]. Ottawa (ON): Outdoor Play Canada; 2015 [cited 2022 Mar 03]. Available from: https://www.outdoorplaycanada.ca/fr/position-statement-on-active-outdoor-play/

2. Tremblay MS, Gray C, Babcock S, et al. Position statement on active outdoor play. Int J Environ Res Public Health. 2015;12:6475-505. https://doi.org/10.3390/ijerph120606475

3. Brussoni M, Gibbons R, Gray C, et al. What is the relationship between risky outdoor play and health in children? A systematic review. Int J Environ Res Public Health. 2015; 12:6423-54. https://doi.org/10.3390/ijerph120606423

4. Gray C, Gibbons R, Larouche R, et al. What is the relationship between outdoor time and physical activity, sedentary behaviour, and physical fitness in children? A systematic review. Int J Environ Res Public Health. 2015;12(6):6455-74. https://doi.org/10.3390/ijerph120606455

5. Peterborough Public Health. Healthy outdoor playspaces for children [Internet]. 2018. Available from: https://www.peterboroughpublichealth.ca/wp-content/uploads/2018/06/Healthy-Outdoor-Playspaces-for-Children-afternoon.pdf

6. Supreme Court of British Columbia. Thompson v. Corp. of the District of Saanich, 2015 BCSC 1750 [Internet]. 2015 [cited 2022 Mar 03]. Available from: https://www.bccourts.ca/jdb-txt/SC/15/17/2015BCSC1750.htm

7. Outdoor Play Canada. Outdoor play in Canada: 2021 state of the sector report [Internet]. Ottawa (ON): Outdoor Play Canada; 2021 [cited 2022 Mar 03]. Available from: https://www.outdoorplaycanada.ca/wp-content/uploads/2021/09/OPC_SSR_english_FINAL.pdf

8. Tremblay M, Barnes J, Janson K, et al.; ParticipACTION. The biggest risk is keeping kids indoors: the ParticipACTION report card on physical activity for children and youth. Toronto (ON): ParticipACTION; 2015.

9. Tremblay M, Guerrero M, Barnes J, et al.; ParticipACTION. Family influence: the role of the family in the physical activity, sedentary and sleep behaviours of children and youth. 2020 ParticipACTION report card on physical activity for children and youth. Toronto (ON): ParticipACTION; 2020.

10. de Lannoy L, Rhodes R, Moore S, Faulkner G, Tremblay MS. Regional differences in access to the outdoors and outdoor play of Canadian children and youth during the COVID-19 outbreak. Can J Public Heal. 2020; 111(6):988-94. https://doi.org/10.17269/s41997-020-00412-4

11. Moore SA, Faulkner G, Rhodes RE, et al. Few Canadian children and youth were meeting the 24-hour movement behaviour guidelines 6-months into the COVID-19 pandemic: follow-up from a national study. Appl Physiol Nutr Metab. 2021;46(10):1225-40. https://doi.org/10.1139/apnm-2021-0354

12. Outdoor Play Canada. PLaTO-Net [Internet]. Ottawa (ON): Outdoor Play Canada; 2019 [cited 2022 Mar 03]. Available from: https://www.outdoorplaycanada.ca/plato-net/ (see: 'Terminology, Taxonomy, Ontology Project')

13. Lee E-Y, de Lannoy L, Li L, et al. Play, Learn, and Teach Outdoors—Network (PLaTO-Net): terminology, taxonomy, and ontology. Int J Behav Nutr Phys Act. 2022;19(1):66. https://doi.org/10.1186/s12966-022-01294-0

14. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7): 467-73. https://doi.org/10.7326/M18-0850

15. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol Theory Pract. 2005;8(1):19-32. https://doi.org/10.1080/1364557032000119616

16. Levac D, Colquhoun H, O'Brien K. Scoping studies: advancing the methodology. Implement Sci. 2010;5:69. https://doi.org/10.1186/1748-5908-5-69

17. The Joanna Briggs Institute. The Joanna Briggs Institute reviewers' manual 2015: methodology for JBI scoping reviews. Adelaide (AU): University of Adelaide; 2015.

18. Moher D, Liberati A, Tetzlaff J, Altman DG; The PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6(6):e1000097. https://doi.org/10.1371/journal.pmed1000097

19. Coutinho P, Mesquita I, Davids K, Davids K, Fonseca AM, Côté J. How structured and unstructured sport activities aid the development of expertise in volleyball players. Psychol Sport Exerc. 2016;25:51-9. https://doi.org/10.1016/j.psychsport.2016.04.004

20. Frederiksen A, McLeman RA, Elcombe TL. Building backyard ice rinks in Canada: an exploratory study. Leis Loisir. 2018;42(1):47-68. https://doi.org/10.1080/14927713.2017.1411822

21. Hewitt L, Benjamin-Neelon SE, Carson V, Stanley RM, Janssen I, Okely AD. Child care centre adherence to infant physical activity and screen time recommendations in Australia, Canada and the United States: an observational study. Infant Behav Dev. 2018;50:88-97. https://doi.org/10.1016/j.infbeh.2017.11.008

22. Ito E, Walker GJ, Mitas O, Liu H. Cultural similarities and differences in the relationship between types of leisure activity and happiness in Canadian, Chinese, and Japanese university students. World Leis J. 2019;61(1):30-42. https://doi.org/10.1080/16078055.2018.1535449

23. Streelasky J. Tanzanian and Canadian children's valued school experiences: a cross case comparison. Int J Early Years Educ. 2017;25(3):274-91. https://doi.org/10.1080/09669760.2017.1352491

24. Tu AW, O'Connor TM, Beauchamp MR, Hughes SO, Baranowski T, Mâsse LC. What do US and Canadian parents do to encourage or discourage physical activity among their 5-12 Year old children? BMC Public Health. 2017;17(1):920. https://doi.org/10.1186/s12889-017-4918-z

25. Waygood EO, Olsson LE, Taniguchi A, Friman M. The role of children's independent mobility and social media use for face-to-face social interaction with friends. Transportation (Amst). 2020;47(4):1987-2009. https://doi.org/10.1007/s11116-019-10037-3

26. Harju ML, Rouse D. "Keeping some wildness always alive": posthumanism and the animality of children's literature and play. Child Lit Educ. 2018;49(4):447-66. https://doi.org/10.1007/s10583-017-9329-3

27. Humphreys C, Blenkinsop S. Ecological identity, empathy, and experiential learning: a young child's explorations of a nearby river. Aust J Environ Educ. 2018;34(2):143-58. https://doi.org/10.1017/aee.2018.20

28. Saunders NR, Macpherson A, Guan J, Sheng L, Guttmann A. The shrinking health advantage: unintentional injuries among children and youth from immigrant families. BMC Public Health. 2017;18(1):73. https://doi.org/10.1186/s12889-017-4612-1

29. Bergeron N, Bergeron C, Lapointe L, et al. Don't take down the monkey bars: rapid systematic review of playground-related injuries. Can Fam Physician. 2019;65(3):e121-8.

30. Carson V, Lee EY, Hewitt L, et al. Systematic review of the relationships between physical activity and health indicators in the early years (0-4 years). BMC Public Health. 2017;17(Suppl 5):854. https://doi.org/10.1186/s12889-017-4860-0

31. Field DA, Miller WC, Ryan SE, Jarus T, Abundo A. Measuring participation for children and youth with power mobility needs: a systematic review of potential health measurement tools. Arch Phys Med Rehabil. 2016;97(3):462-77.e40. https://doi.org/10.1016/j.apmr.2015.08.428

32. Lacoste Y, Dancause KN, Gosselin-Gagne J, Gadais T. Physical activity among immigrant children: a systematic review. J Phys Act Heal. 2020;17(10):1047-58. https://doi.org/10.1123/jpah.2019-0272

33. Lambert A, Vlaar J, Herrington S, Brussoni M. What is the relationship between the neighbourhood built environment and time spent in outdoor play? A systematic review. Int J Environ Res Public Health. 2019;16(20):E3840. https://doi.org/10.3390/ijerph16203840

34. Lee E-Y, Bains A, Hunter S, et al. Systematic review of the correlates of outdoor play and time among children aged 3-12 years. Int J Behav Nutr Phys Act. 2021;18(1):41. https://doi.org/10.1186/s12966-021-01097-9

35. Mahboob A, Richmond SA, Harkins JP, Macpherson AK. Childhood unintentional injury: the impact of family income, education level, occupation status, and other measures of socioeconomic status. A systematic review. Paediatr Child Health. 2019;26(1):e39-45. https://doi.org/10.1093/pch/pxz145

36. McGoey T, Root Z, Bruner MW, Law B. Evaluation of physical activity interventions in children via the reach, efficacy/effectiveness, adoption, implementation, and maintenance (RE-AIM) framework: a systematic review of randomized and non-randomized trials. Prev Med. 2016;82:8-19. https://doi.org/10.1016/j.ypmed.2015.11.004

37. Poitras VJ, Gray CE, Borghese MM, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016;41(6 Suppl 3):S197-239. https://doi.org/10.1139/apnm-2015-0663

38. Prince SA, Butler GP, Rao DP, Thompson W. Evidence synthesis – Where are children and adults physically active and sedentary? – A rapid review of location-based studies. Health Promot Chronic Dis Prev Can. 2019;39(3):67-103. https://doi.org/10.24095/hpcdp.39.3.01

39. Richmond SA, Clemens T, Pike I, Macpherson A. A systematic review of the risk factors and interventions for the prevention of playground injuries. Can J Public Health. 2018;109(1):134-49. https://doi.org/10.17269/s41997-018-0035-8

40. Truelove S, Bruijns BA, Vanderloo LM, O'Brien KT, Johnson AM, Tucker P. Physical activity and sedentary time during childcare outdoor play sessions: a systematic review and meta-analysis. Prev Med. 2018;108:74-85. https://doi.org/10.1016/j.ypmed.2017.12.022

41. Vanderloo LM, Martyniuk OJ, Tucker P. Physical and sedentary activity levels among preschoolers in home-based childcare: a systematic review. J Phys Act Health. 2015;12(6):879-89. https://doi.org/10.1123/jpah.2013-0483

42. Ward SA, Bélanger MF, Donovan D, Carrier N. Relationship between eating behaviors and physical activity of preschoolers and their peers: a systematic review. Int J Behav Nutr Phys Act. 2016;13(1):50. https://doi.org/10.1186/s12966-016-0374-x

43. Zimanyi L, Rossovska O. Who is John the Snail and when can we meet him?: Parent perspectives on children's engagement in a forest nature program. J Innov Polytech Educ. 2020;1-18. https://jipe.ca/index.php/jipe/article/view/130/59

44. Szczytko R, Stevenson KT, Peterson MN, Bondell H. How combinations of recreational activities predict connection to nature among youth. J Environ Educ. 2020;51(6):462-76. https://doi.org/10.1080/00958964.2020.1787313

45. Mygind L, Kjeldsted E, Hartmeyer R, Mygind E, Bølling M, Bentsen P. Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence. Health Place. 2019;58:102136. https://doi.org/10.1016/j.healthplace.2019.05.014

46. Botha L. Mixing methods as a process towards indigenous methodologies. Int J Soc Res Methodol. 2011;14(4):313-25. https://doi.org/10.1080/13645579.2010.516644

47. Chilisa B, Tsheko GN. Mixed methods in Indigenous research: building relationships for sustainable intervention outcomes. J Mixed Methods Res. 2014;8(3):222-33. https://doi.org/10.1177/1558689814527878

48. Borghese MM, Janssen I. Development of a measurement approach to assess time children participate in organized sport, active travel, outdoor active play, and curriculum-based physical activity. BMC Public Health. 2018;18(1):396. https://doi.org/10.1186/s12889-018-5268-1

49. Dodd HF, Nesbit RJ, Maratchi LR. Development and evaluation of a new measure of children's play: the Children's Play Scale (CPS). BMC Public Health. 2021;21(1):878. https://doi.org/10.1186/s12889-021-10812-x

50. Brussoni M, Ishikawa T, Brunelle S, Herrington S. Landscapes for play: effects of an intervention to promote nature-based risky play in early childhood centres. J Environ Psychol. 2017;54:139-50. https://doi.org/10.1016/j.jenvp.2017.11.001

51. Button BL, Clark AF, Martin G, Graat M, Gilliland JA. Measuring temporal differences in rural Canadian children's moderate-to-vigorous physical activity. Int J Environ Res Public Health. 2020;17(23):E8734. https://doi.org/10.3390/ijerph17238734

52. Callender LK, Borghese MM, Janssen I. Which intensities, types, and patterns of movement behaviors are most strongly associated with cardiometabolic risk factors among children? J Sport Health Sci. 2021;10(3):368-78. https://doi.org/10.1016/j.jshs.2019.06.006

53. Côté-Lussier C, Mathieu ME, Barnett TA. Independent associations between child and parent perceived neighborhood safety, child screen time, physical activity and BMI: a structural equation modeling approach. Int J Obes. 2015;39(10):1475-81. https://doi.org/10.1038/ijo.2015.98

54. Chow AF, Leis A, Humbert L, Muhajarine N, Engler-Stringer R. Healthy start – Départ santé: a pilot study of a multilevel intervention to increase physical activity, fundamental movement skills and healthy eating in rural childcare centres. Can J Public Heal. 2016;107(3):e312-8. https://doi.org/10.17269/CJPH.107.5279

55. Harrington DM, Gillison F, Broyles ST, et al.; ISCOLE Research Group. Household-level correlates of children's physical activity levels in and across 12 countries. Obesity (Silver Spring). 2016;24(10):2150-7. https://doi.org/10.1002/oby.21618

56. Houser NE, Cawley J, Kolen AM, et al. A loose parts randomized controlled trial to promote active outdoor play in preschool-aged children: Physical literacy in the early years (PLEY) project. Methods Protoc. 2019;2(2):E27. https://doi.org/10.3390/mps2020027

57. Larouche R, Barnes JD, Blanchette S, et al. Relationships among children's independent mobility, active transportation, and physical activity: a multisite cross-sectional study. Pediatr Exerc Sci. 2020;32(4):189-96. https://doi.org/10.1123/pes.2019-0238

58. Larouche R, Mire EF, Belanger K, et al.; ISCOLE Research Group. Relationships between outdoor time, physical activity, sedentary time, and body mass index in children: a 12-country study. Pediatr Exerc Sci. 2019;31(1):118-29. https://doi.org/10.1123/pes.2018-0055

59. Loebach J, Gilliland J. Examining the social and built environment factors influencing children's independent use of their neighborhoods and the experience of local settings as child-friendly. J Plann Educ Res. 2019;0739456X1982844. https://doi.org/10.1177/0739456X19828444

60. Loebach J, Gilliland J. Neighbourhood play on the endangered list: examining patterns in children's local activity and mobility using GPS monitoring and qualitative GIS. Child Geogr. 2016;14(5):573-89. https://doi.org/10.1080/14733285.2016.1140126

61. Macgregor AP, Borghese MM, Janssen I. Is replacing time spent in 1 type of physical activity with another associated with health in children? Appl Physiol Nutr Metab. 2019;44(9):937-43. https://doi.org/10.1139/apnm-2018-0323

62. Nguyen A, Borghese MM, Janssen I. Pedestrian traffic safety and outdoor active play among 10–13 year olds living in a mid-sized city. Prev Med Rep. 2018;10:304-9. https://doi.org/10.1016/j.pmedr.2018.04.010

63. Rioux BV, Gupta N, Bouchard DR, Dunbar J, Sénéchal M. Outdoor time is not associated with metabolically healthy overweight and obesity phenotype in Canadian children aged 6-14 years. Int J Exerc Sci. 2020;13(2):383-94.

64. Sarker H, Anderson LN, Borkhoff CM, et al. Validation of parent-reported physical activity and sedentary time by accelerometry in young children. BMC Res Notes. 2015;8(1):735. https://doi.org/10.1186/s13104-015-1648-0

65. Stephens L, Spalding K, Aslam H, et al. Inaccessible childhoods: evaluating accessibility in homes, schools and neighbourhoods with disabled children. Child Geogr. 2017;15(5):583-99. https://doi.org/10.1080/14733285.2017.1295133

66. Tucker P, Driediger M, Vanderloo LM, et al. Exploring the feasibility and effectiveness of a childcare physical activity (Play) policy: rationale and protocol for a pilot, cluster-randomized controlled trial. Int J Environ Res Public Health. 2019;16(22):E4400. https://doi.org/10.3390/ijerph16224400

67. Vlaar J, Brussoni M, Janssen I, Mâsse LC. Roaming the neighbourhood: Influences of independent mobility parenting practices and parental perceived environment on children's territorial range. Int J Environ Res Public Health. 2019;16(17):E3129. https://doi.org/10.3390/ijerph16173129

68. Weatherson KA, Locke SR, Jung ME. Exploring the effectiveness of a school-based physical activity policy in British Columbia, Canada: a mixed-methods observational study. Transl Behav Med. 2019;9(2):246-55. https://doi.org/10.1093/tbm/iby053

69. Wilson K, Coen SE, Piaskoski A, Gilliland JA. Children's perspectives on neighbourhood barriers and enablers to active school travel: a participatory mapping study. Can Geogr. 2019;63(1):112-28. https://doi.org/10.1111/cag.12488

70. Veitch J, Salmon J, Ball K. Individual, social and physical environmental correlates of children's active free-play: a cross-sectional study. Int J Behav Nutr Phys Act. 2010;7(1):11. https://doi.org/10.1186/1479-5868-7-11

71. Truth and Reconciliation Commission of Canada. Truth and Reconciliation Commission of Canada: Calls to Action. Winnipeg (MB): Truth and Reconciliation Commission of Canada; 2015. Available from: https://ehprnh2mwo3.exactdn.com/wp-content/uploads/2021/01/Calls_to_Action_English2.pdf

72. Fullan J, Miller M, Rosen J, Gillespie M; Maximum City. COVID-19 Child and Youth Study: The role of play and outdoor space [Internet]. Toronto (ON): Maximum City; 2021 [cited 2022 Mar 03]. Available from: https://static1.squarespace.com/static/5a7a164dd0e628ac7b90b463/t/6053601208bc3850abd83bcf/1616076821403/COVID-19+Child+and+Youth+Study_+PLAY+AND+OUTDOOR+SPACE+REPORT+v2.pdf

73. de Lannoy L, Rhodes RE, Moore S, Faulkner G, Tremblay MS. Regional differences in access to the outdoors and outdoor play of Canadian children and youth during the COVID-19 outbreak. Can J Public Health. 2020;111(6):988-94. https://doi.org/10.17269/s41997-020-00412-4

74. de Lannoy L, Macdonald L, Barbeau, K, Tremblay MS. Environmental scan of child and youth outdoor play-based projects, programs, activities and services available in Canada during the COVID-19 pandemic. Child Youth Environ. 2022;32(1):84-127.

75. Qian H, MIao T, Liu L, Zheng X, Luo D, Li Y. Indoor transmission of SARS-CoV-2. Indoor Air. 2021;31(3):639-45. https://doi.org/10.1111/ina.12766

76. de Lannoy L. Release of the Outdoor Play in Canada State of the Sector Report! [Internet]. Ottawa (ON): Outdoor Play Canada. Outdoor Play Canada; 2021 Oct 06 [cited 2022 Mar 03]. Available from: https://www.outdoorplaycanada.ca/2021/10/06/release-of-the-outdoor-play-in-canada-state-of-the-sector-report/

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Original quantitative research

Factors associated with cannabis use in early adolescence

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This article has been peer reviewed.

Abstract

Introduction: We examined whether factors identified as associated with cannabis use at age 14 to 16 years are also associated with ever use at age 12.

Methods: Participants in the AdoQuest study (n = 1852) were recruited in 2005 from among Grade 5 students in 29 French-language elementary schools in Montréal, Canada. Self-report data were collected from participants in Grade 5 (spring 2005) and 6 (fall 2005 and spring 2006) and from parents/guardians in 2006/07. Inclusion in the analytic sample (n = 1076; mean age [SD] = 10.7 [0.5]) required data from participant and parental questionnaires and data on cannabis use in Grade 6 (mean age [SD] = 11.7 [0.4]). We estimated associations between ever use at age 12 with 33 potential correlates, separately in unadjusted and adjusted logistic regression models.

Results: Fifty-three participants (4.9%) reported ever use at age 12. Factors associated with higher odds of ever use included older age, identifying as male, lower household income, more weekly spending money, ever tried cigarettes or other tobacco products, ever drank alcohol or binge drank, ever gambled, friends or siblings smoke cigarettes, greater nicotine dependence, higher depressive symptoms and greater impulsivity. Protective factors included higher levels of parental/guardian monitoring and greater self-esteem and school connectedness.

Conclusions: Factors associated with cannabis use at later ages are also associated with ever use at age 12. Our findings suggest that surveillance for and interventions to prevent cannabis use are warranted before age 12.

Keywords: *cannabis use, adolescents, early use, risk/protective factors*

Highlights

- We investigated if well-established risk factors for cannabis, alcohol and/or tobacco use during adolescence are associated with ever use of cannabis in youth aged 12 years.
- Among 14- to 18-year-olds, higher odds of cannabis use are associated with the use of other substances, peers or siblings who smoke cigarettes, depressive symptoms and impulsivity.
- Higher levels of parental/guardian monitoring and greater self-esteem and school connectedness are associated with lower odds of cannabis use among 14- to 18-year-olds.
- We found similar associations with ever use of cannabis at age 12 years.
- Our findings suggest that surveillance for and interventions to prevent cannabis use are warranted for youth younger than 12 years.

Introduction

Cannabis use typically begins during adolescence. In Canada, 18% of students in Grades 7 to 12 (12–18 years old) reported past-year cannabis use in 2018/19, including 2% of students in Grade 7 (aged 12–13 years) and 4% of those in Grade 8 (aged 13–14 years).[1] In the US in 2019, 15% of Grade 8 students (aged 13–14 years) reported lifetime cannabis use and 12% reported past-year use.[2] The mean (95% confidence interval [CI]) age of cannabis use initiation among secondary school students (aged 12–18 years) in Canada in 2018/19 was 14.3 (14.1–14.4) years.[1]

Data from the Canadian Youth Smoking Survey (YSS; 2002–2013) show that the mean age [SD] of initiation among younger adolescents in Grades 7–9 (aged 12–15 years) was 12.6 [1.3] years in 2002/03 and 12.7 [1.5] years in 2004/05.[3] The mean age (95% CI) of initiation was 12.8 (12.7–12.9) in 2006/07, when AdoQuest data were collected (unpublished data, personal communication from Health Canada, 8 June 2022). This mean age remained steady until 2012/13, then fluctuated over the next 6 years, reaching 13.1 (12.9–13.2) in 2018/19 (unpublished data from the Canadian Student Alcohol and Drug Survey 2014–2019, personal communication from Health Canada, 8 June 2022). The net increase in age at initiation of 12- to 15-year-olds between 2002/03 and 2018/19 was 6 months.

Compared with later use, early substance use carries greater risk of eventual abuse and dependence as well as higher risks for

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poor outcomes in adulthood (e.g. lower educational attainment, substance dependence, crime, early pregnancy).[4] Yet little is known about factors associated with early cannabis use. Using data from the annual, cross-sectional National Survey on Drug Use and Health, Forman-Hoffman et al.[5] found that 5.5% of participating 12- to 14-year-olds (n ≈ 85 000) in the US reported ever having used cannabis. The researchers also found a greater likelihood of early cannabis use associated with older age, male sex, White non-Hispanic ethnicity, household income below the federal poverty level (as defined by the US government), living in a large urban area, having ever used alcohol or tobacco, lifetime history of major depressive episodes and having been involved in serious physical fights at school.[5]

We reviewed 19 longitudinal studies in which cannabis use onset in adolescence or young adulthood was the outcome.[6-24] Only 2 of the 19 studies examined onset of cannabis use prior to age 14 years. In the first, Baily and Hubbard[6] recruited Grades 6 through 8 students (n = 3454) at baseline and assessed cannabis use a year later. Of 1091 Grade 6 students, 9.7% had initiated cannabis use by Grade 7. "Importance of communication within the family" was protective and "ability to communicate within the family" was a risk factor. Bailey and Hubbard remarked that this finding was contrary to their expectations and speculated that the "'ability to communicate within the family' represents a dimension of liberal acceptance on the part of parents or a dimension of precociousness on the part of the young adolescents."[6,p.65] They found no relationship between onset of cannabis use and peer attachment, school attachment, adults' and friends' attitudes towards alcohol use or cannabis use, or peer use of alcohol or cannabis.

In the second study, Tang and Orwin[7] used data from the US National Survey of Parents and Youth (1998–2004) in which seven nationally representative age cohorts (i.e. 9–15-year-olds at baseline, with each age treated as a separate cohort) of never cannabis users were each followed for 2 years. Risk factors for initiation by age 13 years included parental drug use (not defined by a specific drug), friends' cannabis use, participants' own smoking and drinking, and having been offered cannabis.[7] Parental monitoring was protective.[7]

Onset of smoking and drinking tends to occur earlier than onset of cannabis use,[1] and risk and protective factors for tobacco and alcohol use in young adolescents might also be related to early cannabis use. Therefore, we consulted systematic reviews of risk and protective factors for adolescent onset of cigarette smoking[25] and drinking,[26] in addition to the 19 studies on cannabis use onset,[6-24] to identify factors consistently associated with use of these substances.

Because early cannabis use has particularly harmful long-term effects on physical and mental health,[27-32] and given the dearth of studies addressing use before age 14 years, we sought to determine whether factors associated with adolescent cannabis, tobacco and alcohol use are also associated with ever use of cannabis at age 12 years.

This study adds to the two extant longitudinal studies[6,7] examining early initiation of cannabis use by examining a much broader range of potential risk and protective factors (i.e. sociodemographic characteristics, lifestyle factors, characteristics of the social environment, psychological characteristics and pubertal status) in a large population-based sample of Grade 5 and Grade 6 Canadian youth (10–12 years old).

Methods

The AdoQuest study

We drew data from the first three waves of the six-wave AdoQuest study. In spring 2005, we randomly sampled 40 French-language schools in Greater Montréal (Quebec, Canada) with more than 90 students in Grade 5. We invited equal numbers of schools according to tertile groupings of a school socioeconomic status (SES) indicator.[33] Of the invited schools, 29 (72.5%) agreed to participate, including 10 in the high, 10 in the moderate and 9 in the low SES grouping. Students were recruited from all Grade 5 classes in participating schools.

We collected data in classroom-administered questionnaires once in Grade 5 (spring 2005) and twice in Grade 6 (fall 2005 and spring 2006). Parents/guardians* completed mailed self-report questionnaires in 2006/07. Participants provided assent and parents/guardians provided informed consent.

Baseline characteristics of AdoQuest study participants aligned with those of two provincially representative samples of Quebec youth[34,35] (data available on request from the authors).

Ethics approval

The study received approval from the institutional review boards of Concordia University (Concordia Ethics form 2006 number: UH2006-063) and the Centre de recherche du Centre Hospitalier de l'Université de Montréal (ADOQUEST F9-60229).

Study design

Data for ever use of cannabis were drawn from participant questionnaires completed in Grade 6 (i.e. fall 2005 and/or spring 2006). The value retained for analysis indicated whether the participant had ever reported cannabis use at either of these two time points. Data for 22 factors investigated as potentially associated with ever use were collected in Grade 5 or 6 (i.e. spring 2005, fall 2005 and/or spring 2006); for analysis, we retained the Grade 6 value of the factor unless the Grade 5 value was the only one available.

Data on nine variables (i.e. older sibling(s), lone parent family, parental education, household income, parental cannabis use, parental alcohol use and binge drinking, parental monitoring, parental attachment) were drawn from the parent questionnaire completed in 2006/07 (i.e. after participant data were collected), and data on two variables (i.e. parental smoking, home smoking ban) were collected in both participant and parent questionnaires. Because we could not ascertain the temporal ordering of the retained value of the potential correlate and the report of ever use, we consider the study design to be cross-sectional.

Study variables

Cannabis use was measured in the fall of Grade 6 with two questions: (1) "In your

* While the questionnaire was addressed to students' parents, responses may have included those of other guardians or parental figures.

TABLE 1
Potential correlates of ever use of cannabis associated with adolescent onset of cannabis, alcohol or tobacco use in extant longitudinal studies

Potential correlate	Substance	Source	Direction[a]
Sociodemographic characteristics			
Older age	Cannabis	Andrews et al.[8]	Risk
	Cannabis	von Sydow et al.[22]	Protective
	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Equivocal
Male sex	Cannabis	Brook et al.[11]	Risk
	Cannabis	Fergusson and Horwood[14]	Risk
	Cannabis	Hammer and Vaglum[17]	Risk
	Cannabis	Korhonen et al.[18]	Protective
	Cannabis	von Sydow et al.[22]	Risk
	Smoking	Wellman et al.[25]	Equivocal
	Drinking	Donovan[26]	Equivocal
Older siblings	Cannabis	Atherton et al.[9]	Risk
Lone parent family	Cannabis	Atherton et al.[9]	Protective
	Cannabis	Fergusson et al.[15]	Risk
	Cannabis	Guxens et al.[16]	Risk
	Cannabis	Hammer and Vaglum[17]	Risk
	Cannabis	von Sydow et al.[22]	Risk
	Cannabis	Wade and Pevalin[23]	Risk
	Smoking	Wellman et al.[25]	Risk
Lives with step-parent	Drinking	Donovan[26]	Risk
Lower parental education	Smoking	Wellman et al.[25]	Risk
Low socioeconomic status	Cannabis	Fergusson et al.[15]	Risk
	Cannabis	Pedersen et al.[19]	Risk
	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	None
Lifestyle			
Ever used/uses tobacco	Cannabis	Brook et al.[10]	Risk
	Cannabis	Coffey et al.[12]	Risk
	Cannabis	D'Amico and McCarthy[13]	Risk
	Cannabis	Guxens et al.[16]	Risk
	Cannabis	Korhonen et al.[18]	Risk
	Cannabis	Pedersen et al.[19]	Risk
	Cannabis	Tang and Orwin[7]	Risk
	Cannabis	von Sydow et al.[22]	Risk
	Drinking	Donovan[26]	Risk
Uses other tobacco products	Smoking	Wellman et al.[25]	Risk
Ever drank/drinks alcohol	Cannabis	Guxens et al.[16]	Risk
	Cannabis	Tang and Orwin[7]	Risk
	Cannabis	van den Bree and Pickworth[21]	Risk
	Cannabis	von Sydow et al.[22]	Risk
Frequent or high dose drinking	Cannabis	Coffey et al.[12]	Risk

Continued on the following page

TABLE 1 (continued)
Potential correlates of ever use of cannabis associated with adolescent onset of cannabis, alcohol or tobacco use in extant longitudinal studies

Potential correlate	Substance	Source	Direction[a]
Risky alcohol use	Cannabis	Guxens et al.[16]	Risk
Drinking to intoxication	Cannabis	Korhonen et al.[18]	Risk
Greater lifetime alcohol use	Cannabis	Spechler et al.[20]	Risk
Poor academic performance	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Risk
Greater physical activity	Smoking	Wellman et al.[25]	Risk
Social environment			
Parents use cannabis/other drugs	Cannabis	Andrews et al.[8]	Risk
	Cannabis	Fergusson and Horwood[14]	Risk
	Cannabis	Washburn and Capaldi[24]	Risk
Parents smoke cigarettes	Cannabis	Korhonen et al.[18]	Protective
	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Risk
Siblings smoke cigarettes	Smoking	Wellman et al.[25]	Risk
Parents drink alcohol	Drinking	Donovan[26]	Risk
Parents binge/drink heavily	Cannabis	Korhonen et al.[18]	Protective
Peers smoke cigarettes	Cannabis	Guxens et al.[16]	Risk
	Cannabis	Korhonen et al.[18]	Protective
	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Risk
Smoking banned at home	Smoking	Wellman et al.[25]	Risk
Satisfactory parental support	Cannabis	Brook et al.[10] Brook et al.[11]	Protective
Poor relationship with mother	Cannabis	von Sydow et al.[22]	Risk
Greater family attachment	Cannabis	Wade and Pevalin[23]	Protective
Lower parental support	Drinking	Donovan[26]	Risk
Higher parental monitoring	Cannabis	Atherton et al.[9]	Protective
	Cannabis	Tang and Orwin[7]	Protective
	Smoking	Wellman et al.[25]	Protective
Psychological characteristics			
Nicotine dependence	Cannabis	von Sydow et al.[22]	Risk
Higher self-esteem	Smoking	Wellman et al.[25]	Protective
Higher depressive symptoms	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Equivocal
Higher impulsivity	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Risk
Lower school connectedness	Smoking	Wellman et al.[25]	Risk
	Drinking	Donovan[26]	Risk
Mid-late puberty			
	Cannabis	Patton et al.[36]	Risk
	Smoking	Patton et al.[36]	Risk
	Drinking	Patton et al.[36]	Risk

[a] "Risk" factors were found to have a direct association and "protective" factors an inverse association with initiation of the target substance. Factors labelled "equivocal" had contradictory associations with onset of tobacco or alcohol use in the cited systematic review.

whole life, have you ever consumed cannabis (marijuana, pot, hashish)?" (Possible answers were "No," "Yes," or "I don't know what cannabis is"); and (2) "In the past year, how many times did you consume cannabis?" We asked both questions again in the spring of Grade 6, but this time the second question referred to a 6-month time frame. Response options at both time points were "I don't know what cannabis is," "I have never consumed cannabis in my entire life" and "from 1–2 to 40+ times." Participants who answered "No, I have never..." or "I don't know..." at both assessments were classified as not having used cannabis; those who answered "Yes" or endorsed using cannabis any number of times at either assessment were classified as having used cannabis.

We selected the 33 potential correlates of cannabis use based on the literature as well as on their availability in the AdoQuest study (see Table 1). These included 8 sociodemographic characteristics (i.e. age, sex, older siblings, two-parent family, parents education, household income, neighbourhood deprivation index, participant's weekly spending money); 10 lifestyle factors (i.e. ever tried cigarettes, ever tried other tobacco products, ever drank alcohol, ever binge drank, ever gambled, perceived academic performance, hours/day of TV, hours/day of computer games, frequency of reading not assigned for school, weekly physical activity); 9 characteristics of the social environment (i.e. parents use cannabis, parents smoke cigarettes, parents drink alcohol, parents binge drink, smoking banned at home, siblings smoke cigarettes, friends smoke cigarettes, parental monitoring, quality of caregiver–child relationship); 5 psychological characteristics (i.e. feel mentally or physically dependent on nicotine, self-esteem, depressive symptoms, impulsivity, school connectedness); and pubertal status.[36] Details on these variables, including questionnaire items, response choices, their coding for analyses and their psychometric properties (for derived scales), are available from the authors on request.

Data analysis

Data analyses were conducted with Stata version 14.2 (Stat Corp LLC, College Station, TX, US).

TABLE 2
Baseline characteristics of AdoQuest study participants not retained and retained for analyses

Characteristic	Not retained (n = 776)	Retained (n = 1076)
Mean age (SD)	10.80 (0.59)	10.74 (0.51)
Female sex, %	55.5	52.6
Has older siblings, %	N/A[a]	53.3
Lone parent family, %	N/A[a]	17.8
Both parents university educated, %	13.1	16.7
Household income <CAD 40 000, %	N/A[a]	18.1
High neighbourhood economic deprivation, %	25.2	20.2
Weekly spending money ≥CAD 6, %	32.9	25.6
Ever try cigarettes, %	21.1	16.7
Ever try other tobacco products[b], %	11.9	12.0
School performance average or lower, %	62.1	57.5
≥5 hours of TV per day, %	7.9	6.5
≥5 hours of video games per day, %	7.0	5.3
Reading frequency less than weekly (not for school), %	30.2	25.9
<2 times per week of physical activity, %	31.3	30.9
Parents smoke cannabis, %	N/A[a]	8.1
Parents smoke cigarettes, %	43.3	36.1
Parents drink alcohol, %	N/A[a]	96.3
Parents binge drink, %	N/A[a]	56.8
Smoking allowed in home, %	58.0	50.0
Siblings smoke cigarettes, %	16.4	10.6
Friends smoke cigarettes, %	15.2	12.0
Parental monitoring sometimes or less, %	N/A[a]	0.5
Frequent/constant problems in parent–child relationship, %	N/A[a]	13.3
Feel dependent on nicotine, %	7.9	5.3
Low self-esteem[c], %	46.4	41.5
High degree of depressive symptoms[c], %	30.7	30.1
Low school connectedness[c], %	42.8	37.9
Pre-pubertal status, %	10.8	11.3

Abbreviation: N/A, not applicable.

[a] Only 51–55 parents of non-retained participants completed the parent questionnaire and provided data on these characteristics, precluding accurate comparisons with retained participants.

[b] Other tobacco products include cigars, pipe, bidis, chewing tobacco and snuff.

[c] Low = lowest tertile; high = highest tertile.

Analytic sample

In Grade 5, 1801 students (mean age [SD] = 10.7 [0.6] years) provided data. By Grade 6, an additional 51 students joined the study (mean age [SD] of all Grade 6 participants = 11.7 [0.4] years), yielding a total 1852 participants. To develop the analytic sample, we first retained participants whose parents had completed the parental questionnaire in 2006/07 (n = 1127; 61% of 1852). Then we retained those participants who had provided data on cannabis use (n = 1076; 95% of 1127). Of the 1076 participants retained, 975 (90.6%) completed all three waves; 100 (9.3%) completed two waves and only 1 (0.1%) completed one wave.

Missing values

We used multiple imputation to account for missing values, with predictive mean matching with 10 nearest neighbour comparators for continuous and ordinal variables[37] and logistic regression for binary variables. We employed von Hippel's[38] two-step calculation to determine the

number of imputation sets needed to produce replicable estimates of standard errors. All variables to be examined in the analyses, including ever use, were entered into the imputation models.

Analyses

We estimated the association for each potential correlate in two models only, an unadjusted model and then an adjusted model that included sociodemographic characteristics that were correlated with cannabis use (i.e. age, sex, household income and participants' weekly spending money). Because the unadjusted and adjusted models for each potential correlate constitute a single hypothesis test, we did not correct for multiple comparisons.[39] We did not estimate associations for potential correlates in an omnibus model (i.e. one that included all potential correlates) because omnibus models may include variables on the causal pathway for other covariates,[40] which could lead to attenuated estimates.[41] We conducted logistic regression analyses with cluster robust standard errors to minimize bias in variance estimates related to clustering by school.[42]

Results

Participants

Based on recommendations on how to report descriptive data from the *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)* guidelines,[43] we compared characteristics of AdoQuest study participants retained for analysis (n = 1076) with those of participants who were lost to follow-up since inception or missing data on the variables of interest (n = 776) (see Table 2). Large differences between groups could indicate possible selection bias.

Although data for most variables were drawn from the baseline participant questionnaire, data for eight variables (i.e. older siblings, lone parent family, household income, parental cannabis use, parental drinking, parental binge drinking, parental monitoring, parent–child relationship) were collected in parental questionnaires only. Because only 51 to 55 parents of the 773 AdoQuest study participants not retained for analysis completed the parent questionnaire, we did not report estimates for these variables in

TABLE 3
Bivariate associations between participant characteristics and ever use of cannabis at age 12 (n = 1076)

Characteristic	% Missing values	n[a]	% Used
Sociodemographic			
Age in years	0		
< 11		320	3.1
≥ 11		756	5.7
Sex	0		
Female		566	3.6
Male		510	7.7
Has older siblings	1.2		
No		497	3.6
Yes		566	5.8
Two-parent family	1.2		
Yes		874	4.1
No		189	8.5
Parents' education	0.5		
Both completed university		179	2.8
One completed university		280	3.9
Neither completed university		612	5.7
Household income in CAD	16.6		
< 40 000		162	9.3
40 000–79 999		339	6.2
≥ 80 000		396	2.8
Neighbourhood deprivation	3.3		
Low		481	5.0
Moderate		350	4.9
High		210	5.2
Weekly spending money in CAD	8.6		
0		445	3.2
1–5		286	4.6
≥ 6		252	9.1
Lifestyle			
Ever try cigarettes	0		
No		896	1.1
Yes		180	23.9
Every try other tobacco products[b]	0		
No		947	2.0
Yes		129	26.4
Ever drink alcohol	0.3		
No		760	0.8
Yes		313	15.0
Ever binge drink	0.2		
No		1002	2.9
Yes		72	33.3

Continued on the following page

TABLE 3 (continued)
Bivariate associations between participant characteristics and ever use of cannabis at age 12 (n = 1076)

Characteristic	% Missing values	n[a]	% Used
Ever gamble	0.2		
No		856	3.3
Yes		218	11.0
School performance	1.4		
Better than average		451	3.6
Average		577	5.0
Worse than average		33	18.2
TV in hours/day	0		
< 1		187	3.2
1–2		490	4.3
≥ 3		399	6.5
Video games in hours/day	0.2		
< 1		454	5.3
1–2		400	4.3
≥ 3		220	5.5
Reading (not for school)	5.1		
Monthly or less		183	8.4
Monthly		81	5.3
Weekly		440	5.8
Daily		317	3.5
Physical activity in times/week	0.2		
≤ 2		332	6.3
3–4		329	3.0
≥ 5		413	5.3
Social environment			
Parents use cannabis	0.7		
No		982	4.5
Yes		87	9.2
Parents smoke cigarettes	0		
No		688	3.6
Yes		388	7.2
Parents drink alcohol	0.7		
No		40	5.0
Yes		1029	4.9
Parents binge drink	0.5		
No		463	5.0
Yes		608	4.9
Smoking banned at home	0		
No		538	6.3
Yes		538	3.5
Parental monitoring	0		
Often or less frequent[c]		122	11.5
Always		954	4.1

Continued on the following page

this group as they would likely be imprecise and biased.

Overall, there were few notable differences in the estimates for the 21 variables that we compared across groups, with two possible exceptions. Of participants not retained, 32.9% reported that they had weekly spending money of CAD 6 or more compared to 25.6% of participants retained for analysis; and of parents in the not retained group, 43.3% smoked cigarettes compared to 36.1% of parents in the retained group.

Missing data

The proportion of missing values ranged from 0 (9 variables) to 16.6% (household income; see Table 3). The median (interquartile range) proportion of missing values was 0.5% (0–3.4). We therefore created 20 imputed datasets. Comparisons of imputed and raw data show that the imputations produce similar distributions. Further, sensitivity analyses with complete cases only yield similar estimates to those using imputed datasets (data available on request from the authors).

Correlates of cannabis use

Fifty-three participants (4.9%) reported ever use of cannabis by the end of Grade 6 (mean age [SD] = 11.7 [0.4] years). Table 3 presents bivariate relationships between participant characteristics and ever use of cannabis. Table 4 presents unadjusted and adjusted odds ratios (OR) and 95% CI from the logistic regression analyses.

We note one caveat in interpreting our findings. Categories for five variables (i.e. never tried cigarettes, never drank, parents used cannabis, parents did not drink, pre-pubertal status) had low frequencies and few participants in those categories initiated cannabis use. This affected our ability to report precise estimates, and the magnitude of the estimates for these variables should be interpreted with caution.

Of the 33 variables investigated as potential correlates, 17 were associated with ever use in adjusted models. Four of eight sociodemographic characteristics (i.e. older age, identifying as male, lower household income, having more spending money) were associated with higher odds of ever use, as were 5 of 10 lifestyle factors (i.e.

TABLE 3 (continued)
Bivariate associations between participant characteristics and ever use of cannabis at age 12 (n = 1076)

Characteristic	% Missing values	n[a]	% Used
Parent–child relationship	0.9		
Occasional or less frequent problems[d]		142	7.0
No/almost no problems		924	4.6
Siblings smoke	3.4		
No		929	3.8
Yes		110	15.5
Friends smoke	3.9		
No		910	2.9
Yes		124	21.0
Psychological			
Feel dependent on nicotine	0		
No		1019	3.4
Yes		57	31.6
Self-esteem	0.2		
Low		446	8.7
Moderate		342	2.1
High		286	2.1
Depressive symptoms	6.4		
Low		357	3.9
Moderate		347	4.3
High		303	6.6
Impulsivity	10.4		
Low		320	1.9
Moderate		330	3.0
High		314	11.2
School connectedness	7.1		
Low		379	7.4
Moderate		401	4.5
High		220	2.3
Pubertal status	7.7		
Pubertal/post-pubertal		881	5.3
Pre-pubertal		112	1.8

[a] Calculated prior to imputation.

[b] Other tobacco products include cigars, pipe, bidis, chewing tobacco and snuff.

[c] Often or less frequent includes never (n = 0), rarely (n = 1), sometimes (n = 4) and often (n = 117).

[d] Includes constant problems (n = 0), frequent problems (n = 15) and occasional problems (n = 127).

ever tried cigarettes, ever tried other tobacco products, ever drank alcohol, ever binge drank and ever gambled).

Of the nine social environmental influences investigated, two (i.e. sibling/s smoke cigarettes, friends smoke cigarettes) were positively associated with ever use and one (i.e. parental monitoring) was inversely associated with ever use.

All five psychological characteristics were associated with ever use. Three (i.e. feeling dependent on nicotine, higher depressive symptoms, greater impulsivity) were associated with higher odds, and two (i.e. greater self-esteem and higher school connectedness) were associated with lower odds. Pubertal status was unrelated to ever use of cannabis.

Discussion

This study is one of the few to identify factors associated with cannabis use among children younger than 14. We found that 5% of Grade 6 students in the AdoQuest study (who were on average 11.7 years old in the spring of Grade 6) reported that they had ever used cannabis. This is a full year before the mean age of onset reported among Canadian students in Grade 7 to 9, who were on average 12.8 years old when we conducted our study. It is not yet clear whether legalization has significantly affected age at onset or the prevalence of early cannabis use among youth in Canada, although 2% and 4% of students in Grade 7 and 8, respectively, reported past-year cannabis use in 2018/19.[1]

While the frequency of early cannabis use as well as the frequency of its risk factors can change over time in response to contextual changes such as legalization, the associations between these exposures and early onset are not likely to change substantially, especially over relatively short time spans such as a decade. As an analogy, despite decades of research and profound changes in the tobacco-related context, the main risk factors for the onset of cigarette smoking (i.e. parents' smoking, friends' smoking, psychosocial characteristics) have not changed significantly in decades. Thus, although more than a decade has passed since the AdoQuest study data were collected, the risk factors for early onset have likely also not changed notably and therefore the findings we report continue to be relevant today.

We found that a wide range of sociodemographic, lifestyle, social environmental and psychological factors known to be associated with cannabis use in middle to late adolescence[6-24,44] and with adolescent smoking[25] and drinking[26] have similar associations with cannabis use at an earlier age. A notable finding in the current study are the associations among Grade 6 children for numerous correlates including use of combustible cigarettes, other tobacco products and alcohol. Although causal inference is limited given the study design, it is possible that the social environmental and psychological risk factors we identified (e.g. friends and siblings smoking, lower parental monitoring, lower self-esteem, depressive symptoms, impulsivity and low school connectedness)

TABLE 4
Associations between participant characteristics and ever use of cannabis at age 12 (n = 1076)

Characteristic	Unadjusted odds ratio (95% CI)	Adjusted odds ratio[a] (95% CI)
Sociodemographic		
Age[b]		
< 11	Ref	Ref
≥ 11	**1.56 (1.13, 2.15)**	**1.39 (1.06, 1.84)**
Sex		
Female	Ref	Ref
Male	**3.62 (1.68, 7.82)**	**3.76 (1.72, 8.23)**
Has older siblings		
No	Ref	Ref
Yes	1.56 (0.82, 3.00)	1.82 (0.95, 3.48)
Two-parent family		
Yes	Ref	Ref
No	**2.11 (1.03, 4.30)**	1.32 (0.55, 3.19)
Parents' education		
Both university	Ref	Ref
One university	1.44 (0.43, 4.78)	1.19 (0.34, 4.22)
Neither university	2.19 (0.74, 6.42)	1.23 (0.39, 3.86)
Household income[b]	**0.85 (0.77, 0.94)**	**0.86 (0.79, 0.95)**
Neighbourhood deprivation		
Low	Ref	Ref
Moderate	0.97 (0.49, 1.92)	0.80 (0.43, 1.49)
High	1.06 (0.46, 2.43)	0.73 (0.31, 1.74)
Weekly spending money[b]	**1.59 (1.23, 2.05)**	**1.54 (1.20, 1.98)**
Lifestyle		
Ever try cigarettes		
No	Ref	Ref
Yes	**27.81 (11.57, 66.82)**	**22.03 (9.31, 52.14)**
Every try other tobacco products[c]		
No	Ref	Ref
Yes	**17.48 (10.55, 28.97)**	**13.36 (7.28, 24.52)**
Ever drink alcohol		
No	Ref	Ref
Yes	**22.25 (10.29, 48.11)**	**19.78 (7.40, 38.03)**
Ever binge drink		
No	Ref	Ref
Yes	**16.79 (9.71, 29.05)**	**11.75 (6.18, 22.32)**
Ever gamble		
No	Ref	Ref
Yes	**3.60 (1.97, 6.58)**	**2.95 (1.55, 5.62)**
School performance		
Better than average	0.71 (0.39, 1.30)	0.79 (0.44, 1.44)
Average	Ref	Ref
Worse than average	**4.08 (1.71, 9.72)**	2.63 (0.96, 7.21)

Continued on the following page

signal vulnerabilities underpinning early use of multiple substances that are amenable to intervention. At a minimum, these data suggest that children who report early cannabis use are also at higher risk of early use of combustible cigarettes and alcohol, such that intervention to curb early onset of cannabis use should take polysubstance use into account.

In contrast to reports that parental lifetime and past-year cannabis use was associated with use by adolescents aged 12 to 17 years,[44-46] we did not detect an association in the current study. We also found no association between parental smoking, drinking or binge drinking and early cannabis use. It is possible that young children are not yet cognizant of parental substance use so that role modelling of these behaviours is not yet an influence in terms of offspring substance use behaviours. Alternatively, our analyses were simply underpowered to detect these associations (i.e. only 87 parents reported cannabis use and only 40 did not drink alcohol). The relationship between parental substance use behaviours and early cannabis use warrants further study.

Early and frequent cannabis use has long-term implications for outcomes in young adulthood. Specifically, earlier cannabis use is linked to harmful effects on attention, memory and decision-making, and mental health.[4,27-32] In addition, cannabis use before age 15 is associated with lower educational attainment; higher frequency of binge drinking, coupled with an increased risk of future alcohol abuse/dependence and greater alcohol-related harms; higher frequency and greater quantity of cannabis consumption and higher risk of cannabis use disorder symptoms; and more frequent use of other illicit drugs by age 30.[44] Further, substance use trajectory studies indicate that risky behaviours, which can cluster in youth, are strongly related to substance use and abuse in early adulthood and beyond.[47] Our data thus underscore that early cannabis use prevention interventions are critical for vulnerable children who already exhibit signs of engaging in other risky behaviours. Consequently, substance use interventions should be comprehensive, addressing numerous substances and risky behaviours concurrently.

Strengths and limitations

Study strengths include the large population-based sample and the investigation of

TABLE 4 (continued)
Associations between participant characteristics and ever use of cannabis at age 12 (n = 1076)

Characteristic	Unadjusted odds ratio (95% CI)	Adjusted odds ratio[a] (95% CI)
TV hours/day[b]	1.44 (0.95, 2.17)	1.32 (0.87, 2.00)
Video games hours/day[b]	1.07 (0.75, 1.54)	0.95 (0.67, 1.35)
Reading (not for school)[b]	**0.82 (0.71, 0.95)**	0.84 (0.71, 1.00)
Physical activity[b]	1.03 (0.79, 1.34)	0.95 (0.73, 1.24)
Social environment		
Parents use cannabis		
No	Ref	Ref
Yes	2.19 (0.95, 5.06)	1.86 (0.72, 4.83)
Parents smoke cigarettes		
No	Ref	Ref
Yes	**2.06 (1.09, 3.91)**	1.59 (0.78, 3.23)
Parents drink alcohol		
No	Ref	Ref
Yes	0.99 (0.21, 4.61)	1.82 (0.37, 9.03)
Parents binge drink		
No	Ref	Ref
Yes	0.99 (0.59, 1.67)	0.96 (0.59, 1.57)
Smoking banned at home		
No	Ref	Ref
Yes	**0.54 (0.32, 0.91)**	0.63 (0.37, 1.07)
Parental monitoring[b]	**0.42 (0.26, 0.68)**	**0.56 (0.36, 0.88)**
Parent–child relationship[b]	0.79 (0.54, 1.16)	0.94 (0.68, 1.32)
Siblings smoke		
No	Ref	Ref
Yes	**4.56 (2.54, 8.54)**	**4.23 (2.28, 7.83)**
Friends smoke		
No	Ref	Ref
Yes	**8.57 (5.33, 13.79)**	**8.82 (5.20, 14.98)**
Psychological		
Feel dependent on nicotine		
No	Ref	Ref
Yes	**12.98 (6.94, 24.24)**	**12.16 (6.02, 24.58)**
Self-esteem[b,d]	**0.47 (0.38, 0.57)**	**0.45 (0.34, 0.58)**
Depressive symptoms[b,d]	1.31 (0.99, 1.74)	**1.34 (1.01, 1.79)**
Impulsivity[b,d]	**2.45 (1.82, 3.29)**	**2.38 (1.67, 3.39)**
School connectedness[b,d]	**0.65 (0.52, 0.83)**	**0.69 (0.54, 0.90)**
Pubertal status		
Pubertal/post-pubertal	Ref	Ref
Pre-pubertal	0.36 (0.10, 1.37)	0.30 (0.08, 1.18)

Abbreviations: CI, confidence interval; OR, odds ratio; Ref, reference; SD, standard deviation.
Note: Estimates in bold font indicate that the CI excludes the null.
[a] Adjusted for age, sex, household income and weekly spending money.
[b] Entered into analyses as a continuous variable.
[c] Other tobacco products include cigars, pipe, bidis, chewing tobacco and snuff.
[d] OR represents the odds per a 1 SD change in the correlate.

a wide range of potential risk and protective factors. Limitations include its cross-sectional study design, which limits causal inference, and the use of self-report data, which may have contributed to recall error and/or misclassification bias. Loss to follow-up may have resulted in selection bias.

As the AdoQuest study was not designed as a cannabis use study, some potential correlates such as siblings' or friends' cannabis use were not measured. Given the 33 separate potential associations examined, some statistically significant findings may be attributable to chance. However, this seems unlikely as our findings align with those from numerous previous studies. In addition, the sample is 93% White, which may limit generalizability.

Finally, data collection predated legalization of non-medicinal cannabis use in Canada in 2018. However, legalization appears to have had little effect on ever or current (i.e. monthly or more frequently in the past year) cannabis use among Canadian high school students.[48] Moreover, the effect of legalization on age at onset is as yet unknown, but it is not likely to have altered factors associated with early use.[49]

Conclusion

We found that many characteristics associated with cannabis use in mid to late adolescence are also associated with early use. Our findings suggest that surveillance for cannabis use and preventive intervention use are warranted even earlier than age 12. Interventions should incorporate consideration of impulsivity, other risky behaviours (e.g. tobacco use, drinking or gambling) and having friends who smoke as well as encouraging parents/guardians to monitor their children's whereabouts. Surveillance to detect trends in risk factors is needed because these may differ across study populations or with time.

Future studies should assess early and later predictors of frequency and quantity of cannabis use. Moreover, studies should consider both individual and contextual level correlates or predictors, as illustrated by our finding that higher household income was inversely related to cannabis use after adjusting for weekly spending money, while having more spending money was directly related to cannabis use after adjusting for household income.

Finally, replication is critical because different methods across studies can lead to different conclusions. In particular, replication studies using data collected post-legalization are needed to investigate whether risk factors for early cannabis use might have changed since 2018.

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Conflicts of interest

The authors have no financial relationships relevant to this article and no conflicts of interest to disclose.

Authors' contributions and statement

RJW reviewed the literature, conducted analyses and wrote the first draft.

EKO'L coordinated data collection in the AdoQuest study and conducted analyses.

M-PS consulted on the analytic plan.

END reviewed the literature.

JO'L conceived, obtained funding for and oversaw all aspects of the AdoQuest study.

All authors contributed to conceptualization of the study, interpreted the results, and reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Views expressed in this document are those of the authors and do not necessarily reflect those of the Ministère de la Santé et des Services sociaux or of the Government of Canada.

References

1. Summary of results for the Canadian Student Tobacco, Alcohol and Drugs Survey 2018-19 [Internet]. Ottawa (ON): Government of Canada; [modified 2019 Dec 23; cited 2020 Mar 7]. Available from: https://www.canada.ca/en/health-canada/services/canadian-student-tobacco-alcohol-drugs-survey/2018-2019-summary.html

2. Johnston LD, Miech RA, O'Malley PM, Bachman JG, Schulenberg JE, Patrick ME. Monitoring the Future national survey results on drug use, 1975-2019: Overview, key findings on adolescent drug use. Ann Arbor (MI): Institute for Social Research, University of Michigan; 2020. https://doi.org/10.3998/2027.42/162579

3. Leatherdale ST, Hammond D, Ahmed R. Alcohol, marijuana, and tobacco use patterns among youth in Canada. Cancer Causes Control. 2008;19(4):361-9. https://doi.org/10.1007/s10552-007-9095-4

4. Odgers CL, Caspi A, Nagin DS, et al. Is it important to prevent early exposure to drugs and alcohol among adolescents? Psychol Sci. 2008;19(10):1037-44. https://doi.org/10.1111/j.1467-9280.2008.02196.x

5. Forman-Hoffman VL, Glasheen C, Batts KR. Marijuana use, recent marijuana initiation, and progression to marijuana use disorder among young male and female adolescents aged 12-14 living in US households. Subst Abuse. 2017;11:1178221817711159. https://doi.org/10.1177/1178221817711159

6. Bailey SL, Hubbard RL. Developmental variation in the context of marijuana initiation among adolescents. J Health Soc Behav. 1990;31(1):58-70. https://doi.org/10.2307/2137045

7. Tang Z, Orwin RG. Marijuana initiation among American youth and its risks as dynamic processes: prospective findings from a national longitudinal study. Subst Use Misuse. 2009;44(2):195-211. https://doi.org/10.1080/10826080802347636

8. Andrews JA, Hops H, Ary D, Tildesley E, Harris J. Parental influence on early adolescent substance use: specific and nonspecific effects. J Early Adolesc. 1993;13(3):285-310. https://doi.org/10.1177/0272431693013003004

9. Atherton OE, Conger RD, Ferrer E, Robins RW. Risk and protective factors for early substance use initiation: a longitudinal study of Mexican-origin youth. J Res Adolescence. 2016;26(4):864-79. https://doi.org/10.1111/jora.12235

10. Brook JS, Kessler RC, Cohen P. The onset of marijuana use from preadolescence and early adolescence to young adulthood. Dev Psychopathol. 1999;11(4):901-14. https://doi.org/10.1017/S0954579499002370

11. Brook JS, Lukoff IF, Whiteman M. Initiation into adolescent marijuana use. J Genet Psychol. 1980;137(1):133-42. https://doi.org/10.1080/00221325.1980.10532808

12. Coffey C, Lynskey M, Wolfe R, Patton GC. Initiation and progression of cannabis use in a population-based Australian adolescent longitudinal study. Addiction. 2000;95(11):1679-90. https://doi.org/10.1046/j.1360-0443.2000.951116798.x

13. D'Amico EJ, McCarthy DM. Escalation and initiation of younger adolescents' substance use: the impact of perceived peer use. J Adolesc Health. 2006;39(4):481-7. https://doi.org/10.1016/j.jadohealth.2006.02.010

14. Fergusson DM, Horwood LJ. Cannabis use and dependence in a New Zealand birth cohort. N Z Med J. 2000;113(1109):156-8.

15. Fergusson DM, Lynskey MT, Horwood LJ. Conduct problems and attention deficit behaviour in middle childhood and cannabis use by age 15. Aust N Z J Psychiatry. 1993;27:673-82. https://doi.org/10.3109/00048679309075830

16. Guxens M, Nebot M, Ariza C. Age and sex differences in factors associated with the onset of cannabis use: a cohort study. Drug Alcohol Depend. 2007;88(2-3):234-43. https://doi.org/10.1016/j.drugalcdep.2006.10.018

17. Hammer T, Vaglum P. Users and nonusers within a high-risk milieu of cannabis use. a general population study. Int J Addict. 1991;26(5):595-604. https://doi.org/10.3109/10826089109058907

18. Korhonen T, Huizink AC, Dick DM, Pulkkinen L, Rose RJ, Kaprio J. Role of individual, peer and family factors in the use of cannabis and other illicit drugs: a longitudinal analysis among Finnish adolescent twins. Drug Alcohol Depend. 2008;97(1-2):33-43. https://doi.org/10.1016/j.drugalcdep.2008.03.015

19. Pedersen W, Mastekaasa A, Wichstrøm L. Conduct problems and early cannabis initiation: a longitudinal study of gender differences. Addiction. 2001;96(3):415-31. https://doi.org/10.1046/j.1360-0443.2001.9634156.x

20. Spechler PA, Allgaier N, Chaarani B, et al.; IMAGEN Consortium. The initiation of cannabis use in adolescence is predicted by sex-specific psychosocial and neurobiological features. Eur J Neurosci. 2019;50(3):2346-56. https://doi.org/10.1111/ejn.13989

21. van den Bree MB, Pickworth WB. Risk factors predicting changes in marijuana involvement in teenagers. Arch Gen Psychiatry. 2005;62(3):311-9. https://doi.org/10.1001/archpsyc.62.3.311

22. von Sydow K, Lieb R, Pfister H, Höfler M, Wittchen HU. What predicts incident use of cannabis and progression to abuse and dependence? A 4-year prospective examination of risk factors in a community sample of adolescents and young adults. Drug Alcohol Depend. 2002;68(1):49-64. https://doi.org/10.1016/S0376-8716(02)00102-3

23. Wade TJ, Pevalin DJ. Adolescent delinquency and health. Can J Criminol Crim Justice. 2005;47(4):619-54. https://doi.org/10.3138/cjccj.47.4.619

24. Washburn IJ, Capaldi DM. Influences on boys' marijuana use in high school: a two-part random intercept growth model. J Res Adolesc. 2014;24(1):117-30. https://doi.org/10.1111/jora.12030

25. Wellman RJ, Dugas EN, Dutczak H, et al. Predictors of the onset of cigarette smoking: a systematic review of longitudinal population-based studies in youth. Am J Prev Med. 2016;51(5):767-78. https://doi.org/10.1016/j.amepre.2016.04.003

26. Donovan JE. Adolescent alcohol initiation: a review of psychosocial risk factors. J Adolesc Health. 2004;35:529.e7-529.e18. https://doi.org/10.1016/j.jadohealth.2004.02.003

27. Levine A, Clemenza K, Rynn M, Lieberman J. Evidence for the risks and consequences of adolescent cannabis exposure. J Am Acad Child Adolesc Psychiatry. 2017;56(3):214-25. https://doi.org/10.1016/j.jaac.2016.12.014

28. Meier MH, Caspi A, Ambler A, et al. Persistent cannabis users show neuropsychological decline from childhood to midlife. Proc Natl Acad Sci U S A. 2012;109(40):E2657-64. https://doi.org/10.1073/pnas.1206820109

29. Fischer B, Russell C, Sabioni P, et al. Lower-risk cannabis use guidelines: a comprehensive update of evidence and recommendations. Am J Public Health. 2017;107(8):e1-12. https://doi.org/10.2105/AJPH.2017.303818

30. Saxena S, Poznyak V, Renström M, Gehring E, Rekve D, Clark N; Department of Mental Health and Substance Abuse. The health and social effects of nonmedical cannabis use. Geneva (CH): World Health Organization; 2016 [cited 2020 Aug 9]. Available from: https://apps.who.int/iris/bitstream/handle/10665/251056/9789241510240-eng.pdf?sequence=1&isAllowed=y

31. Chadwick B, Miller ML, Hurd YL. Cannabis use during adolescent development: susceptibility to psychiatric illness. Front Psychiatry. 2013;4:129. https://doi.org/10.3389/fpsyt.2013.00129

32. Lynskey MT, Heath AC, Bucholz KK, et al. Escalation of drug use in early-onset cannabis users vs. co-twin controls. JAMA. 2003;289(4):427-33. https://doi.org/10.1001/jama.289.4.427

33. Québec Ministère de l'Éducation. La carte de la population scolaire et les indices de défavorisation. Bull Stat Educ [Internet]. 2003 [cited 2021 Mar 1];26:1e9. Available from: http://www.education.gouv.qc.ca/fileadmin/site_web/documents/PSG/statistiques_info_decisionnelle/bulletin_26.pdf

34. Paradis G, Lambert M, O'Loughlin J, et al. The Québec Child and Adolescent Health and Social Survey: design and methods of a cardiovascular risk factor survey for youth. Can J Cardiol. 2003;19(5):523-31.

35. Elton-Marshall T, Leatherdale ST, Manske SR, Wong K, Ahmed R, Burkhalter R. Research methods of the Youth Smoking Survey (YSS). Chronic Dis Inj Can. 2011;32(1):47-54. https://doi.org/10.24095/hpcdp.32.1.07

36. Patton GC, McMorris BJ, Toumbourou JW, Hemphill SA, Donath S, Catalano RF. Puberty and the onset of substance use and abuse. Pediatrics. 2004;114(3):e300-6. https://doi.org/10.1542/peds.2003-0626-F

37. Morris TP, White IR, Royston, P. Tuning multiple imputation by predictive mean matching and local residual draws. BMC Med Res Methodol. 2014;14(1):75. https://doi.org/10.1186/1471-2288/14/75

38. von Hippel PT. How many imputations do you need? A two-stage calculation using a quadratic rule. Sociol Methods Res. 2020;49(3):699-718. https://doi.org/10.1177/0049124117747303

39. Bender R, Lange S. Adjusting for multiple testing—when and how? J Clin Epidemiol. 2001;54(4):343-9. https://doi.org/10.1016/S0895-4356(00)00314-0

40. Westreich D, Greenland S. The Table 2 fallacy: presenting and interpreting confounder and modifier coefficients. Am J Epidemiol. 2013;177(4):292-8. https://doi.org/10.1093/aje/kws412

41. Schisterman EF, Cole SR, Platt RW. Overadjustment bias and unnecessary adjustment in epidemiologic studies. Epidemiology. 2009;20(4):488-95. https://doi.org/10.1097/EDE.0b013e3181a819a1

42. Williams RL. A note on robust variance estimation for cluster-correlated data. Biometrics. 2000;56(2):645-6. https://doi.org/10.1111/j.0006-341X.2000.00645.x

43. Vandenbrouke JP, von Elm E, Altman DG, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297. https://doi.org/10.1371/journal.pmed.0040297

44. Merrin GJ, Leadbeater BJ, Sturgess CM, Ames ME, Thompson K. Predictors of early-onset cannabis use in adolescence and risks for substance use disorder symptoms in young adulthood. J Drug Issues. 2022;52(2):182-206. https://doi.org/10.1177/00220426211049356

45. Madras BK, Han B, Compton WM, Jones CM, Lopez EL, McCance-Katz EF. Associations of parental marijuana use with offspring marijuana, tobacco, and alcohol use and opioid misuse. JAMA Netw Open. 2019;2(11):e1916015. https://doi.org/10.1001/jamanetworkopen.2019.16015

46. O'Loughlin JL, Dugas EN, O'Loughlin EK, et al. Parental cannabis use is associated with cannabis initiation and use in offspring. J Pediatr. 2019;206:142-7. https://doi.org/10.1016/j.jpeds.2018.10.057

47. Taylor M, Collin SM, Munafò MR, MacLeod J, Hickman M, Heron J. Patterns of cannabis use during adolescence and their association with harmful substance use behaviour: findings from a UK birth cohort. J Epidemiol Community Health. 2017;71(8):764-70. https://doi.org/10.1136/jech-2016-208503

48. Zuckermann AM, Battista KV, Bélanger RE, et al. Trends in youth cannabis use across cannabis legalization: data from the COMPASS prospective cohort study. Prev Med Rep. 2021;22(4):101351. https://doi.org/10.1016/j.pmedr.2021.101351

49. Melchior M, Nakamura A, Bolze C, et al. Does liberalisation of cannabis policy influence levels of use in adolescents and young adults? A systematic review and meta-analysis. BMJ Open. 2019;9(7):e025880. https://doi.org/10.1136/bmjopen-2018-025880

https://doi.org/10.24095/hpcdp.43.1.03

Original quantitative research

Stressors and symptoms associated with a history of adverse childhood experiences among older adolescents and young adults during the COVID-19 pandemic in Manitoba, Canada

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Abstract

Introduction: The COVID-19 pandemic has had major economic, social and psychological consequences for adolescents and young adults. It is unclear whether those with a history of adverse childhood experiences (ACEs) were particularly vulnerable. We examined whether a history of ACEs was associated with financial difficulties, lack of emotional support, feeling stressed/anxious, feeling down/depressed, increased alcohol and/or cannabis use and increased conflict with parents, siblings and/or intimate partners among 16- to 21-year-olds during the pandemic.

Methods: Data were collected in November and December 2020 from respondents aged 16 to 21 years (n = 664) participating in the longitudinal and intergenerational Well-being and Experiences Study (Wave 3) conducted in Manitoba, Canada. Age-stratified associations between ACEs and pandemic-related stressors/symptoms were examined with binary and multinomial logistic regression.

Results: A history of ACEs was associated with pandemic-related financial difficulties (adjusted relative risk ratio [aRRR] range: 2.44–7.55); lack of emotional support (aRRR range: 2.13–26.77); higher levels of feeling stressed/anxious and down/depressed (adjusted odds ratio [aOR] range: 1.78–5.05); increased alcohol and cannabis use (aOR range: 1.99–8.02); and increased relationship conflict (aOR range: 1.98–22.59). Fewer associations emerged for older adolescents and these were not to the same degree as for young adults.

Conclusion: Adolescents and young adults with a history of ACEs reported increased odds of pandemic-related stressors and symptoms, and may need more resources and greater support compared to peers without an ACE history. Differences in results for adolescents and young adults suggest that interventions should be tailored to the needs of each age group.

Keywords: *SARS-CoV-2, child abuse, neglect, substance use, mental health, emotional support, interpersonal conflict, financial hardship*

Highlights

- The COVID-19 pandemic has exacerbated financial, social and psychological difficulties for young people.
- Older adolescents and young adults with a history of adverse childhood experiences (ACEs) were more vulnerable to pandemic-related stressors and symptoms compared to their peers without an ACEs history.
- Young adults with a history of ACEs may need additional resources that provide financial assistance, address mental health concerns, foster emotional support, reduce substance use and facilitate positive relationships.
- Older adolescents with a history of ACEs may benefit from interventions that improve feelings of depression and foster emotional support and healthy relationships with parents.
- Psychological first aid that provides practical and emotional support may be a suitable approach for supporting recovery from the pandemic.

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Introduction

The first COVID-19 case was identified in Manitoba, Canada, on 12 March 2020, and on 20 March 2020 the province declared a state of emergency.[1] Several public health measures were implemented to mitigate SARS-CoV-2 transmission, including restrictions on public gatherings and closures of schools and non-essential businesses.[1] After 1 May 2020, new cases diminished substantially and restrictions eased.[1] Infection rates increased again in August 2020, and by November 2020 critical-level disease containment restrictions were enacted.[1] Gathering sizes were extremely limited and non-essential businesses were ordered to close.

Stressors resulting from these public health measures, such as unemployment, have disproportionately impacted young populations.[2] The economic, social and psychological consequences of the COVID-19 pandemic have been particularly problematic for adolescents and young adults.[2-5] Those who were exposed to child maltreatment and other adversities in childhood may have been especially vulnerable.

Adverse childhood experiences (ACEs) are stressful, potentially traumatic events that threaten a child's sense of living in a safe, stable and nurturing environment.[6] ACEs typically refer to abuse (physical, sexual and emotional); neglect (physical and emotional); exposure to intimate partner violence (IPV); and household challenges (substance abuse and mental illness in the household, parental separation or divorce, and parental incarceration or problems with police).[6] ACEs may also include spanking, parental gambling, foster care or child protection involvement, living in an unsafe community, poverty and peer victimization.[7,8]

ACEs research has uncovered an extensive range of outcomes that can have repercussions across the lifespan.[9] For example, meta-analytic results indicate robust associations between ACEs and poor mental (e.g. depression, anxiety, substance abuse) and physical health.[10] An ACEs history can also hinder the formation of healthy relationships, and has been associated with lower perceived social support[11] and a higher risk for interpersonal conflict.[12] In addition, ACEs can negatively impact socioeconomic status in adulthood, including education, employment and income.[13] Consequently, a childhood adversity history presents a substantial burden on health and well-being; it is important to determine if this burden was exacerbated during the COVID-19 pandemic.

Vulnerability to the effects of stressful life events, such as the pandemic, among people with a history of ACEs is hypothesized to arise via a mechanism known as stress sensitization.[14] It is theorized that physiological changes occur in response to childhood adversities (conceptualized as "toxic stress"[15]) as an adaptive mechanism to help the child survive in their adverse environment.[16] These adaptations, however, can disrupt physiological systems and functioning including neural, neuroendocrine, metabolic and immune functioning.[16] For instance, alterations to brain structure and activity are linked to dysregulation of stress responses, fear learning, emotion regulation, executive functioning and reward processing.[16] In the face of chronic exposure to toxic stress during childhood, regulatory functions are increasingly sensitized to subsequent stressors. Individuals with a history of ACEs have lower thresholds of stress tolerance that are associated with increased risk of potentially harmful physiological, emotional and behavioural responses.[14,16] Several studies have observed stress sensitization among survivors of childhood adversity, whose risk of psychopathology after traumatic events is high compared with people without histories of adversity.[17-20]

The literature on how individuals with a history of ACEs are faring during the COVID-19 pandemic is sparse. Three studies conducted in China early in the pandemic (February and March 2020)—two with post-secondary student samples and one with a sample of rural adolescents—found significant associations between ACEs and self-reported symptoms of acute stress, anxiety and depression.[21-23] To our knowledge, no studies have investigated associations between a history of ACEs and pandemic-related financial difficulties, emotional support, substance use or interpersonal conflict. It is also possible that any associations between ACEs and pandemic-related impacts differ by age group. The transition from adolescence to emerging adulthood typically involves greater independence from parents/caregivers as well as added responsibility.[24] Young adults may experience more life stressors than adolescents and may have less access to and/or reliance on family resources.

The objectives of our study were to estimate the associations between a history of ACEs and self-reported stressors and symptoms (financial difficulties; lack of emotional support; high levels of feeling stressed/anxious and down/depressed; increased alcohol consumption and cannabis use; and increased conflict with parents*, siblings and/or an intimate partner) during the pandemic among older adolescents and young adults.

Methods

Data and sample

A community sample of older adolescents (aged 16 or 17 years) and young adults (aged 18–21 years) was drawn from the longitudinal and intergenerational Well-being and Experiences (WE) Study, conducted in Manitoba, Canada. Baseline recruitment for Wave 1 in 2017–18 (N = 1002; aged 14–17 years) involved random digit dialling (21%), referrals (40.6%) and community advertisements (38.4%) to contact parents or caregivers and adolescents from Winnipeg and surrounding rural areas. Sampling method differences were not detected for sex, age, ethnicity and several ACEs.[25] Postal codes (Forward Sortation Area) and demographic characteristics were monitored to ensure the adolescent sample resembled the Winnipeg population based on characteristics of age, sex, household income and ethnicity.[8]

The adolescents were recontacted to participate in Wave 2 in 2019 (n = 748) and in Wave 3 from November to December 2020 (n = 664; 66.3% of the original adolescent cohort; aged 16–21 years), with online questionnaires administered by text or email. Compared to Wave 1 respondents, a larger proportion of Wave 3 respondents were female and had a higher household income; no differences were detected in respondent age.

* While the question about conflict specifically asked about parents only, responses may have included other guardians or parental figures.

Written informed consent was obtained from all participants. The University of Manitoba Health Research Ethics Board granted ethics approval (#HS24159/H2020:359).

Measures

Adverse childhood experiences

Sixteen ACEs were assessed: seven child maltreatment ACEs; peer victimization; and eight household challenges ACEs. Most ACEs were assessed at Wave 3 and pertained to respondents' experiences before they were 16 years old; exceptions are noted below. Because of mandatory child abuse reporting laws for minors, assessments of child maltreatment ACEs differed depending on respondent age at Wave 3. For adults, physical abuse, sexual abuse, emotional abuse, physical neglect and emotional neglect were measured using the Childhood Trauma Questionnaire (CTQ).[26] These ACEs were scored according to CTQ instructions and dichotomized according to established cut-points.[8]

For adolescents, emotional neglect was also measured using the CTQ. Emotional abuse was assessed using a single item adapted from the Childhood Experiences of Violence Questionnaire (CEVQ)[27]: "How many times has a parent or guardian said hurtful or mean things to you?" Responses of "once a month" or more frequently were coded "yes."

For adults, exposure to physical IPV was assessed with a question adapted from the CEVQ[27]: "How many times did you see or hear any one of your parents, step-parents or guardians hit each other or another adult in your home?" Responses of "3 to 5 times" or more were coded "yes." For adolescents, exposure to verbal IPV was also assessed with a question adapted from the CEVQ[27]: "How often have you seen or heard adults say hurtful or mean things to another adult in your home?" Responses of "once a month" or more frequently were coded "yes."

Spanking was assessed at Wave 1 with one question adapted from the CEVQ[27] referring to a typical year when the respondent was aged 10 years or younger: "How often do you remember an adult spanking you with their hand on your bottom (bum)?" Responses of "2 to 3 times a year" or more were coded "yes."

For adolescents and young adults separately, each child maltreatment ACE was combined into a single dichotomous variable indicating exposure to "any" child maltreatment ACE. The remaining ACEs were assessed in the same way for all respondents.

Peer victimization was measured at Waves 1 and 2, with seven items assessing the frequency of past-year exposure to physical, verbal, social and cyber victimization as well as three types of discriminatory victimization. A response of "once a month" or more frequently at either wave was coded "yes." The seven items were then combined into a single dichotomous variable for exposure to "any" peer victimization.

Measurement of household challenges ACEs included problems with alcohol and/or drugs (two items); mental health problems such as depression or anxiety (one item); parental separation or divorce (one item); parental problems with police (one item); parental problems with gambling (one item); foster care placement and/or contact with a child protective organization (two items); household running out of money for rent/mortgage and/or basic necessities such as food or clothing (a proxy for poverty; two items); and living in an unsafe community (one item). Poverty and unsafe community were assessed at Wave 1. Because of a low prevalence of several household challenges items in the sample, a single dichotomous variable was computed to indicate exposure to "at least one." The ACEs measures are outlined in Table 1, and additional details are available elsewhere.[8,28]

COVID-19 pandemic impacts

Self-reported stressors and symptoms experienced during the COVID-19 pandemic were identified at Wave 3. Financial hardship was assessed with the question "Have you or your family experienced financial difficulties because of the COVID-19 pandemic?" We recoded the five ordinal response options as "not at all/a little," "some" and "quite a bit/a lot." Emotional support was assessed with the question "Have you felt emotionally supported during the COVID-19 pandemic?" with the same response options recoded as "not at all," "a little," "some" and "quite a bit/a lot." Stress/anxiety and depression were each assessed with one question asking whether the respondent felt "stressed or anxious…" or "down or depressed because of the COVID-19 pandemic"; response options were dichotomized as "quite a bit/a lot" versus "some/a little/not at all." Changes in alcohol consumption and cannabis use were assessed with two questions (e.g. "Has your consumption of alcohol changed due to the COVID-19 pandemic?"). The response options for each question were "increased," "remained the same" and "decreased"; these response options were dichotomized as "increased" versus "remained the same/decreased." Changes in conflict with parents, siblings and intimate partners were assessed with three questions (e.g. "Has conflict with your parents changed due to the COVID-19 pandemic?"). The response options for each question were also dichotomized as "increased" versus "remained the same/decreased."

Covariates

Sociodemographic characteristics were respondent age at Wave 3, stratified by older adolescents (16 or 17 years) and young adults (18–21 years); male and female sex at Wave 1; race/ethnicity reported at Wave 1; parents' highest level of education at Wave 1; and household income reported by the parent at Wave 1.

Data analysis

Descriptive statistics for sociodemographic characteristics, COVID-19 pandemic stressors and symptoms, and ACEs were computed for the total sample and by age group. Associations between ACEs and financial hardship and emotional support were assessed with multinomial logistic regression; associations between ACEs and feeling stressed/anxious and down/depressed, increased alcohol consumption and cannabis use, and increased conflict with parents, siblings and intimate partners were assessed with binary logistic regression. We stratified models by age group because of the potential differences in adolescents' and young adults' life stages as well as differences in the measurement of ACEs. Models were first unadjusted and then adjusted for sex, age and household income. Analyses were conducted in Stata version 16.1 (StataCorp LLC, College Station, TX, US). Of note, exponentiated coefficients are computed in Stata as relative risk ratios in multinomial logistic regression, whereas odds ratios are computed in binary logistic regression.

TABLE 1
Measures of adverse childhood experiences

ACE	Source	Age of respondent, years	WE Study wave
Child maltreatment ACE			
Physical abuse	CTQ[26]	18–21	3
Sexual abuse	CTQ[26]	18–21	3
Emotional abuse	CTQ[26]	18–21	3
	CEVQ[27]	16–17	3
Physical neglect	CTQ[26]	18–21	3
Emotional neglect	CTQ[26]	All ages	3
Exposure to physical IPV	Adapted from the CEVQ[27]	18–21	3
Exposure to verbal IPV	Adapted from the CEVQ[27]	16–17	3
Spanking	Adapted from the CEVQ[27]	All ages	1
Peer victimization	Manitoba Youth Health Survey[29]; Ontario Child Health Survey[30]	All ages	1, 2
Household challenges ACE			
Household problems with alcohol and/or drugs	Adapted from the ACE Questionnaire[31]	All ages	3
Household mental illness	Adapted from the ACE Questionnaire[31]	All ages	3
Parental separation or divorce	Adapted from the ACE Questionnaire[31]	All ages	3
Parental problems with police	Adapted from the ACE Questionnaire[31]	All ages	3
Parental problems with gambling	Developed for this questionnaire	All ages	3
Foster care placement and/or contact with a child protective organization	Developed for this questionnaire	All ages	3
Household running out of money (proxy for poverty)	Developed for this questionnaire	All ages	1
Living in an unsafe community	Manitoba Youth Health Survey[29]	All ages	1

Abbreviations: ACE, adverse childhood experience; CEVQ, Childhood Experiences of Violence Questionnaire; CTQ, Childhood Trauma Questionnaire; IPV, intimate partner violence; WE Study, Well-being and Experiences Study.

Results

The Wave 3 sample (n = 664) comprised 60.5% (n = 401) young adults and 39.5% (n = 262) older adolescents. Compared to older adolescents, young adults had greater odds of reporting "quite a bit/a lot" of financial difficulties (odds ratio [OR] = 1.83, 95% confidence interval [CI]: 1.04–3.20) and lower odds of reporting conflict with siblings (OR = 0.60; 95% CI: 0.38–0.95) (see Table 2). No other age group differences were detected.

Age-stratified associations between ACEs and self-reports of pandemic-related financial difficulties were adjusted for age, sex, race/ethnicity, parental education and household income. The biserial correlation between household income and financial difficulties (r_{bis} = −0.34; standard error = 0.04) was determined to be sufficiently low for inclusion in the model.[32] Among young adults, all ACEs (except spanking) were associated with increased relative risk of reporting "quite a bit/a lot" of financial difficulties rather than "not at all/a little" (adjusted relative risk ratio [aRRR] range: 2.59–4.99). Older adolescents with a history of emotional abuse, being spanked, any child maltreatment ACE and any household challenge ACE had increased relative risk of "some" financial difficulties rather than "not at all/a little" (aRRR range: 2.44–7.55) (see Table 3).

Among young adults, all ACEs (except spanking) were associated with increased relative risk of feeling emotionally supported "not at all" rather than "quite a bit/a lot" (aRRR range: 4.11–26.77). Among older adolescents, all child maltreatment ACEs and peer victimization were associated with increased relative risk of feeling less emotionally supported (aRRR range: 2.36–26.11) (see Table 4).

Emotional abuse (adjusted OR [aOR] = 1.78; 95% CI: 1.03–3.08) and physical neglect (aOR = 1.90; 95% CI: 1.06–3.41) among young adults were associated with increased odds of feeling stressed/anxious "quite a bit/a lot." Greater odds of feeling down/depressed "quite a bit/a lot" were found among young adults with histories of emotional abuse, physical neglect and any household challenge ACE (aOR range: 1.95–2.67) and among older adolescents with histories of emotional abuse, emotional neglect, exposure to verbal IPV, any child maltreatment ACE and peer victimization (aOR range: 1.89–5.05) (see Table 5).

In the sample, 80% of young adults and 50% of older adolescents consumed alcohol (data not shown). For young adults, physical abuse, sexual abuse, emotional abuse, emotional neglect and peer victimization histories were associated with greater odds of reporting increased pandemic-related alcohol consumption (aOR range: 2.27–6.27). No associations between ACEs and increased alcohol consumption emerged among older adolescents (see Table 5).

Close to half (52%) of young adults and one-third (33%) of older adolescents in the sample used cannabis (data not shown). For young adults, all ACEs except physical abuse and spanking were associated with greater odds of increased pandemic-related cannabis use (aOR range:

TABLE 2
Sociodemographic characteristics, pandemic-related stressors and symptoms, and ACEs, in the total sample and by age group

Characteristic, stressor/symptom, ACE	Sample, % (n)			OR[a] (95% CI)
	Total (n = 664)	Older adolescents aged 16 or 17 years (n = 262)	Young adults aged 18–21 years (n = 401)	
Characteristic				
Mean age (SD), years	17.97 (1.22)	16.73 (0.45)	18.79 (0.80)	–
Sex[b]				
Male (reference)	45.3 (299)	50.0 (130)	42.3 (169)	1.00
Female	54.7 (361)	50.0 (130)	57.8 (231)	1.37 (1.00–1.87)
Household income, CAD[b]				
≤49 999 (reference)	15.1 (100)	14.9 (39)	15.3 (61)	1.00
50 000–99 999	36.5 (241)	35.5 (93)	37.1 (148)	1.02 (0.63–1.64)
100 000–149 999	23.5 (155)	24.4 (64)	22.8 (91)	0.91 (0.54–1.52)
≥150 000	20.9 (138)	21.4 (56)	20.6 (82)	0.94 (0.55–1.58)
No response	4.1 (27)	3.8 (10)	4.3 (17)	1.09 (0.45–2.62)
Pandemic-related stressors and symptoms				
Financial difficulties				
Not at all/a little (reference)	74.3 (459)	79.0 (188)	71.3 (271)	1.00
Some	14.6 (90)	13.0 (31)	15.5 (59)	1.32 (0.82–2.12)
Quite a bit/a lot	11.2 (69)	8.0 (19)	13.2 (50)	1.83 (1.04–3.20)*
Felt emotionally supported				
Quite a bit/a lot (reference)	48.0 (303)	48.2 (120)	47.9 (183)	1.00
Some	24.4 (154)	22.5 (56)	25.7 (98)	1.15 (0.77–1.71)
A little	19.0 (120)	19.3 (48)	18.9 (72)	0.98 (0.64–1.51)
Not at all	8.6 (54)	10.0 (25)	7.6 (29)	0.76 (0.42–1.36)
Feeling stressed/anxious “quite a bit/a lot”				
No (reference)	52.7 (343)	56.6 (146)	50.1 (197)	1.00
Yes	47.3 (308)	43.4 (112)	49.9 (196)	1.30 (0.95–1.78)
Feeling down/depressed “quite a bit/a lot”				
No (reference)	63.8 (410)	65.1 (166)	62.9 (244)	1.00
Yes	36.2 (233)	34.9 (89)	37.1 (144)	1.10 (0.79–1.53)
Increased alcohol consumption (n = 434)				
No (reference)	81.8 (346)	80.8 (97)	82.2 (249)	1.00
Yes	18.2 (77)	19.2 (23)	17.8 (54)	0.91 (0.53–1.57)
Increased cannabis use (n = 278)				
No (reference)	64.9 (174)	67.1 (53)	64.0 (121)	1.00
Yes	35.1 (94)	32.9 (26)	36.0 (68)	1.15 (0.66–2.00)
Increased conflict with parents				
No (reference)	77.8 (439)	74.8 (160)	79.7 (279)	1.00
Yes	22.2 (125)	25.2 (54)	20.3 (71)	0.75 (0.50–1.13)
Increased conflict with siblings (n = 592)				
No (reference)	83.7 (462)	79.2 (164)	86.4 (298)	1.00
Yes	16.3 (90)	20.8 (43)	13.6 (47)	0.60 (0.38–0.95)*
Increased conflict with partner in intimate relationship (n = 288)				
No (reference)	73.7 (193)	72.3 (60)	74.3 (133)	1.00
Yes	26.3 (69)	27.7 (23)	25.7 (46)	0.90 (0.50–1.62)

Continued on the following page

TABLE 2 (continued)
Sociodemographic characteristics, pandemic-related stressors and symptoms, and ACEs, in the total sample and by age group

Characteristic, stressor/symptom, ACE	Sample, % (n)			OR[a] (95% CI)
	Total (n = 664)	Older adolescents aged 16 or 17 years (n = 262)	Young adults aged 18–21 years (n = 401)	
ACE				
Physical abuse				
No	–	–	89.8 (343)	–
Yes	–	–	10.2 (39)	–
Sexual abuse				
No	–	–	81.7 (316)	–
Yes	–	–	18.4 (71)	–
Emotional abuse				
No	73.8 (475)	64.3 (162)	79.9 (313)	–
Yes	26.2 (169)	35.7 (90)	20.2 (79)	–
Physical neglect				
No	–	–	82.6 (322)	–
Yes	–	–	17.4 (68)	–
Emotional neglect				
No (reference)	86.2 (556)	85.6 (219)	86.6 (337)	1.00
Yes	13.8 (89)	14.5 (37)	13.4 (52)	0.91 (0.58–1.44)
Exposure to IPV (physical or verbal)				
No	84.7 (533)	70.3 (175)	94.2 (358)	–
Yes	15.3 (96)	29.7 (74)	5.8 (22)	–
Spanking[b]				
No (reference)	70.2 (436)	71.7 (177)	69.3 (259)	1.00
Yes	29.8 (185)	28.3 (70)	30.8 (115)	1.12 (0.79–1.60)
Any child maltreatment ACE				
No	43.3 (270)	40.1 (99)	45.5 (171)	–
Yes	56.7 (353)	59.9 (148)	54.5 (205)	–
Peer victimization[b,c]				
No (reference)	60.8 (351)	56.3 (129)	63.8 (222)	1.00
Yes	39.2 (226)	43.7 (100)	36.2 (126)	0.73 (0.52–1.03)
Any household challenge ACE				
No (reference)	34.4 (195)	35.3 (78)	33.8 (117)	1.00
Yes	65.6 (372)	64.7 (143)	66.2 (229)	1.07 (0.75–1.52)

Abbreviations: ACE, adverse childhood experience; CAD, Canadian dollar; CI, confidence interval; IPV, intimate partner violence; OR, odds ratio.

Note: Age group differences were not tested for the ACEs that differed in measurement depending on the age of the respondent at Wave 3 (i.e. physical abuse, sexual abuse, physical neglect, exposure to IPV and any child maltreatment ACE).

[a] Adolescents are the reference group.

[b] Collected at Wave 1.

[c] Collected at Wave 2.

$^{*}p < 0.05$.

$^{**}p < 0.01$.

$^{***}p < 0.001$.

1.99–5.14). Among older adolescents, emotional neglect was associated with increased cannabis use (aOR = 8.02; 95% CI = 1.26–51.17) (see Table 5).

Among young adults, emotional abuse, physical neglect, any child maltreatment ACE and peer victimization were associated with greater odds of increased conflict with parents (aOR range: 1.98–2.60) and siblings (aOR range: 2.16–2.61); a history of sexual abuse was also associated with increased sibling conflict (aOR = 2.56; 95% CI: 1.20–5.45) (see Table 6).

Among older adolescents, emotional abuse, emotional neglect, exposure to verbal IPV, any child maltreatment ACE and peer victimization were associated with higher odds of increased conflict with parents (aOR range: 3.39–8.79); peer victimization was associated with increased sibling

TABLE 3
Associations between ACEs and self-reported financial difficulties due to the COVID-19 pandemic, by age group

ACE	Financial difficulties, aRRR[a] (95% CI)	
	"Some" versus "not at all/a little"	"Quite a bit/a lot" versus "not at all/a little"
Young adults aged 18–21 years		
Physical abuse	1.39 (0.53-3.65)	2.59 (1.04–6.49)*
Sexual abuse	1.70 (0.82–3.54)	3.33 (1.52–7.30)**
Emotional abuse	1.47 (0.70–3.08)	4.99 (2.36-10.58)***
Physical neglect	1.69 (0.78–3.68)	4.57 (2.14–9.77)***
Emotional neglect	1.02 (0.40–2.56)	4.14 (1.84–9.30)**
Exposure to physical IPV	1.32 (0.32–5.39)	4.35 (1.46–12.94)**
Spanking[b]	1.00 (0.51–1.96)	1.37 (0.67–2.79)
Any child maltreatment ACE	1.08 (0.58–2.02)	2.69 (1.28–5.64)**
Peer victimization[b,c]	1.14 (0.58–2.23)	3.38 (1.60–7.13)**
Any household challenge ACE	1.68 (0.82–3.44)	4.39 (1.58–12.18)**
Older adolescents aged 16 or 17 years		
Emotional abuse	2.44 (1.02–5.81)*	0.94 (0.27–3.29)
Emotional neglect	1.62 (0.55–4.82)	2.56 (0.67–9.76)
Exposure to verbal IPV	1.78 (0.73–4.32)	1.09 (0.33–3.64)
Spanking[b]	2.45 (1.00–6.01)*	0.89 (0.25–3.17)
Any child maltreatment ACE	3.15 (1.18–8.45)*	2.25 (0.63–7.99)
Peer victimization[b,c]	2.18 (0.84–5.68)	1.12 (0.33–3.84)
Any household challenge ACE	7.55 (1.97–29.02)**	2.14 (0.45–10.14)

Abbreviations: ACE, adverse childhood experience; aRRR, adjusted relative risk ratio; CI, confidence interval; IPV, intimate partner violence.

[a] Adjusted for age, sex, race/ethnicity, parental education and household income.

[b] Collected at Wave 1.

[c] Collected at Wave 2.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

conflict (aOR = 3.09; 95% CI: 1.41–6.77) (see Table 6).

About half (53%) of young adults and 41% of older adolescents were in an intimate relationship (data not shown). Young adults with histories of physical, sexual and emotional abuse, physical and emotional neglect, exposure to physical IPV, any child maltreatment ACE and any household challenge ACE had higher odds of reporting increased conflict with their partner (aOR range: 2.72–8.15); this was also the case for older adolescents with any household challenge ACE (aOR = 22.59; 95% CI: 1.94–263.30) (see Table 6).

Discussion

The current findings demonstrated an association between a history of ACEs and several self-reported stressors and symptoms related to the COVID-19 pandemic. These findings support the stress sensitization hypothesis, which suggests that individuals with ACEs are particularly susceptible to negative outcomes after exposure to subsequent life stressors.[14,16-20] The COVID-19 pandemic has been an acutely stressful life event that has exacerbated and prolonged financial, social and psychological difficulties, particularly for young people.[2,3,5] As hypothesized, this study indicates that ACEs increased vulnerability among older adolescents and young adults.

The findings are consistent with and contribute to the scant existing literature.[21-23] The analysis identified pandemic-related stressors and symptoms associated with a history of ACEs that have not been examined previously. Furthermore, while studies conducted in the early months of the COVID-19 pandemic are important, it is possible that experiences changed over time. The current study was conducted 8 to 9 months after the declaration of the COVID-19 pandemic and demonstrates its enduring impact. Importantly, as well as experiencing more problems during the pandemic, adolescents and young adults with an ACE history may have greater difficulty recovering when it is over. The results of this study indicate that older adolescents and young adults with an ACE history may need increased supports and resources that provide financial assistance, address mental health concerns, foster emotional support, reduce substance use and facilitate positive relationships.

Psychological first aid (PFA) is a recommended intervention for providing practical, social and emotional support in the context of crisis events.[33] Components of PFA outlined by the World Health Organization include providing non-intrusive practical care and support to address basic needs, promote safety and a sense of calm and provide connections to additional resources.[33] Emerging evidence, summarized in a recent review, indicated several strengths of PFA to support children and families, though there was a notable lack of studies involving youth populations.[34] Investigations of the effectiveness of PFA for addressing COVID-19 pandemic–related stressors and mental health symptoms among older adolescents and young adults with an ACE history are warranted. In addition to providing immediate support in response to the pandemic, upstream strategies for primary prevention of ACEs as well as interventions to treat the psychological effects of ACEs are needed. Such strategies will be important to support young people to better cope with future stressful situations, including the possibility of future epidemics or pandemics.

Different trends in the findings for older adolescents and young adults indicate the need for age group–specific interventions. For young adults, associations were observed between ACEs and reporting financial difficulties, not feeling emotionally supported, reporting increased alcohol and cannabis use, and increased conflict with siblings and an intimate partner. Associations were not observed to the same degree among older adolescents.

TABLE 4
Associations between ACEs and self-reported emotional support during the COVID-19 pandemic, by age group

ACE	Felt emotionally supported, aRRR[a] (95% CI)		
	"Some" versus "quite a bit/a lot"	"A little" versus "quite a bit/a lot"	"Not at all" versus "quite a bit/a lot"
Young adults aged 18–21 years			
Physical abuse	1.41 (0.50–4.03)	2.66 (1.03–6.89)*	4.28 (1.27–14.35)**
Sexual abuse	0.86 (0.39–1.87)	2.72 (1.33–5.55)**	4.38 (1.56–12.31)**
Emotional abuse	3.55 (1.55–8.12)**	9.10 (4.12–20.07)***	10.76 (3.83–30.23)***
Physical neglect	2.43 (1.03–5.70)*	5.09 (2.24–11.52)***	12.23 (4.51–33.16)***
Emotional neglect	5.17 (1.69–15.80)**	12.05 (4.05–35.88)***	26.77 (7.69–93.22)***
Exposure to physical IPV	1.30 (0.27–6.22)	3.93 (1.11–13.98)*	5.74 (1.21–27.31)*
Spanking[b]	0.70 (0.37–1.31)	1.18 (0.63–2.22)	2.40 (0.97–5.93)
Any child maltreatment ACE	1.36 (0.78–2.36)	3.11 (1.67–5.81)***	6.88 (2.21–21.40)***
Peer victimization[b,c]	1.07 (0.57–2.00)	2.13 (1.11–4.06)*	5.50 (2.13–14.16)***
Any household challenge ACE	1.28 (0.70–2.34)	2.26 (1.12–4.59)*	4.11 (1.25–13.49)*
Older adolescents aged 16 or 17 years			
Emotional abuse	1.92 (0.88–4.16)	2.67 (1.26–5.68)*	6.47 (2.35–17.82)***
Emotional neglect	6.80 (1.87–24.71)**	7.52 (2.20–25.75)**	26.11 (6.78–100.48)***
Exposure to verbal IPV	2.78 (1.24–6.24)*	2.36 (1.07–5.22)*	2.28 (0.84–6.19)
Spanking[b]	1.53 (0.68–3.45)	2.57 (1.16–5.71)*	1.08 (0.36–3.23)
Any child maltreatment ACE	1.85 (0.90–3.80)	5.45 (2.23–13.33)***	5.84 (1.76–19.35)**
Peer victimization[b,c]	1.15 (0.55–2.42)	2.59 (1.20–5.61)*	2.44 (0.86–6.94)
Any household challenge ACE	1.63 (0.75–3.58)	2.75 (1.03–7.36)*	1.57 (0.51–4.87)

Abbreviations: ACE, adverse childhood experience; aRRR, adjusted relative risk ratio; CI, confidence interval; IPV, intimate partner violence.

[a] Adjusted for age, sex, race/ethnicity, parental education and household income.

[b] Collected at Wave 1.

[c] Collected at Wave 2.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

The strong associations between ACEs and COVID-19 challenges observed in young adults indicate a need to prioritize additional supports for this age group. By contrast, fewer associations between ACEs and feeling down/depressed and increased conflict with parents emerged among young adults than among older adolescents. Although fewer associations were found for older adolescents overall and not to the same degree as for young adults, the results emphasize interventions that foster emotional support, healthy relationships with parents, and improve feelings of depression as key target areas for supporting older adolescents during and after the COVID-19 pandemic.

Reports of financial difficulties as a result of the measures implemented to contain the pandemic, particularly among young adults with an ACE history, are consistent with research conducted prior to the pandemic.[13] Recent research has indicated that material hardship due to financial strain is associated with poor self-rated health, sleep problems, depression and suicidal thoughts in early adulthood.[35] Young workers disproportionately experienced underemployment and unemployment during the COVID-19 pandemic.[2,36] Support that alleviates financial strain during and after the pandemic is imperative for this age group.

Furthermore, increased odds of elevated alcohol and cannabis use in young adults with a history of ACEs is concerning. The present study did not examine reasons for increased substance use, but coping motives for increased alcohol consumption among college students during the pandemic have been reported.[37,38] Substance use is a common, but potentially harmful, means of coping.[39] For instance, excessive consumption may result in injury and death, addiction and long-term physical and mental health conditions.[40] Public health strategies aimed at reducing substance use among young adults are needed.

Young adults and older adolescents with an ACE history reported elevated interpersonal conflict. Conflict with parents, siblings and intimate partners can be normative. However, research has also found that such conflict increases the risk of internalizing and externalizing problems.[41-45] Family conflict in adolescence has also been associated with a lack of closeness in relationships with parents and with romantic partners in adulthood.[46] Findings from this work indicate that several child maltreatment ACEs are related to increased conflict among

TABLE 5
Associations between ACEs and feeling stressed/anxious and down/depressed "quite a bit/a lot" and self-reported increase in alcohol and cannabis use due to the COVID-19 pandemic, by age group

ACE	aOR[a] (95% CI)			
	Feeling stressed/anxious "quite a bit/a lot"	Feeling down/depressed "quite a bit/a lot"	Increased alcohol consumption	Increased cannabis use
Young adults aged 18 to 21 years				
Physical abuse	1.12 (0.54–2.33)	1.50 (0.72–3.11)	5.34 (2.09–13.64)***	2.06 (0.79–5.42)
Sexual abuse	1.46 (0.83–2.57)	1.43 (0.82–2.51)	2.27 (1.05–4.93)*	3.80 (1.71–8.43)**
Emotional abuse	1.78 (1.03–3.08)*	1.98 (1.16–3.38)*	6.27 (2.94–13.37)***	2.58 (1.25–5.35)*
Physical neglect	1.90 (1.06–3.41)*	1.95 (1.09–3.47)*	1.73 (0.74–4.04)	5.14 (2.31–11.43)***
Emotional neglect	1.27 (0.67–2.39)	1.49 (0.80–2.80)	4.37 (1.91–10.01)***	3.02 (1.31–7.01)**
Exposure to physical IPV	1.69 (0.63–4.55)	1.74 (0.66–4.56)	3.07 (0.87–10.81)	4.61 (1.26–16.86)*
Spanking[b]	0.78 (0.49–1.26)	0.78 (0.47–1.28)	0.94 (0.45–1.97)	1.00 (0.48–2.11)
Any child maltreatment ACE	1.11 (0.72–1.72)	1.44 (0.91–2.28)	2.20 (1.12–4.35)*	2.68 (1.33–5.39)**
Peer victimization[b,c]	1.43 (0.89–2.29)	1.46 (0.90–2.38)	2.27 (1.18–4.38)*	1.99 (1.02–3.88)*
Any household challenge ACE	1.59 (0.97–2.61)	2.67 (1.54–4.62)***	1.44 (0.69–2.98)	4.07 (1.64–10.05)**
Older adolescents aged 16–17 years				
Emotional abuse	1.15 (0.65–2.03)	1.89 (1.02–3.51)*	0.96 (0.32–2.92)	1.18 (0.37–3.69)
Emotional neglect	1.41 (0.67–2.97)	5.05 (2.15–11.86)***	4.48 (0.96–20.99)	8.02 (1.26–51.17)*
Exposure to verbal IPV	0.88 (0.48–1.60)	2.03 (1.07–3.88)*	0.47 (0.13–1.72)	1.89 (0.62–5.71)
Spanking[b]	0.94 (0.51–1.73)	1.36 (0.70–2.65)	1.10 (0.34–3.62)	1.04 (0.30–3.64)
Any child maltreatment ACE	1.27 (0.72–2.22)	2.32 (1.22–4.42)*	0.92 (0.29–2.96)	1.84 (0.47–7.23)
Peer victimization[b,c]	1.75 (0.98–3.14)	2.16 (1.13–4.15)*	0.55 (0.18–1.65)	0.43 (0.13–1.47)
Any household challenge ACE	1.06 (0.56–2.00)	1.72 (0.84–3.51)	0.81 (0.19–3.39)	0.74 (0.19–2.78)

Abbreviations: ACE, adverse childhood experience; aOR, adjusted odds ratio; CI, confidence interval; IPV, intimate partner violence.

[a] Adjusted for age, sex, race/ethnicity, parental education and household income.

[b] Collected at Wave 1.

[c] Collected at Wave 2.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

parents, siblings and intimate partners for young adults and increased conflict among parents for older adolescents. The home environment and relationships with parents, siblings and partners during the pandemic should be considered along with post-pandemic recovery strategies. Interventions designed to help young people effectively deal with interpersonal conflict and facilitate positive relationships are recommended.

Strengths and limitations

Strengths of the current study include (1) the measurement of child maltreatment using an instrument that has demonstrated good psychometric properties, and (2) the examination of individual ACEs, with the exception of household challenges ACEs. This analysis was based on a community sample from Manitoba, Canada. The sample was comparable to the population from which it was drawn, but not necessarily representative of older adolescents and young adults. In addition, some differences were noted between the baseline and Wave 3 samples that suggest non-random attrition. It is possible that individuals experiencing stressors and symptoms were underrepresented. However, it is important to note that 66.3% of the original adolescent cohort from baseline was maintained at Wave 3. Owing to the nature of the data, causal inferences cannot be made. Even so, the ACEs occurred before respondents were 16 years of age, which for young adults aged 18 to 21 years, preceded onset of the COVID-19 pandemic. Another shortcoming is that older adolescents were not asked about all ACEs. As well, pandemic-related stressors and symptoms were identified based on respondents' self-reports rather than on validated tools; however, these self-reports were specific to the pandemic. It was also not possible to develop a standardized COVID-19 instrument before administration of the Well-being and Experiences (WE) Study: Wave 3. Data on living situations during the pandemic were not available, and we were unable to determine whether this accounted for some of the differences observed between adolescents and young adults. Finally, the sample size was relatively small, and when stratified, yielded a low prevalence of some ACEs. As a result, power was limited and aggregation of household challenge ACEs was necessary. For this same reason, it was

TABLE 6
Associations between ACEs and self-reported increase in relationship conflict due to the COVID-19 pandemic, by age group

ACE	Increased conflict, aOR[a] (95% CI)		
	With parents	With siblings	With a partner
Young adults aged 18–21 years			
Physical abuse	2.11 (0.88–5.03)	1.68 (0.60–4.71)	8.15 (2.80–23.69)***
Sexual abuse	1.12 (0.55–2.26)	2.56 (1.20–5.45)*	3.68 (1.63–8.34)**
Emotional abuse	2.12 (1.13–3.99)*	2.16 (1.05–4.47)*	5.43 (2.29–12.84)***
Physical neglect	1.98 (1.00–3.90)*	2.58 (1.23–5.41)*	2.72 (1.14–6.47)*
Emotional neglect	1.68 (0.80–3.50)	1.07 (0.43–2.69)	6.41 (2.33–17.61)***
Exposure to physical IPV	0.59 (0.16–2.24)	1.04 (0.27–4.11)	5.06 (1.13–22.62)*
Spanking[b]	1.14 (0.62–2.13)	1.15 (0.57–2.34)	1.74 (0.81–3.73)
Any child maltreatment ACE	2.10 (1.15–3.84)*	2.58 (1.25–5.32)**	3.25 (1.37–7.75)**
Peer victimization[b,c]	2.60 (1.40–4.81)**	2.61 (1.28–5.31)**	1.91 (0.85–4.28)
Any household challenge ACE	1.55 (0.79–3.05)	1.73 (0.80–3.72)	2.80 (1.03–7.58)*
Older adolescents aged 16 or 17			
Emotional abuse	3.39 (1.65–6.98)**	1.16 (0.54–2.49)	0.55 (0.15–2.07)
Emotional neglect	8.79 (3.42–22.60)***	1.03 (0.36–2.99)	1.49 (0.35–6.41)
Exposure to verbal IPV	4.15 (1.93–8.91)***	1.47 (0.66–3.27)	0.97 (0.26–3.58)
Spanking[b]	1.18 (0.55–2.55)	1.03 (0.46–2.30)	2.61 (0.72–9.44)
Any child maltreatment ACE	4.17 (1.78–9.75)**	0.95 (0.43–2.07)	2.00 (0.48–8.29)
Peer victimization[b,c]	3.63 (1.71–7.73)**	3.09 (1.41–6.77)**	1.12 (0.32–3.92)
Any household challenge ACE	1.42 (0.62–3.26)	2.51 (0.95–6.60)	22.59 (1.94–263.30)*

Abbreviations: ACE, adverse childhood experience; aOR, odds ratio; CI, confidence interval; IPV, intimate partner violence.

[a] Adjusted for age, sex, race/ethnicity, parental education and household income.

[b] Collected at Wave 1.

[c] Collected at Wave 2.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

not possible to examine interactions by sex or stratify by sex.

Conclusion

Research has shown that the COVID-19 pandemic has taken a heavy toll on older adolescents and young adults.[2-5] The current study found that the impact was even greater for those with a history of childhood adversity. Differences between the experiences of older adolescents and young adults suggest that interventions be tailored to the needs of each age group. ACEs were found to be associated with many pandemic-related impacts among 18- to 21-year-olds, which suggests that young adults with a history of ACEs may be a group that could benefit from additional resources including both practical and emotional support. Fewer associations between ACEs and pandemic-related impacts emerged among 16- and 17-year-olds. Nonetheless, interventions that foster emotional support and healthy relationships with parents and improve feelings of depression are warranted for older adolescents during and after the pandemic. PFA may be a suitable approach for supporting recovery from the COVID-19 pandemic.

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Conflicts of interest

Tracie O. Afifi is an Associate Scientific Editor with *Health Promotion and Chronic Disease Prevention in Canada*, but has recused herself from the review process for this article.

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Authors' contributions and statement

TOA conceptualized and designed the study, and supervised data collection and data analysis.

SS conducted the data analysis and drafted the initial manuscript.

TLT conducted data coding.

All authors reviewed and revised the manuscript. All authors approved the final manuscript as submitted.

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References

1. Interactive: A timeline of COVID-19 in Manitoba [Internet]. CTV News (Winnipeg Ed.). 2020 Mar 24 [cited 2022 Jan 20]. Available from: https://winnipeg.ctvnews.ca/interactive-a-timeline-of-covid-19-in-manitoba-1.4866501

2. Statistics Canada. Labour force survey, April 2020 [Internet]. Ottawa (ON): Statistics Canada; 2020 May 08 [modified 2020 Jun 05; cited 2021 Apr 07]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/200508/dq200508a-eng.htm

3. Vaillancourt T, Szatmari P, Georgiades K, Krygsman A. The impact of COVID-19 on the mental health of Canadian children and youth. Facets. 2021;6:1628-48. https://doi.org/10.1139/facets-2021-0078

4. Shields M, Tonmyr L, Gonzalez A, et al. Symptoms of major depressive disorder during the COVID-19 pandemic: results from a representative sample of the Canadian population. Health Promot Chronic Dis Prev Can. 2021;41(11):340-58. https://doi.org/10.24095/hpcdp.41.11.04

5. Wickens CM, McDonald AJ, Elton-Marshall T, et al. Loneliness in the COVID-19 pandemic: associations with age, gender and their interaction. J Psychiatr Res. 2021;136:103-8. https://doi.org/10.1016/j.jpsychires.2021.01.047

6. Centers for Disease Control and Prevention. Adverse childhood experiences (ACEs) [Internet]. Washington (DC): U.S. Department of Health & Human Services; 2020 [reviewed 2021 Apr 02; cited 2021 Jun 14]. Available from: https://www.cdc.gov/violenceprevention/aces/index.html

7. Afifi TO, Ford D, Gershoff ET, et al. Spanking and adult mental health impairment: the case for the designation of spanking as an adverse childhood experience. Child Abuse Negl. 2017;71:24-31. https://doi.org/10.1016/j.chiabu.2017.01.014

8. Afifi TO, Salmon S, Garcés I, et al. Confirmatory factor analysis of adverse childhood experiences (ACEs) among a community-based sample of parents and adolescents. BMC Pediatr. 2020;20(1):178. https://doi.org/10.1186/s12887-020-02063-3

9. Struck S, Stewart-Tufescu A, Asmundson AJ, Asmundson GJ, Afifi TO. Adverse childhood experiences (ACEs) research: A bibliometric analysis of publication trends over the first 20 years. Child Abuse Negl. 2021;112:104895. https://doi.org/10.1016/j.chiabu.2020.104895

10. Bellis MA, Hughes K, Ford K, Ramos Rodriguez G, Sethi D, Passmore J. Life course health consequences and associated annual costs of adverse childhood experiences across Europe and North America: a systematic review and meta-analysis. Lancet Public Health. 2019;4(10):e517-28. https://doi.org/10.1016/s2468-2667(19)30145-8

11. Karatekin C, Ahluwalia R. Effects of adverse childhood experiences, stress, and social support on the health of college students. J Interpers Violence. 2020;35(1-2):150-72. https://doi.org/10.1177/0886260516681880

12. Hébert M, Daspe MÈ, Lapierre A, et al. A meta-analysis of risk and protective factors for dating violence victimization: the role of family and peer interpersonal context. Trauma Violence Abuse. 2019;20(4):574-90. https://doi.org/10.1177/1524838017725336

13. Metzler M, Merrick MT, Klevens J, Ports KA, Ford DC. Adverse childhood experiences and life opportunities: shifting the narrative. Child Youth Serv Rev. 2017;72:141-9. https://doi.org/10.1016/j.childyouth.2016.10.021

14. Post RM. Transduction of psychosocial stress into the neurobiology of recurrent affective disorder. Am J Psychiatry. 1992;149:999-1010. https://doi.org/10.1176/ajp.149.8.999

15. Shonkoff JP, Garner AS; Committee on Psychosocial Aspects of Child and Family Health; Committee on Early Childhood A, and Dependent Care; Section on Developmental and Behavioral Pediatrics. The lifelong effects of early childhood adversity and toxic stress. Pediatrics. 2012;129(1):e232-46. https://doi.org/10.1542/peds.2011-2663

16. Berens AE, Jensen SK, Nelson CA 3rd. Biological embedding of childhood adversity: from physiological mechanisms to clinical implications. BMC Med. 2017;15(1):135. https://doi.org/10.1186/s12916-017-0895-4

17. McLaughlin KA, Conron KJ, Koenen KC, Gilman SE. Childhood adversity, adult stressful life events, and risk of past-year psychiatric disorder: a test of the stress sensitization hypothesis in a population-based sample of adults. Psychol Med. 2010;40(10):1647-58. https://doi.org/10.1017/S0033291709992121

18. McLaughlin KA, Koenen KC, Bromet EJ, et al. Childhood adversities and post-traumatic stress disorder: evidence for stress sensitisation in the World Mental Health Surveys. Br J Psychiatry. 2017;211:280-8. https://doi.org/10.1192/bjp.bp.116.197640

19. Meyers JL, Lowe SR, Eaton NR, Krueger R, Grant BF, Hasin D. Childhood maltreatment, 9/11 exposure, and latent dimensions of psychopathology: a test of stress sensitization. J Psychiatr Res. 2015;68:337-45. https://doi.org/10.1016/j.jpsychires.2015.05.005

20. Hammen C, Henry R, Daley SE. Depression and sensitization to stressors among young women as a function of childhood adversity. J Consult Clin Psychol. 2000;68(5):782-7. https://doi.org/10.1037//0022-006x.68.5.782

21. Chi X, Becker B, Yu Q, et al. Prevalence and psychosocial correlates of mental health outcomes among Chinese college students during the coronavirus disease (COVID-19) pandemic. Front Psychiatry. 2020;11:803. https://doi.org/10.3389/fpsyt.2020.00803

22. Guo J, Fu M, Liu D, Zhang B, Wang X, van IJzendoorn MH. Is the psychological impact of exposure to COVID-19 stronger in adolescents with pre-pandemic maltreatment experiences? A survey of rural Chinese adolescents. Child Abuse Negl. 2020;110(Pt 2):104667. https://doi.org/10.1016/j.chiabu.2020.104667

23. Li X, Lv Q, Tang W, et al. Psychological stresses among Chinese university students during the COVID-19 epidemic: the effect of early life adversity on emotional distress. J Affect Disord. 2021;282:33-8. https://doi.org/10.1016/j.jad.2020.12.126

24. Wood D, Crapnell T, Lau L, et al. Emerging adulthood as a critical stage in the life course. In: Halfon N, Forrest CB, Lerner RM, Faustman EM, eds. Handbook of life course health development. New York (NY): Springer; 2018:123-43.

25. Afifi TO, Taillieu T, Salmon S, et al. Adverse childhood experiences (ACEs), peer victimization, and substance use among adolescents. Child Abuse Negl. 2020;106:104504. https://doi.org/10.1016/j.chiabu.2020.104504

26. Bernstein DP, Fink L. Childhood Trauma Questionnaire: a retrospective self-report. San Antonio (TX): Harcourt Brace & Co.; 1998.

27. Walsh CA, MacMillan HL, Trocmé N, Jamieson E, Boyle MH. Measurement of victimization in adolescence: development and validation of the Childhood Experiences of Violence Questionnaire. Child Abuse Negl. 2008;32(11):1037-57. https://doi.org/10.1016/j.chiabu.2008.05.003

28. Afifi TO, Salmon S, Taillieu T, Stewart-Tufescu A, Fortier J, Driedger SM. Older adolescents and young adults willingness to receive the COVID-19 vaccine: implications for informing public health strategies. Vaccine. 2021;39(26):3473-9. https://doi.org/10.1016/j.vaccine.2021.05.026

29. Partners in Planning for Healthy Living. Manitoba Youth Health Survey 2012/2013 User Guide. Winnipeg (MB): 2013.

30. Boyle MH, Georgiades K, Duncan L, Comeau J, Wang L; 2014 Ontario Child Health Study Team. The 2014 Ontario Child Health Study-Methodology. Can J Psychiatry. 2019;64(4):237-45. https://doi.org/10.1177/0706743719833675

31. Felitti VJ, Anda RF, Nordenberg D, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. Am J Prev Med. 1998;14(4):245-58. https://doi.org/10.1016/S0749-3797(98)00017-8

32. Field AP. Discovering statistics using SPSS. 3rd ed. London: SAGE Publications; 2009. 822 p.

33. World Health Organization. Psychological first aid: guide for field workers. Geneva (CH): World Health Organization; 2011. Available from: https://www.who.int/publications/i/item/9789241548205

34. Gilbert R, Abel MR, Vernberg EM, Jacobs AK. The use of psychological first aid in children exposed to mass trauma. Curr Psychiatry Rep. 2021;23(9):53. https://doi.org/10.1007/s11920-021-01270-8

35. Huang Y, Heflin CM, Validova A. Material hardship, perceived stress, and health in early adulthood. Ann Epidemiol. 2021;53:69-75.e63. https://doi.org/10.1016/j.annepidem.2020.08.017

36. Gould E, Kassa M. Young workers hit hard by the COVID-19 economy: workers ages 16–24 face high unemployment and an uncertain future [Internet]. Washington (DC): Economic Policy Institute; 2020 Oct 14 [cited 2021 Apr 07]. Available from: https://www.epi.org/publication/young-workers-covid-recession/

37. Jackson KM, Merrill JE, Stevens AK, Hayes KL, White HR. Changes in alcohol use and drinking context due to the COVID-19 pandemic: a multimethod study of college student drinkers. Alcohol Clin Exp Res. 2021;45(4):752-64. https://doi.org/10.1111/acer.14574

38. Fruehwirth JC, Gorman BL, Perreira KM. The effect of social and stress-related factors on alcohol use among college students during the COVID-19 pandemic. J Adolesc Health. 2021;69(4):557-65. https://doi.org/10.1016/j.jadohealth.2021.06.016

39. Hawn SE, Cusack SE, Amstadter AB. A systematic review of the self-medication hypothesis in the context of posttraumatic stress disorder and comorbid problematic alcohol use. J Trauma Stress. 2020;33(5):699-708. https://doi.org/10.1002/jts.22521

40. Schulte MT, Hser Y-I. Substance use and associated health conditions throughout the lifespan. Public Health Rev. 2013;35(3):1-27. https://doi.org/10.1007/BF03391702

41. Campione-Barr N, Greer KB, Kruse A. Differential associations between domains of sibling conflict and adolescent emotional adjustment. Child Dev. 2013;84(3):938-54. https://doi.org/10.1111/cdev.12022

42. Odudu C, Williams M, Campione-Barr N. Associations between domain differentiated sibling conflict and adolescent problem behavior. J Marriage Fam. 2020;82(3):1015-25. https://doi.org/10.1111/jomf.12663

43. Alaie I, Låftman SB, Jonsson U, Bohman H. Parent-youth conflict as a predictor of depression in adulthood: a 15-year follow-up of a community-based cohort. Eur Child Adolesc Psychiatry. 2020;29(4):527-36. https://doi.org/10.1007/s00787-019-01368-8

44. Weymouth BB, Buehler C, Zhou N, Henson RA. A meta-analysis of parent-adolescent conflict: disagreement, hostility, and youth maladjustment. J Fam Theory Rev. 2016;8(1):95-112. https://doi.org/10.1111/jftr.12126

45. La Greca AM, Harrison HM. Adolescent peer relations, friendships, and romantic relationships: do they predict social anxiety and depression? J Clin Child Adolesc Psychol. 2005;34(1):49-61. https://doi.org/10.1207/s15374424jccp3401_5

46. Heinze JE, Hsieh HF, Aiyer SM, Buu A, Zimmerman MA. Adolescent family conflict as a predictor of relationship quality in emerging adulthood. Fam Relat. 2020;69(5):996-1011. https://doi.org/10.1111/fare.12493

https://doi.org/10.24095/hpcdp.43.1.04

Original quantitative research

The Alberta Congenital Anomalies Surveillance System: a 40-year review with prevalence and trends for selected congenital anomalies, 1997–2019

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Abstract

Introduction: Current published long-term provincial or territorial congenital anomaly data are lacking for Canada. We report on prevalence (per 1000 total births) and trends in 1997–2019, in Alberta, Canada, for selected congenital anomalies. Associated risk factors are also discussed.

Methods: We used data from the Alberta Congenital Anomalies Surveillance System (ACASS) to calculate the prevalence and perform chi-square linear trend analyses.

Results: From 1997 to 2019, the overall prevalence of neural tube defects was stable, at 0.74 per 1000 total births. The same was true for spina bifida (0.38), orofacial clefts (1.99), more severe CHDs (transposition of the great arteries, 0.38; tetralogy of Fallot, 0.33; and hypoplastic left heart syndrome, 0.32); and gastroschisis (0.38). Anencephaly, cleft palate and anorectal malformation significantly decreased with a prevalence of 0.23, 0.75 and 0.54 per 1000 total births, respectively. Significantly increasing trends were reported for anotia/microtia (0.24), limb reduction anomalies (0.73), omphalocele (0.36) and Down syndrome (2.21) and for hypospadias and undescended testes (4.68 and 5.29, respectively, per 1000 male births).

Conclusion: Congenital anomalies are an important public health concern with significant social and societal costs. Surveillance data gathered by ACASS for over 40 years can be used for planning and policy decisions and the evaluation of prevention strategies. Contributing genetic and environmental factors are discussed as is the need for continued surveillance and research.

Keywords: *congenital anomalies, surveillance, prevalence, trends, Alberta*

Highlights

- The Alberta Congenital Anomalies Surveillance System reports prevalence of anomalies and trends from 1997 to 2019 among live births, stillbirths and terminations of pregnancy at less than 20 weeks gestation.
- Overall prevalence of each of the following was stable, showing no significant trends: neural tube defects, spina bifida, orofacial clefts, cleft lip with or without cleft palate, severe congenital heart defects and gastroschisis.
- Anencephaly, cleft palate and anorectal malformations show significantly decreasing trends.
- Anotia/microtia, ventricular septal defects, hypospadias, undescended testes, limb reductions, omphalocele and Down syndrome show significantly increasing trends.
- Precise risk factors are challenging to address, supporting the need for continued congenital anomalies surveillance and research to be integral to public health.

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Introduction

Congenital anomalies surveillance in Alberta started in 1963 in response to malformations caused by thalidomide in the late 1950s. In addition to collecting data on structural congenital anomalies, this surveillance system included all physical and neurodevelopmental disabilities of children and included adults. In 1979, the Alberta government restricted surveillance to only congenital anomalies. In 1982, the government proposed to discontinue congenital anomaly surveillance completely, but agreed to transfer the surveillance system to the Alberta Children's Hospital, Department of Medical Genetics, without transfer of funds. Funds were secured by grant applications until 1994, when the government resumed funding.

The Alberta Congenital Anomalies Surveillance System (ACASS), a provincial population-based program, has data from 1980. Current, published long-term national, provincial or territorial congenital anomaly data are lacking for Canada.

The objectives of this paper are to report prevalence rates and trends for neural tube defects (NTDs), anotia/microtia, orofacial clefts, anorectal malformations, specific congenital heart defects (CHDs), hypospadias, undescended testes, limb reduction anomalies, gastroschisis, omphalocele and Down syndrome for 1997 to 2019, using data from ACASS. These data allow for other Canadian provinces and territories and the Canadian Congenital Anomalies Surveillance System (CCASS) to compare rates and trends.

ACASS is one of the only surveillance systems in Canada with data on termination of pregnancies at less than 20 weeks gestation with more complete ascertainment to contribute to better prevalence estimates. Although inclusion of ascertainment of termination of pregnancies was recommended for CCASS in 1997,[1] it has not been sufficiently achieved.

ACASS also provides context to the reported rates and trends, which is necessary for valid interpretation. Currently, CCASS reports numbers without context via their Public Health Infobase,[2] with their last comprehensive report published in 2013 with data to 2009.[3]

Methods

ACASS is primarily a passive system that relies on health care professionals and administrative data for case ascertainment as opposed to an active system where trained surveillance staff abstract case data. Still, it is best described as a hybrid system because we have both aspects, with legal permission to access patient medical records including supporting documentation (e.g. reports from consultations, operations, cytogenetics, diagnostic imaging and pathology). Thus, we can verify or clarify diagnoses including those that occur after termination of pregnancies at less than 20 weeks gestation. Eligible cases are born in Alberta to mothers who reside in Alberta at the time of delivery. Cases that have structural, syndromic, chromosomal, neoplasm, endocrine and/or metabolic abnormalities are ascertained for up to 1 year after delivery. Anomalies are coded using the Royal College of Paediatrics and Child Health (RCPCH) adaptation of the International Classification of Diseases, 10th Revision (ICD-10). Only selected congenital anomalies are included in this paper; however, data for additional anomalies are available.[4]

Multiple ascertainment sources are used (see Table 1) to include live births and stillbirths (>20 weeks gestation and/or >500 g) born since 1 January 1980. Data since 1 January 1997 also include early fetal deaths and termination of pregnancies (<20 weeks gestation and/or <500 g), which is why this paper focusses on the period 1 January 1997 to 31 December 2019.

The ACASS methodology is described in greater detail by Lowry et al.[4]

Alberta Vital Statistics provided denominators. We calculated prevalence as number of cases divided by total number of live births and stillbirths and, for hypospadias and undescended testes, as number of cases divided by total number of male live births and stillbirths, with 95% confidence intervals. Chi-square linear trend analysis was performed.

As this Registry is a part of public health surveillance in Alberta, which is covered by provincial legislation, no ethics approval is required from Alberta Health or the University of Calgary.

Results

Table 2 shows the case prevalence for selected congenital anomalies per 1000 total births. The overall rate of NTDs is 0.74 and of orofacial clefts is 1.99. The most frequent CHDs are septal defects (ventricular septal defects [VSDs] at 3.10 and atrial septal defects [ASDs] at 2.01). The rates of the more severe CHDs, including hypoplastic left heart syndrome (HLHS; 0.32), transposition of the great arteries (0.38) and tetralogy of Fallot (0.33), are comparable. Gastroschisis and omphalocele rates are similar (0.38 and 0.36, respectively). The rate of Down syndrome is 2.21. The prevalence, per 1000 total male births, of hypospadias is 4.68 and of undescended testes is 5.29.

TABLE 1
Sources of data for the Alberta Congenital Anomalies Surveillance System

Alberta Vital Statistics	Physicians' Notice of Birth
	Medical Certificate of Death
	Medical Certificate of Stillbirth
All Alberta hospitals	Case notifications from Alberta Hospital Health Records Department via the Congenital Anomalies Reporting Form (CARF)
	Alberta Children's Hospital (Calgary) and Stollery Children's Hospital (Edmonton)
Specialty data sources	Outpatient Clinics (e.g. genetics, prenatal, metabolics)
	Alberta Precision Laboratories (e.g. Cytogenetics, Newborn Metabolic Screening)
	Calgary and Edmonton Pathology

TABLE 2
Case prevalence of selected congenital anomalies in Alberta, 1997–2019

Congenital anomaly	ICD-10 RCPCH code	Prevalence per 1000 total births[a] (95% CI)
NTDs (all)	Q00…, Q01…, Q05…	0.74 (0.69–0.79)
Anencephaly	Q00.00, Q00.01, Q00.1	0.23 (0.20–0.26)
Spina bifida	Q05…	0.38 (0.35–0.42)
Anotia/microtia	Q16.0, Q17.2	0.24 (0.21–0.27)
Orofacial clefts (all)	Q35…, Q36…, Q37…	1.99 (1.91–2.08)
CLP	Q36…, Q37…	1.23 (1.17–1.30)
Cleft palate only	Q35…	0.75 (0.70–0.81)
Anorectal malformations	Q42…	0.54 (0.50–0.58)
CHDs		
Transposition of the great arteries	Q20.11, Q20.3, Q20.5	0.38 (0.34–0.42)
Tetralogy of Fallot	Q21.3…, Q21.82	0.33 (0.30–0.36)
VSD	Q21.0	3.10 (3.00–3.21)
ASD[b]	Q21.1…	2.01 (1.93–2.10)
Hypoplastic left heart syndrome	Q23.4	0.32 (0.29–0.35)
Hypospadias[c]	Q54… (exclude Q54.4)	4.68 (4.51–4.87)
Undescended testes[b,c]	Q53…	5.29 (5.10–5.48)
Limb reduction	Q71…, Q72…	0.73 (0.68–0.78)
Gastroschisis	Q79.3	0.38 (0.35–0.42)
Omphalocele	Q79.2	0.36 (0.32–0.39)
Down syndrome	Q90…	2.21 (2.12–2.30)

Source: Alberta Congenital Anomalies Surveillance System

Abbreviations: ASD, atrial septal defect; CHD, congenital heart defect; CI, confidence interval; CLP, cleft lip with or without cleft palate; ICD-10, International Classification of Diseases, 10th Revision; NTD, neural tube defect; RCPCH, Royal College of Paediatrics and Child Health; VSD, ventricular septal defect.

[a] Total number of births (1997–2019) = 1 074 927.

[b] >36 weeks gestation.

[c] Per male births only; total number of male births (1997–2019) = 550 712.

Results from the chi-square linear trend analyses for 1997–2019 are shown in Table 3. While there are no significant trends for NTDs overall or for spina bifida, anencephaly is significantly decreasing. Rates for cleft palate are also decreasing, while cleft lip with or without cleft palate (CLP) and overall orofacial clefts rates show no significant change. Anorectal malformation rates are significantly decreasing. Although the majority of selected CHD rates show no change, VSD rates are significantly increasing. Rates of both hypospadias and undescended testes show significant increases, as do limb reductions. Gastroschisis has stabilized, while omphalocele is significantly increasing, as is Down syndrome.

Discussion

Neural tube defects

NTDs show no significant change (p = 0.0585). Anencephaly prevalence rates started to decline in 2016 and continued to 2019. In contrast, spina bifida rates have remained stable.

Anencephaly rates are influenced by very early termination of pregnancies and perhaps by the terminology used to describe prenatal findings, for example, "absent calvarium," which is coded in ICD-10 RCPCH under the musculoskeletal system (Q75.8) and not with anencephaly/exencephaly. As a result, such cases are not classified as NTDs.

Acrania can progress to exencephaly and anencephaly.[5] The method of termination often precludes an accurate postmortem diagnosis.

The most recent statistics from the Public Health Agency of Canada (PHAC) use data to 2014 and show no trend for NTDs.[2]

Folic acid fortification was introduced in Canada in 1998 and has had a significant impact on the prevalence of NTDs. Nevertheless, a substantial number of such defects remain,[6] which may be due to red blood cell folate levels being below 906 nmol/L and/or the need to supplement with vitamin B12[7] or inositol.[8] Additional risk factors include maternal obesity, diabetes mellitus and the use of anticonvulsants and folic acid antagonists.[9]

Anotia/microtia

Most clinicians and surveillance programs classify anotia/microtia into four categories, with type 4 anotia the most severe and type 1 being a smaller ear with normal structure. Some studies record only types 2 to 4,[10] which include most ACASS cases. While the rate sharply dropped in 2019, ACASS closely monitors the overall significantly increasing trend, which remains unexplained.

Risk factors include male sex, maternal diabetes and obesity, Hispanic ethnicity, advanced maternal age, high parity, multifetal gestation, cold symptoms and viral infection.[10] Luquetti et al. summarized the epidemiology and genetics of microtia, including higher risks associated with Asian, Pacific Islander, Native/Alaskan and Indigenous ethnicities.[11] Living at an altitude greater than 2000 m is a risk factor, but this risk factor does not apply in Alberta (Calgary is at 1048 m and Edmonton at 645 m). Maternal smoking and alcohol are reported as risk factors in nonisolated cases[10] and alcohol exposure in isolated cases.[11] Known teratogens include thalidomide, isotretinoin and mycophenolate mofetil.[11]

Orofacial clefts

The overall rates for CLP have remained stable in Alberta for over 40 years and in other jurisdictions for over 30–50 years.[12] In contrast, cleft palate has shown a significantly declining trend (see Table 3). A decline in California has been reported for CLP, but not for cleft palate (1987–2010), suggesting a possible contribution of folic acid fortification to this decline.[13] Lowry et al.[14] compared the period prior to the introduction of folic acid fortification (1993–1997) with two periods after (2000–2004 and 2012–2016), in Alberta, and reported no decline for total CLP cases or for isolated cases over the three timeframes.

TABLE 3
Chi-square linear trend analyses and p values for selected anomalies in Alberta, 1997–2019

Congenital anomaly	Trend direction	Chi-square analysis (X^2LT)	*p* value
NTDs (all)	No significant change	3.58	0.0585
Anencephaly	Decreasing	7.00	0.0082
Spina bifida	No significant change	0.01	0.9203
Anotia/microtia	Increasing	5.67	0.0173
Orofacial clefts (all)	No significant change	0.88	0.3482
CLP	No significant change	0.32	0.5716
Cleft palate only	Decreasing	5.05	0.0246
Anorectal malformations	Decreasing	10.39	0.0013
CHDs			
Transposition of the great arteries	No significant change	1.14	0.2857
Tetralogy of Fallot	No significant change	0.90	0.3428
VSD	Increasing	4.79	0.0286
ASD[a]	No significant change	0.08	0.7773
Hypoplastic left heart syndrome	No significant change	2.26	0.1328
Hypospadias	Increasing	55.83	< 0.0001
Undescended testes[a]	Increasing	14.22	0.0002
Limb reduction	Increasing	4.49	0.0341
Gastroschisis	No significant change	0.07	0.7913
Omphalocele	Increasing	12.07	0.0005
Down syndrome	Increasing	23.54	< 0.0001

Abbreviations: ASD, atrial septal defect; CHD, congenital heart defects; CLP, cleft lip with or without cleft palate; LT, linear trend; NTD, neural tube defect; VSD, ventricular septal defect.

[a] >36 weeks gestation.

A decline was reported in prevalence of orofacial clefts for 1994–2017 in Ontario, especially for cleft palate; however, data from stillbirths and terminations of pregnancy were lacking.[15] The only national Canadian reported data covers 2005–2014 and show no change in trend for CLP but a possible downward trend for cleft palate.[2]

Risk factors include active and passive smoking; alcohol consumption, particularly binge drinking; and maternal obesity. Gene polymorphisms also play a role.[16,17] Meta-analysis of maternal supplementation suggests that periconception intake of folic acid plus multivitamins can reduce occurrence as well as recurrence.[18] The Hutterite Brethren, whose smoking and alcohol consumption is limited and nutrition probably adequate, had zero cases of cleft lip with cleft palate in 1980–2016.[19]

Anorectal malformations

The overall trend is significantly decreasing (p = 0.0013). A 2007 ACASS study for the years 1990–2004 showed stable rates[20] that compared favourably with the results of other studies of that time. The current decline is for both isolated and associated anomaly cases. Khanna et al.[21] reviewed genetic factors contributing to the etiopathogenesis of isolated cases and concluded that a number of copy number variants and/or single nucleotide variants contributed to the defect. Families with autosomal dominant inheritance are reported to exist.[21]

Risk factors include maternal smoking, maternal body mass index (BMI) greater than 30, assisted reproductive technology, maternal chronic respiratory disease, maternal use of anti-asthmatic medications, hypnotics and benzodiazepine.[22] Zwink and Jenetzky[22] report inconsistent results for the protective effects of folic acid supplements.

Zwink and Jenetzky[22] found that in the majority of studies in their systematic review approximately 60% of cases have an associated anomaly; this compares with 82% of ACASS cases. This difference should be interpreted with caution, as inclusion criteria and case classification differed. Other studies may only include live-born and surgically treated cases.

Congenital heart defects

The more severe anomalies show no significant trends with similar case prevalence rates (per 1000 total births: HLHS, 0.32; tetralogy of Fallot, 0.33; and transposition of the great arteries, 0.38). Öhman et al.[23] reported a decrease of live births with HLHS in Sweden, and suggest that this decrease was due to increased prenatal detection and termination of pregnancies. This highlights the importance of ascertaining termination of pregnancies to determine more accurate prevalence.

While the prevalence of ASDs remained stable between 1997 and 2019 (p = 0.7773), the prevalence of VSDs has statistically significantly increased (p = 0.0286), likely because small septal defects are better diagnosed as a result of advances in echocardiography and heart ultrasound. However, ACASS does not accept patent foramen ovales, ASDs in premature infants or ASDs that are smaller than 3 mm and spontaneously close; conversely, ACASS does accept VSDs, regardless of their size, the need for intervention or their spontaneous closing.

Although most CHDs are multifactorial, genetic diagnoses have been reported in 15.7% of cases that have a severe CHD requiring surgery or therapeutic intervention in the first year of life.[24] Cases with a known aneuploidy were excluded.[24] There is emerging evidence that complex single-gene disorders often present as isolated CHDs prenatally, as complete phenotyping may not be possible.[25] In the past two decades, genetic variants have been associated with nonsyndromic or isolated CHDs, particularly for highly conserved transcription factors essential for cardiac development (e.g. *GATA4* variants associated with tetralogy of Fallot, ASDs, VSDs, atrioventricular septal defects and pulmonary stenosis).[26]

Reported risk factors for CHDs include teratogens (e.g. thalidomide, isotretinoin, anticonvulsants, potassium channel blockers, lithium, alcohol), nutritional deficiencies (e.g. vitamin A, vitamin B3) and maternal conditions (diabetes, obesity, phenylketonuria, viral infections and hyperthermia).[27] Dolk et al.[28] reported significant associations with low maternal

education, vaginal infections, maternal clotting disorders and prescriptions for the anticlotting medication enoxaparin. With limited evidence to support such an association, more research is needed to confirm this reported increased risk with enoxaparin. Although the data did not support a protective effect of folic acid supplementation, risk was significantly increased for mothers with diets particularly low in fruits and vegetables, emphasizing the need to consider the entire dietary context.[28]

Placental abnormalities (e.g. low placental weight, altered gene expression in placental tissue) have also been reported to be associated with CHDs.[29] A more comprehensive framework has been proposed to include the environmental complement to the genome, an emerging field of the exposome.[30] Instead of a siloed approach, the interplay between internal and external prenatal environmental exposures that influence placental vascularization and subsequent fetal growth and development needs to be advanced.[30]

Hypospadias

The prevalence of hypospadias for both isolated and nonisolated cases peaked in 2015 and shows an overall significant increase ($p < 0.0001$) for 1997–2019. It is difficult to compare prevalence rates because of methodological differences, such as differences in the degree of severity, the inclusion of surgical cases only and whether rates are for total births versus male births. The EUROCAT report showed wide variability per 1000, with Portugal at 0.51 and Mainz (Germany) at 3.68.[31]

George et al.[32] have described the challenges with associations to determine the etiology of hypospadias and summarized the genetic and environmental factors. Consistent associated risk factors include a positive family history, low birth weight and/or small gestational age, maternal hypertension, preeclampsia, multiple gestations, placental insufficiency, diabetes mellitus and exposures to certain drugs such as progesterone derivatives or valproic acid. Evidence is inconsistent for risk factors such as maternal age and weight, paternal or maternal occupations and agriculture practices.

Genetic variants, such as the diacylglycerol kinase kappa (DGKK) variants, have been shown to be significant risk factors.[33] In California, cases with the DGKK variants and residential proximity to pesticide application had the highest odds ratios for hypospadias.[34] In Nova Scotia, the highest prevalence rates of hypospadias were in two counties that were associated with intense farming.[35] The prevalence of isolated hypospadias in the Hutterite Brethren is approximately double that of the general Alberta population, which may be associated with farming and agricultural practices.[19]

Undescended testes

While there was a sharp drop in rates of undescended testes in 2019, the trend from 1997 to 2019 shows a significant increase ($p = 0.0002$). These results have to be interpreted with caution, as this condition may resolve spontaneously or may in fact be retractile testes. A more accurate prevalence would be determined by knowing which full-term and normal birthweight cases came to orchidopexy. Surgical numbers could include preterm and low birth-weight babies. Hence, the difficulty in obtaining a true prevalence rate.

ACASS does not accept cases born before 37 weeks gestation or with a birth weight of less than 2500 g, but considers these to be physiological and caused by immaturity.

Although the etiology is likely multifactorial, there are some familial cases as well as multiple susceptibility genes.[36] Consistent risk factors are maternal smoking and diabetes, while maternal obesity, alcohol use, use of analgesics and exposure to endocrine-disrupting chemicals, such as agricultural pesticides, are inconsistently reported as risk factors.[37] No differences were reported in the prevalence of undescended testes in the Hutterite population and the general Alberta population.[19]

Limb reductions

Since 1980, rates have fluctuated[38] and we report a significant increase ($p = 0.0341$) for 1997–2019. As one case may have multiple limb reduction anomalies, we report both anomaly and case rates. Our rate of 0.73/1000 total births is comparable to studies from, for example, northern Netherlands (0.64/1000 for 1981–2017), which did not report a trend.[39]

Results of studies of folic acid, with or without supplements, reducing the risk of limb reductions are equivocal,[40] but it is clear that folic acid fortification has had no effect in Alberta. In most cases, the precise cause is unknown. Bergman et al.[39] recently found that an etiological cause was more likely to be identified in a case when more than one limb is affected or in a multiple congenital anomalies case with one affected limb, compared to cases with one limb affected and no other congenital anomalies. Risk factors include maternal smoking, pregestational diabetes, gestational hypertension, maternal age less than 25 years, upper respiratory tract infection in the first trimester, antiepileptic medications and lower educational level of parents.[41]

Gastroschisis

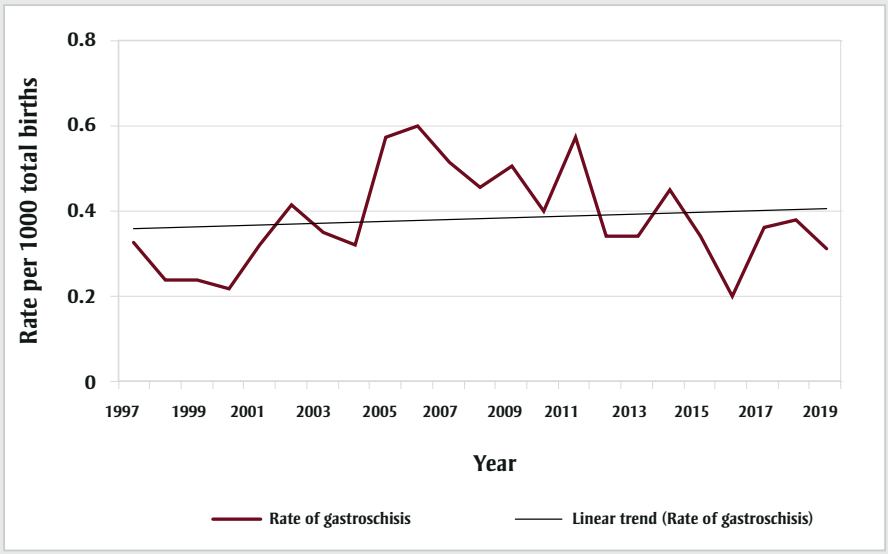
An increase in the prevalence of gastroschisis was noted in the early 1970s in many jurisdictions. In Alberta, the rate rose from 0.15 to 0.57/1000 total births between 1980 and 2011. Rates subsequently declined every year and have now stabilized (see Figure 1), which coincides with a decline in the number of teenage pregnancies (mothers < 20 years old) (see Figure 2). Young maternal age is a known risk factor, and the percentage of mothers younger than 20 years in Alberta fell from 7.3% in 2000 to 1.8% in 2019.[4]

A recent Canadian study using 2006–2017 data found similar results to those of ACASS for trend and a decrease in mothers younger than 20 years.[42] However, the North–South classification methodology the authors used and their interpretation of a geographical variation is problematic.[42] An Ontario study (2012–2018) reported no trend.[43] Neither study included early fetal deaths or terminations.[42,43]

Additional social risk factors include maternal smoking, use of marijuana, illicit drugs and alcohol, low BMI, poor nutrition and socioeconomic disadvantage.[43] There are fewer exposures to many of these risk factors in the Hutterite population, where there were no cases of gastroschisis between 1980 and 2016.[19] A recently recognized risk factor is exposure to wildfires during pre-pregnancy and the first trimester.[44]

While gastroschisis is usually an isolated anomaly, 28% of ACASS cases (data not shown) had a co-occurring anomaly; this is similar to findings in a study from

FIGURE 1
Trend for gastroschisis in Alberta, 1997–2019



* $p = 0.7913$.

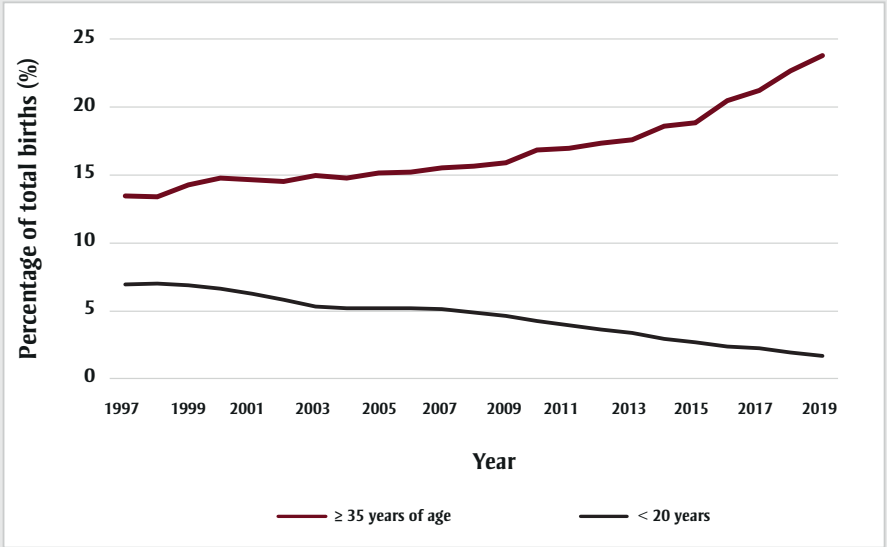
Sweden,[45] but was not mentioned by either of the recent Canadian studies.[42,43] Although gastroschisis is usually sporadic, there are familial reports of inheritance, including parent to child, full siblings, half siblings and distant relatives.[46] Geospatial studies have reported some provincial differences and clusters, with urban/rural differences in Ontario.[43]

Omphalocele

Comparable prevalence rates of omphalocele per 1000 total births have been recorded for several jurisdictions despite differing study years: 0.31 for 1997–2016;[47] 0.47 for 1993–2014;[48] and 0.38 for 2005–2011.[49] Neither trends for live births[47,48] nor for total births[49] were reported, but ACASS has a significantly increased trend for 1997–2019 ($p = 0.005$) (see Figure 3).

Associated anomalies, which include a malformation in another organ system, chromosomal abnormalities and syndromes, are present in 78% of cases recorded by ACASS. Trisomy 18 is very common, but a wide variety of abnormal karyotypes have been reported.

FIGURE 2
Proportion of births to women ≥35 years compared with women <20 years, as a percentage of total births in Alberta, 1997–2019



Risk factors include maternal age greater than 35 years or less than 20 years, maternal obesity and diabetes mellitus. Risks for exposures to smoking and alcohol are inconclusive.[50] A recent study has linked first trimester broad spectrum penicillin treatment with a reduced risk.[51]

Down syndrome

Down syndrome is significantly increasing ($p < 0.0001$) and is strongly correlated with increasing maternal age. In 1983, approximately 4% of mothers were 35 years or older; in 2019, 24% were in that age group.[4]

Frequently associated major malformations include CHDs and duodenal atresia. As most live-born infants with trisomy 21 require ongoing health services, ascertaining associated anomalies can help with future health care planning.

Strengths and limitations

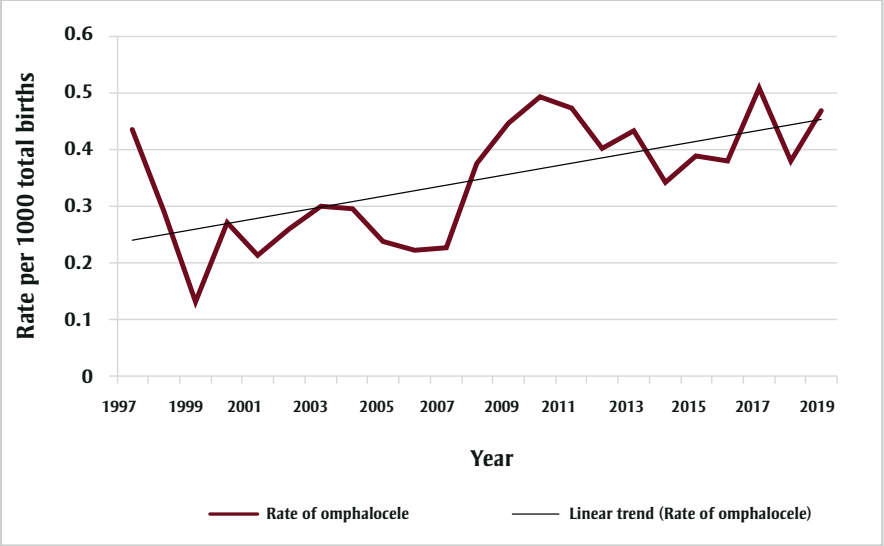
The strengths of this study are supported by the principal features of ACASS and include long-term baseline data, which are fundamental for valid descriptive and analytic studies. Additional features include provincial population-based coverage, multiple sources of ascertainment, ability to critically assess notifications and verify diagnoses that are reported to the system, and the expertise of ACASS personnel.

A limitation is that ACASS is technically a "passive" system, although it is augmented by active components, such as access to hospital records and correspondence with attending physicians for verification. ACASS primarily depends on others for case notifications and thus may not have complete ascertainment. The best systems, practised in many US States (e.g. Texas, Utah) and European and South American countries, have "active" ascertainment.

Conclusion

Congenital anomalies occur in approximately 3–5% of live births and 15% of stillbirths. They are an important public health concern and have significant social and societal costs. The majority of congenital anomalies are multifactorial, with

FIGURE 3
Trend for omphalocele in Alberta, 1997–2019



* $p = 0.0005$.

established risk factors often requiring a change in behaviour, which can be challenging (e.g. smoking and alcohol cessation, better control of maternal obesity and diabetes, folic acid/multivitamin supplementation and better nutrition).

Congenital anomalies surveillance data can be used for planning and policy decisions and the evaluation of prevention strategies, as exemplified by the success of folic acid fortification in the prevention of NTDs. These data are also required to respond to real and potential emerging threats such as Zika virus and the identification of congenital Zika syndrome. Many congenital anomalies surveillance programs now track outcomes of COVID-19 infection in pregnancy.

While funding is often challenging to obtain and maintain in Canada, PHAC is working with the provinces and territories to enhance CCASS data with more local datasets, which will provide more accurate prevalence rates of congenital anomalies across Canada. The last comprehensive congenital anomaly report published by PHAC used Canadian Institute for Health Information data from 1998–2009.[3] The British Columbia Health Status Registry was a world-class congenital anomalies surveillance system and after 70 years, the data were archived in 2021. Their last report was in 2005 using data to 2002.

With over 40 years in operation, ACASS has the most published prevalence data in Canada and provides context for more prevention. Congenital anomalies surveillance constitutes an essential data source for further research and to guide public health actions.[52]

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Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

RBL: Writing – Original draft. RBL, TB: Conceptualization of the work. RBL, TB, XG, SC, MAT: Data curation and analysis.

All the authors revised the manuscript for relevant and important intellectual content, edited the working manuscript and approved the final version for submission.

The content and views expressed in this article are those of the authors and do not necessarily reflect those of the Government of Canada.

References

1. Johnson KC, Rouleau J. Temporal trends in Canadian birth defects prevalences, 1979-1993. Can J Public Health. 1997;88(3):169-76. https://doi.org/10.1007/BF03403882

2. Public Health Infobase. Congenital anomalies in Canada [Internet]. Ottawa (ON): Government of Canada; 2017 [updated 2021 Oct 06; cited 2022 Mar 11]. Available from: https://health-infobase.canada.ca/congenital-anomalies/data-tool/

3. Public Health Agency of Canada. Congenital anomalies in Canada 2013: a perinatal health surveillance report. Ottawa (ON): Government of Canada; 2013. https://publications.gc.ca/collections/collection_2014/aspc-phac/HP35-40-2013-eng.pdf

4. Lowry RB, Thomas MA, Bedard T, Grevers X. Alberta Congenital Anomalies Surveillance System: Thirteenth report: data for 1997–2018. Calgary (AB): Alberta Health Services; 2021. 84 p. Report No.:13. https://www.albertahealthservices.ca/assets/info/cmg/if-cmg-ab-congenital-abnormalities-report.pdf

5. Martins Santana EF, Araujo Júnior E, Tonni G, Costa FDS, Meagher S. Acrania-exencephaly-anencephaly sequence phenotypic characterization using two- and three-dimensional ultrasound between 11 and 13 weeks and 6 days of gestation. J Ultrason. 2018;18(74):240-6. https://doi.org/10.15557/JoU.2018.0035

6. Lowry RB, Bedard T, MacFarlane AJ, Crawford S, Sibbald B, Agborsangaya BC. Prevalence rates of spina bifida in Alberta, Canada: 2001-2015. Can we achieve more prevention? Birth Defects Res. 2019;111(3):151-8. https://doi.org/10.1002/bdr2.1438

7. Molloy AM. Should vitamin B_{12} status be considered in assessing risk of neural tube defects? Ann N Y Acad Sci. 2018;1414(1):109-25. https://doi.org/10.1111/nyas.13574

8. Greene ND, Leung KY, Gay V, et al. Inositol for the prevention of neural tube defects: a pilot randomised controlled trial. Br J Nutr. 2016; 115(6):974-83. https://doi.org/10.1017/S0007114515005322

9. Dean JH, Pauly R, Stevenson RE. Neural tube defects and associated anomalies before and after folic acid fortification. J Pediatr. 2020;226:186-94. https://doi.org/10.1016/j.jpeds.2020.07.002

10. Ryan MA, Olshan AF, Canfield MA, et al.; National Birth Defects Prevention Study. Sociodemographic, health behavioral, and clinical risk factors for anotia/microtia in a population-based case-control study. Int J Pediatr Otorhinolaryngol. 2019;122:18-26. https://doi.org/10.1016/j.ijporl.2019.03.026

11. Luquetti DV, Heike CL, Hing AV, Cunningham ML, Cox TC. Microtia: epidemiology and genetics. Am J Med Genet A. 2012;158A(1):124-39. https://doi.org/10.1002/ajmg.a.34352

12. Lowry RB, Sibbald B, Bedard T. Stability of orofacial clefting rate in Alberta, 1980-2011. Cleft Palate Craniofac J. 2014;51(6):e113-21. https://doi.org/10.1597/13-340

13. Andrew T, Yang W, Bernstein JA, Shaw GM. Change in prevalence of orofacial clefts in California between 1987 and 2010. Am J Med Genet A. 2018;176(9):1910-6. https://doi.org/10.1002/ajmg.a.40384

14. Lowry RB, Crawford S, Bedard T, Sibbald B. Orofacial clefts in California: no decline in Alberta, Canada. Am J Med Genet A. 2019;179(6):1077-9. https://doi.org/10.1002/ajmg.a.61136

15. Malic CC, Lam M, Donnelle J, Richard L, Vigod SN, Benchimol EI. Incidence, risk factors, and mortality associated with orofacial cleft among children in Ontario, Canada. JAMA Netw Open. 2020;3(2):e1921036. https://doi.org/10.1001/jamanetworkopen.2019.21036

16. Mossey PA, Little J, Steegers-Theunissen R, et al. Genetic interactions in nonsyndromic orofacial clefts in Europe – EUROCRAN Study. Cleft Palate Craniofac J. 2017;54(6):623-30. https://doi.org/10.1597/16-037

17. Sabbagh JH, Hassan MH, Innes NP, Elkodary HM, Little J, Mossey PA. Passive smoking in the etiology of non-syndromic orofacial clefts: a systematic review and meta-analysis. PLoS One. 2015;10(3):e0116963. https://doi.org/10.1371/journal.pone.0116963

18. Jahanbin A, Shadkam E, Miri HH, Shirazi AS, Abtahi M. Maternal folic acid supplementation and the risk of oral clefts in offspring. J Craniofac Surg. 2018;29(6):e534-41. https://doi.org/10.1097/SCS.0000000000004488

19. Lowry RB, Bedard T, Crawford S, Grevers X, Bernier FP, Thomas MA. Prevalence rates study of selected isolated non-Mendelian congenital anomalies in the Hutterite population of Alberta, 1980-2016. Am J Med Genet A. 2020;182(11):2594-604. https://doi.org/10.1002/ajmg.a.61834

20. Lowry RB, Sibbald B, Bedard T. Stability of prevalence rates of anorectal malformations in the Alberta Congenital Anomalies Surveillance System 1990-2004. J Pediatr Surg. 2007;42(8):1417-21. https://doi.org/10.1016/j.jpedsurg.2007.03.045

21. Khanna K., Sharma S, Pabalan N, Singh N, Gupta DK. A review of genetic factors contributing to the etiopathogenesis of anorectal malformations. Pediatr Surg Int. 2018;34(1):9-20. https://doi.org/10.1007/s00383-017-4204-2

22. Zwink N, Jenetzky E. Maternal drug use and the risk of anorectal malformations: systematic review and meta-analysis. Orphanet J Rare Dis. 2018; 13(1):75. https://doi.org/10.1186/s13023-018-0789-3

23. Öhman A, El-Segaier M, Bergman G, et al. Changing epidemiology of hypoplastic left heart syndrome: results of a national Swedish cohort study. J Am Heart Assoc. 2019; 8(2):e010893. https://doi.org/10.1161/JAHA.118.010893

24. van Nisselrooij AE, Lugthart MA, Clur SA, et al. The prevalence of genetic diagnoses in fetuses with severe congenital heart defects. Genet Med. 2020;22(7):1206-14. https://doi.org/10.1038/s41436-020-0791-8

25. Thibodeau ML, Langlois S. Correspondence on "The prevalence of genetic diagnoses in fetuses with severe congenital heart defects" by Nisselrooij et al. Genet Med. 2021; 23(1):234-5. https://doi.org/10.1038/s41436-020-00964-3

26. Lin H, McBride KL, Garg V, Zhao MT. Decoding genetics of congenital heart disease using patient-derived induced pluripotent stem cells (iPSCs). Front Cell Dev Biol. 2021;9:630069. https://doi.org/10.3389/fcell.2021.630069

27. Kalisch-Smith JI, Ved N, Sparrow DB. Environmental risk factors for congenital heart disease. Cold Spring Harb Perspect Biol. 2020;12(3):a037234. https://doi.org/10.1101/cshperspect.a037234

28. Dolk H, McCullough N, Callaghan S, et al. Risk factors for congenital heart disease: The Baby Hearts Study, a population-based case-control study. PLoS One. 2020;15(2):e0227908. https://doi.org/10.1371/journal.pone.0227908

29. Snoep MC, Aliasi M, van der Meeren LE, Jongbloed MR, DeRuiter MC, Haak MC. Placenta morphology and biomarkers in pregnancies with congenital heart disease – a systematic review. Placenta. 2021;112:186-96. https://doi.org/10.1016/j.placenta.2021.07.297

30. Boyd R, McMullen H, Beqaj H, Kalfa D. Environmental exposures and congenital heart disease. Pediatrics. 2022;149(1):e2021052151. https://doi.org/10.1542/peds.2021-052151

31. Bergman JE, Loane M, Vrijheid M, et al. Epidemiology of hypospadias in Europe: a registry-based study. World J Urol. 2015;33(12):2159-67. https://doi.org/10.1007/s00345-015-1507-6

32. George M, Schneuer FJ, Jamieson SE, Holland AJ. Genetic and environmental factors in the aetiology of hypospadias. Pediatr Surg Int. 2015;31(6):519-27. https://doi.org/10.1007/s00383-015-3686-z

33. Joodi M, Amerizadeh F, Hassanian SM, et al. The genetic factors contributing to hypospadias and their clinical utility in its diagnosis. J Cell Physiol. 2019;234(5):5519-23. https://doi.org/10.1002/jcp.27350

34. Carmichael SL, Yang W, Ma C, et al. Joint effects of genetic variants and residential proximity to pesticide applications on hypospadias risk. Birth Defects Res A Clin Mol Teratol. 2016;106(8):653-8. https://doi.org/10.1002/bdra.23508

35. Lane C, Boxall J, MacLellan D, Anderson PA, Dodds L, Romao RL. A population-based study of prevalence trends and geospatial analysis of hypospadias and cryptorchidism compared with non-endocrine mediated congenital anomalies. J Pediatr Urol. 2017;13(3):284.e1-7. https://doi.org/10.1016/j.jpurol.2017.02.007

36. Barthold JS, Reinhardt S, Thorup J. Genetic, maternal, and environmental risk factors for cryptorichidism: an update. Eur J Pediatr Surg. 2016;26(5):399-408. https://doi.org/10.1055/s-0036-1592416

37. Gurney JK, McGlynn KA, Stanley J, et al. Risk factors for cryptorichidism. Nat Rev Urol. 2017;14(9):534-48. https://doi.org/10.1038/nrurol.2017.90

38. Bedard T, Lowry RB, Sibbald B, Kiefer GN, Metcalfe A. Congenital limb deficiencies in Alberta-a review of 33 years (1980-2012) from the Alberta Congenital Anomalies Surveillance System (ACASS). Am J Med Genet A. 2015;167A(11):2599-609. https://doi.org/10.1002/ajmg.a.37240

39. Bergman JE, Löhner K, van der Sluis CK, Rump P, de Walle HE. Etiological diagnosis in limb reduction defects and the number of affected limbs: A population-based study in the Northern Netherlands. Am J Med Genet A. 2020;182(12):2909-18. https://doi.org/10.1002/ajmg.a.61875

40. Liu J, Li Z, Ye R, Ren A, Liu J. Folic acid supplementation and risk for congenital limb reduction defects in China. Int J Epidemiol. 2019;48(6):2010-7. https://doi.org/10.1093/ije/dyz130

41. Syvänen J, Nietosvaara Y, Hurme S, et al. Maternal risk factors for congenital limb deficiencies: a population-based case-control study. Paediatr Perinat Epidemiol. 2021;35(4):450-8. https://doi.org/10.1111/ppe.12740

42. Liu S, Evans J, Boutin A, et al. Time trends, geographic variation and risk factors for gastroschisis in Canada: a population-based cohort study 2006-2017. Paediatr Perinat Epidemiol. 2021;35(6):664-73. https://doi.org/10.1111/ppe.12800

43. Bourque DK, Meng L, Dougan S, et al. Gastroschisis in Ontario, Canada: 2012–2018. Birth Defects Res. 2021;113(14):1044-51. https://doi.org/10.1002/bdr2.1896

44. Park BY, Boles I, Monavvari S, et al. The association between wildfire exposure in pregnancy and foetal gastroschisis: a population-based cohort study. Paediatr Perinat Epidemiol. 2021;36(1):45-53. https://doi.org/10.1111/ppe.12823

45. Caldeman C, Fogelström A, Oddsberg J, Mesas Burgos C, Löf Granström A. National birth prevalence, associated anomalies and mortality for gastroschisis in Sweden. Acta Paediatr. 2021;110(9):2635-40. https://doi.org/10.1111/apa.15954

46. Salinas-Torres VM, Salinas-Torres RA, Cerda-Flores RM, Martínez-de-Villarreal LE. Evaluation of familial factors in a Mexican population-based setting with gastroschisis: further evidence for an underlying genetic susceptibility. J Pediatr Surg. 2018;53(3):521-4. https://doi.org/10.1016/j.jpedsurg.2017.08.021

47. Fogelström A, Caldeman C, Oddsberg J, Löf Granström A, Mesas Burgos C. Omphalocele: national current birth prevalence and survival. Pediatr Surg Int. 2021;37(11):1515-20. https://doi.org/10.1007/s00383-021-04978-z

48. Raitio A, Tauriainen A, Syvänen J, et al. Omphalocele in Finland from 1993 to 2014: trends, prevalence, mortality, and associated malformations – a population-based study. Eur J Pediatr Surg. 2021;31(2):172-6. https://doi.org/10.1055/s-0040-1703012

49. Springett A, Draper ES, Rankin J, et al. Birth prevalence and survival of exomphalos in England and Wales: 2005 to 2011. Birth Defects Res A Clin Mol Teratol. 2014;100(9):721-5. https://doi.org/10.1002/bdra.23301

50. Frolov P, Alali J, Klein MD. Clinical risk factors for gastroschisis and omphalocele in humans: a review of the literature. Pediatr Surg Int. 2010;26(12):1135-48. https://doi.org/10.1007/s00383-010-2701-7

51. Raitio A, Tauriainen A, Leinonen MK, et al. Extended spectrum penicillins reduce the risk of omphalocele: a population-based case-control study. J Pediatr Surg. 2021;56(9):1590-5. https://doi.org/10.1016/j.jpedsurg.2020.10.034

52. Melo DG, Sanseverino MT, Schmalfuss TO, Larrandaburu M. Why are birth defects surveillance programs important? Front Public Health. 2021;9:753342. https://doi.org/10.3389/fpubh.2021.753342

https://doi.org/10.24095/hpcdp.43.1.05

Release notice

Canadian Cancer Statistics: A 2022 special report on cancer prevalence

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Just released!

Canadian Cancer Statistics: A 2022 special report on cancer prevalence was released on November 8, 2022.

This publication is produced through a collaboration between the Canadian Cancer Society, Statistics Canada and the Public Health Agency of Canada, with data provided by the provincial and territorial cancer registries and analyses completed by Statistics Canada and the Canadian Partnership Against Cancer. It provides estimates of cancer prevalence by cancer type, sex, age, geographic region, duration, neighbourhood income and urban and rural status for adults, and by cancer type for childhood cancers.

Highlights include:

- At the beginning of 2018, over 1.5 million people in Canada were living with or beyond cancer. Of those, approximately 60% were diagnosed 5 to 25 years prior.
- 1 in 24 Canadians had been diagnosed with at least one cancer in the previous 25 years.
- The number of people living with or beyond cancer in Canada continues to increase.
- At the beginning of 2018, breast and colorectal cancers combined accounted for nearly half (47.1%) of all 25-year prevalent cancers among females, with an estimated 328 125 breast cancer cases and 88 150 colorectal cancer cases.
- At the beginning of 2018, prostate and colorectal cancers combined accounted for half (49.8%) of all 25-year prevalent cancers among males, with an estimated 301 840 prostate cancer cases and 103 370 colorectal cancer cases.

Access or download the latest *Canadian Cancer Statistics* and related resources.

Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals. Look for the following articles published in 2022:

De Rubeis V, Anderson LN, **Khattar J**, **de Groh M**, **Jiang Y**, et al. Stressors and perceived consequences of the COVID-19 pandemic among older adults: a cross-sectional study using data from the Canadian Longitudinal Study on Aging. CMAJ Open. 2022;10(3):E721-30. https://doi.org/10.9778/cmajo.20210313

Guay M, **Maquiling A**, **Chen R**, **Lavergne V**, **Baysac DL**, […] **Gilbert NL**. Measuring inequalities in COVID-19 vaccination uptake and intent: results from the Canadian Community Health Survey 2021. BMC Public Health. 2022;22(1):1708. https://doi.org/10.1186/s12889-022-14090-z

Lang JJ, Zhang K, Agostinis-Sobrinho C, […] **Prince SA**, […] **Roberts KC**, et al. Top 10 international priorities for physical fitness research and surveillance among children and adolescents: a twin-panel Delphi study. Sports Med. 2022;1-16. https://doi.org/10.1007/s40279-022-01752-6

Medina A, Nilles C, Martino D, **Pelletier C**, et al. The prevalence of idiopathic or inherited isolated dystonia: a systematic review and meta-analysis. Mov Disord Clin Pract (Hoboken). 2022;9(7):860-8. https://doi.org/10.1002/mdc3.13524

Prince SA, **Roberts KC**, **Lang JJ**, **Butler GP**, et al. The influence of removing the 10-minute bout requirement on the demographic, behaviour and health profiles of Canadian adults who meet the physical activity recommendations. Health Rep. 2022;33(8):3-18. https://doi.org/10.25318/82-003-x202200800001-eng

Stockwell T, Zhao J, Alam F, […] **Shi Y**, et al. Alcohol sales in Canadian liquor outlets as a predictor of subsequent COVID-19 infection rates: a time-series analysis. Addiction. 2022;117(12):3069-78. https://doi.org/10.1111/add.16011