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Original quantitative research

Lactation supports implemented within the Canada Prenatal Nutrition Program: findings from a national survey

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Abstract

Introduction: Supporting breastfeeding is integral to the Canada Prenatal Nutrition Program (CPNP), although details on lactation support implementation are limited. This research aimed to assess lactation support delivery by CPNP sites across Canada, excluding Quebec, and how the COVID-19 pandemic affected services.

Methods: From May to July 2023, we conducted a cross-sectional survey; 207 sites were invited to participate. We investigated the types of lactation supports delivered; how and by whom; and the role of site characteristics (locality, Community Action Program for Children funding, breastfeeding clinic on-site, primary healthcare facility on-site) and funding sources (CPNP only, CPNP and other funds, other funds only) on lactation support provision.

Results: All respondents (n = 91 sites) reported providing at least one lactation support: 95% offered educational materials, 89% community referrals, 77% personalized support from a community-based provider, 69% live education sessions, 68% breast pumps, 51% peer support programming, 34% personalized support from a board-certified lactation professional, and 34% lactation-related supplies. Most sites continued to offer lactation supports during the COVID-19 pandemic but faced multiple service provision challenges. Availability of lactation supports that required additional resources beyond CPNP core funds varied by site characteristics. To provide lactation supports, particularly personalized support, most sites reported relying heavily on non-CPNP funds (e.g. donations, private funding).

Conclusion: Lactation support delivery varied widely across CPNP sites, with access differing by site characteristics and external resource availability. Increased programmatic guidance and support of core lactation resources holds potential to ensure consistent lactation support availability and reduce disparities in perinatal health and nutrition.

Keywords: *lactation, breastfeeding, infant feeding, perinatal nutrition, vulnerable population, Canada Prenatal Nutrition Program, community programming*

Introduction

Breastfeeding benefits maternal and child health in both the short- and long-term, with economic implications through reduced healthcare costs.¹⁻⁴ The World Health

Organization (WHO) and Canadian guidelines recommend exclusive breastfeeding to six months.^{5,6} In Canada, 91% of mothers start breastfeeding; however, only 69% continue and 36% exclusively breastfeed to six months.⁷ Among those who

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Highlights

- Supporting breastfeeding is central to the Canada Prenatal Nutrition Program (CPNP) goals, although lactation supports vary by site.
- This study is the first to document what lactation supports are offered within the CPNP flexible programming model, how they are implemented, and how the COVID-19 pandemic affected programming.
- While lactation educational material and/or community referrals were universally offered by sites across Canada, the provision of other lactation supports requiring additional human resources or materials varied, as did the method of delivery.
- To provide lactation supports, sites require external resources beyond CPNP core funds, which leads to inequities between sites.
- To contextualize findings on lactation supports, future research should assess the fidelity of CPNP lactation support programming, as well as examine participants' breastfeeding outcomes and experiences with service quality, adequacy, and appropriateness.

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stop breastfeeding early, 71% report a preventable or treatable reason (i.e. not enough breastmilk, difficulty with breastfeeding).⁸ Furthermore, mothers with lower incomes or education are less likely to breastfeed in Canada.⁹ The WHO highlights the importance of skilled lactation support, although access and socioeconomic barriers persist.¹⁰

The Canada Prenatal Nutrition Program (CPNP) is a federal program through the Public Health Agency of Canada (PHAC) that funds community groups to support the health of pregnant women and people, new parents, and their infants who face challenges that may put their health at risk.¹¹ Promoting and supporting breastfeeding is a stated goal of the CPNP,¹² although there is limited programmatic guidance and a lack of designated lactation support resources. Programming implemented at CPNP sites, including lactation support, is adaptive to the needs of communities and shaped by the availability of local partnerships (e.g. public health, community groups) and additional resources (e.g. donations, private funding).¹³

Understanding how CPNP sites deliver lactation supports can strengthen programming guidance, and there is a need to understand how the COVID-19 pandemic affected service delivery. This study is the first national survey to (1) assess what types of lactation supports are implemented by CPNP participants and how the pandemic affected service delivery; (2) explore how CPNP site characteristics relate to lactation supports availability; and (3) investigate types of funding used to provide lactation supports. To align with the terminology used by PHAC in reporting and publications, we have used the terminology “breastfeeding.” We acknowledge that there is great diversity among lactating CPNP participants and our definition of breastfeeding is intended to be inclusive of chest feeding.

Methods

Study design, eligibility and survey respondents

From May to July 2023, a cross-sectional survey of CPNP site characteristics, lactation supports, food supports, and coping during the COVID-19 pandemic was administered.¹⁴ All CPNP sites across Canada were eligible to participate, excluding Quebec because CPNP administration

differs compared to other provinces and territories.

Survey tool development and distribution

The survey tool was developed following review of publicly available CPNP documentation.^{12,15} There were three sections: site characteristics, service provision, and coping during the COVID-19 pandemic. Feedback on the survey tool was initially obtained from local CPNP coordinators in Toronto, and further review from an Advisory Group of CPNP coordinators (N = 16) from all five PHAC regions in Canada (BC and AB; SK and MB; the Territories [YT, NT, NU]; Central [ON and QC]; and Atlantic Canada [NB, NL, NS, PE]) to ensure relevance, clarity, and face validity. Advisory Group members self-identified from an open call to CPNP sites shared by PHAC regional leads on behalf of the researchers.¹⁴ Both local CPNP coordinators and Advisory Group members represented racialized and diverse lived and professional perspectives. The Advisory Group included coordinators from CPNP sites that were community-based, Indigenous-led, and embedded within public health agencies. After incorporating feedback, the Advisory Group pilot tested the survey for their CPNP sites to confirm clarity and flow. Questions were found to be clear, and the finalized survey was professionally translated to French.¹⁴ Post-survey, both local CPNP coordinators and the Advisory Group members were re-engaged to give feedback on the study findings and interpretation.

Lactation support questions appeared within the service provision section. Using a 5-year reference period (2018 to 2023), survey respondents were asked what types of lactation supports CPNP participants could access via their site from seven pre-defined categories (educational materials, live education sessions, community-based lactation referrals, board-certified lactation professional, another community-based lactation support provider [e.g. public health nurse, doula], breastfeeding peer support programming, breast pumps). If survey respondents reported offering a predefined lactation support, additional implementation questions were asked, including CPNP participant eligibility, frequency, location, personnel providing service, and funding. This was asked at each COVID-19 pandemic-related time period of interest: before the pandemic (2018 to March 2020), during the pandemic (March

2020 to late spring 2023), and/or in the upcoming 2024 fiscal year (starting in April 2024 [hereafter referred to as “post-pandemic”]). If participants were unsure about implementation details for a lactation support category, they could select an “unsure” response option. Across survey items, “unsure” and missing responses were generally infrequent (< 10%). In an open-ended category, survey respondents could list any additional lactation supports or supplies accessible to CPNP participants via their site; no further implementation questions were asked for these. As an optional question, survey respondents could describe additional lactation supports they would like their CPNP site to provide, if additional sustainable funds were available.

The survey was administered virtually, using Research Electronic Data Capture (REDCap; Vanderbilt University).^{16,17} CPNP Regional Leads at PHAC, representing all PHAC regions in Canada, supported survey distribution by sharing a standardized invitation email to CPNP sites within their region.

Ethics

After completing an online consent form, survey respondents could access the survey in English or French. The University of Toronto Office of Research Ethics provided ethical approval of study procedures (Protocol: 00044170). Post-completion, survey respondents were offered their choice of a selection of \$25 electronic gift cards as a token of appreciation. Contact information for gift card distribution was collected separately from survey responses to maintain confidentiality.

Data analysis

Data were exported from REDCap into Stata, version 15.0 (StataCorp LP, College Station, TX, US).¹⁸ To describe the CPNP site and service delivery characteristics, proportions were presented. Data from all CPNP sites that reported providing one or more lactation supports were included, even if no further implementation details were provided. Across time periods, paired proportions were compared using McNemar’s test, given small cell counts.¹⁹ In an exploratory analysis, lactation support provision was further examined by comparing proportions between four subgroups perceived to influence resource availability (hereafter referred to as “site

characteristics of interest”): locality (urban/rural); whether an agency had Community Action Program for Children (CAPC) funding (a parallel PHAC-funded program for socially and/or economically vulnerable families to promote healthy development from birth to six-years);¹³ offered a breastfeeding clinic on-site; or offered a primary healthcare facility on-site. Because this is the first study to assess lactation supports within the CPNP, and these data are not routinely collected by PHAC, the distribution of lactation supports across sites was unknown a priori. Since the study was not designed or sufficiently powered to support formal subgroup comparisons, and several site characteristics were anticipated to produce small cell counts, site-level analyses were intended to be exploratory and descriptive in nature. Accordingly, formal statistical comparisons were not performed. Additional lactation support data were reviewed by three researchers, categorized collaboratively by type of desired lactation support, and frequencies were calculated to identify priorities for additional lactation support.

Results

Survey completion and CPNP site characteristics

Survey completion

Of the 207 CPNP sites invited to complete the survey, 98 consented, and 91 sites (44%) provided survey data. All invited Canadian provinces and territories were represented ([Supplemental Table 1](#)). Twenty-one percent of sites were identified as Indigenous-led. Most CPNP sites were operated by a lead agency that offered multiple services to the community (88%), and/or worked with partner agencies within the community to deliver CPNP programming (73%; Table 1). Most were based in an urban setting (75%) and 45% additionally offered CAPC; 23% percent and 19% offered a breastfeeding clinic or primary healthcare facility, respectively, with 7% offering both (Table 2).

General CPNP service provision and the effect of the COVID-19 pandemic

CPNP programming was most commonly offered weekly (Table 3). Among survey

respondents that reported their CPNP site annual participation numbers (N = 77), most (81%) enrolled less than 110 CPNP participants per year ([Supplemental Table 2](#)). Urban CPNP sites tended to be larger than rural (average: 95 versus 41 participants/year, respectively). While a comparable number of rural and urban sites offered CAPC in addition to CPNP programming (43% versus 45%), fewer rural sites compared to urban sites were embedded within a lead agency that offered primary healthcare facility (9% versus 22%; Table 2).

Between 2019 and 2021, around one-quarter of CPNP sites indicated that their program was at maximum capacity and that they had to limit enrolment or service provision; this increased over time (2019: 24%, 2020: 26%, 2021: 29%). In 2021, CPNP sites more often reported being at maximum capacity if they also offered CAPC (41% versus 20%) or did not offer a breastfeeding clinic (32% versus 19%).

Following the onset of the COVID-19 pandemic, all CPNP sites reported remaining

TABLE 1
Characteristics of lead agencies that offered CPNP programming and contributed survey data (N = 91)

Characteristic	n (%)
Agency offered multiple services, in addition to CPNP programming, that CPNP participants could access	
Yes	80 (88)
No	10 (11)
Did not respond	1 (1)
Other supports offered by multi-service lead agencies (N = 80)	
Child development program	45 (56)
Food bank or meal program	39 (49)
Counselling services	37 (46)
Mental health services	35 (44)
Indigenous cultural programming	23 (29)
Breastfeeding clinic	21 (26)
Primary healthcare facility	17 (21)
Other	39 (49)
Agency works with community partners to deliver CPNP program activities	
Yes	65 (71)
No	24 (26)
Did not respond	2 (2)
Types of community partner organizations^a (N = 65)	
Public (government, public health)	55 (85)
Non-profit (charity, church, school)	46 (71)
Private (donor, business)	23 (35)

Abbreviation: CPNP, Canada Prenatal Nutrition Program.

^a Survey respondents could report one or more options.

TABLE 2
Site characteristics of interest, lactation supports and disaggregation of lactation supports
by site characteristic of interest among survey respondents (N = 91)

Characteristic	All sites in past 5 years (N = 91) n (%)	Locality ^a n (%)		Receive CAPC funding n (%)		Breastfeeding clinic on-site n (%)		Primary healthcare facility on-site n (%)	
		Rural (N = 23)	Urban (N = 68)	No (N = 50)	Yes (N = 41)	No (N = 70)	Yes (N = 21)	No (N = 74)	Yes (N = 17)
Site characteristics									
Urban	68 (75)	–	–	37 (74)	31 (76)	51 (73)	17 (81)	53 (72)	15 (88)
Receive CAPC funding	41 (45)	10 (43)	31 (46)	–	–	33 (47)	8 (38)	35 (47)	6 (35)
Breastfeeding clinic on-site	21 (23)	4 (17)	17 (25)	13 (26)	8 (20)	–	–	15 (20)	6 (35)
Primary healthcare facility on-site	17 (19)	2 (9)	15 (22)	11 (22)	6 (15)	11 (16)	6 (29)	–	–
Lactation support characteristics – types of lactation supports									
Educational materials	86 (95)	21 (91)	65 (96)	47 (94)	39 (95)	66 (94)	20 (95)	71 (96)	15 (88)
Live education sessions	63 (69)	13 (57)	50 (74)	36 (72)	27 (66)	46 (66)	17 (81)	50 (68)	13 (76)
Referrals to community-based lactation service	81 (89)	16 (70)	65 (96)	47 (94)	34 (83)	61 (87)	20 (95)	66 (89)	15 (88)
Board-certified lactation professional (IBCLC)	31 (34)	5 (22)	26 (38)	19 (38)	12 (29)	22 (31)	9 (43)	23 (31)	8 (47)
Other community-based lactation support provider	70 (77)	15 (65)	55 (81)	43 (86)	27 (66)	53 (76)	17 (81)	57 (77)	13 (76)
Breastfeeding peer support programming	46 (51)	11 (48)	35 (51)	23 (46)	23 (56)	35 (50)	11 (52)	39 (53)	7 (41)
Breast pump	62 (68)	18 (78)	44 (65)	36 (72)	26 (63)	46 (66)	16 (76)	52 (70)	10 (59)

Abbreviations: CAPC, Community Action Program for Children; CPNP, Canada Prenatal Nutrition Program; IBCLC, International Board-Certified Lactation Consultant.

^a Two sites reported having both urban and rural CPNP locations, and have been classified as urban.

open for some duration of 2020 and 2021. However, there was an increase in virtual service provision within CPNP programming (Table 3). This did not differ by site characteristics of interest.

Lactation supports provided by CPNP sites and the effect of the COVID-19 pandemic

All survey respondents reported providing at least one type of lactation support in the past five years (Table 2). Providing lactation education was most common, with 95% offering educational materials and 69% live education sessions. Referrals to community services were also widely reported (89%). For personalized lactation support, 34% reported offering support from a board-certified lactation professional (i.e. International Board-Certified Lactation Consultant [IBCLC]); 77% from another community-based provider, and 51% peer support programming. Sixty-eight percent reported offering breast pumps. Provision of other lactation-related supplies (e.g. breast pads, nipple ointment, breastfeeding pillows, breast pump accessories, teas, supplementary nursing systems) was also reported by 34% of survey respondents.

While there was no disruption in offering educational materials during the COVID-19 pandemic, there was a decrease for all other lactation supports, although provision was largely expected to recover post-pandemic (Table 4). During the pandemic the greatest magnitudes of decrease in lactation support provision were observed for live education sessions (18%), followed by breastfeeding peer support (13%) and community referrals (12%; Table 4).

Understanding lactation support implementation, with reference to the characteristics of interest, across the three time periods of interest relative to the COVID-19 pandemic

Education about lactation

Both types of lactation education were typically available for all registered CPNP participants to access (Supplemental Table 3). Survey respondents reported offering educational materials (pamphlets, books, posters, YouTube clips, videos) nearly universally; these could be provided during group sessions, one-on-one sessions, or with other items. Offering educational materials was independent of the

site characteristics considered (Table 2). However, live education sessions (workshops, webinars) were reported more often by urban CPNP sites (74% versus 57%) and when a lead agency offered a breastfeeding clinic (81% versus 66%). Live education sessions were typically led by CPNP program staff, public health partners, nurses, IBCLCs, and/or dietitians (Supplemental Table 3).

Regardless of the COVID-19 pandemic, educational materials continued to be provided to CPNP participants (Table 4). With the pandemic, there was an 18% decrease in sites that offered live education sessions, although this was anticipated to recover post-pandemic (Table 4). With the pandemic, live education sessions transitioned from mostly in-person (98%) to primarily virtual (79%), with in-person dropping to 30% (Supplemental Table 3). Notably, among survey respondents offering live education sessions during the pandemic, delivery by public health partners decreased and CPNP program staff increased, although public health engagement was expected to return post-pandemic (Supplemental Table 3).

TABLE 3
Characteristics of service delivery at CPNP sites, across the three time periods of interest relative to the COVID-19 pandemic

Characteristic	Pre-pandemic (before March 2020) n (%)	During pandemic (March 2020– time of survey) n (%)	Post-pandemic (upcoming 2024 fiscal year) n (%)
Frequency of programming			
N	81	79	85
Weekly	71 (88)	54 (68)	70 (82)
Monthly	3 (4)	6 (8)	5 (6)
Modular design	4 (5)	7 (9)	5 (6)
Occasionally	1 (1)	7 (9)	0 (0)
Other	2 (2)	5 (6)	5 (6)
Services provided at CPNP site^a			
N	91	91	91
Group sessions in-person	81 (89)	21 (23)	85 (93)
Group sessions virtually	2 (2)	74 (81)	42 (46)
One-on-one session in-person	65 (71)	29 (32)	68 (75)
One-on-one session virtually	7 (8)	61 (67)	39 (43)
Centre-based services	58 (64)	28 (31)	64 (70)
In-home services	40 (44)	15 (16)	47 (52)
Phone/text	63 (69)	74 (81)	70 (77)
Email	53 (58)	69 (76)	59 (65)

Abbreviation: CPNP, Canada Prenatal Nutrition Program.

^a Survey respondents could report one or more options.

Referrals to community-based lactation services

Referrals to community-based lactation services were most often to public health clinics (84%), followed by hospital clinics

(42%), and/or telehealth (42%; [Supplemental Table 4](#)). Referrals were reported more often by urban CPNP sites (96% versus 70%) and sites that did not offer CAPC (94% versus 83%; Table 2).

Among CPNP sites that reported providing referrals to community-based lactation services, referrals decreased during the COVID-19 pandemic (86% to 74%), but were anticipated to return to pre-pandemic

TABLE 4
Number of sites delivering different lactation supports overall and across the three time periods of interest relative to the COVID-19 pandemic (N = 91)

Type of lactation support ^a	All sites in past 5 years n (%)	Time period of interest n (%)			% change		
		Pre-pandemic (before March 2020)	Pandemic (March 2020–time of survey)	Post-pandemic (upcoming 2024 fiscal year)	Pre-pandemic to pandemic	Pandemic to post-pandemic	Pre-pandemic to post-pandemic
Educational materials	86 (95)	85 (93)	85 (93)	86 (95)	0%	+1%	+1%
Live education sessions	63 (69)	59 (65)	43 (47)	63 (69)	−18%***	+22%***	+4%
Referrals to community-based lactation service	81 (89)	78 (86)	67 (74)	81 (89)	−12%*	+15%***	+3%
Board-certified lactation professional (IBCLC)	31 (34)	30 (33)	25 (27)	29 (32)	−6%	+5%	−1%
Other community-based lactation support provider	70 (77)	64 (70)	58 (64)	65 (71)	−6%	+7%	+1%
Breastfeeding peer support programming	46 (51)	46 (51)	35 (38)	45 (49)	−13%***	+11%**	−2%
Breast pump	62 (68)	58 (64)	53 (58)	59 (65)	−6%	+7%	+1%

Abbreviation: IBCLC, International Board-Certified Lactation Consultant.

^a Values are n (%).

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

levels (Table 4). This reduction occurred in urban sites (93% to 76%), but not rural sites ([Supplemental Table 5](#)), due to a notable decrease in referrals to public health clinics during the pandemic in urban settings (84% to 50%; [Supplemental Table 6](#)). Referrals decreased whether a site had CAPC or not ([Supplemental Table 7](#)). Referrals remained unchanged at sites with a breastfeeding clinic or primary healthcare facility, but decreased by 16% and 15%, respectively, at sites without them ([Supplemental Tables 8 and 9](#)).

Offering personalized lactation support

Among sites that offered personalized lactation support from IBCLCs, another community-based provider (public health nurse, dietitian, midwife, doula, elder), and/or peers, this was typically available to all registered CPNP participants (reported by > 70% of survey respondents), although some CPNP sites reported offering these services upon request (~20%; [Supplemental Table 10](#)). IBCLC support was more often offered in urban sites (38% versus 22%), and more common among lead agencies with a breastfeeding clinic (43% versus 31%) or primary healthcare facility (47% versus 31%; Table 2). Among sites that reported offering lactation support from another community-based provider, more were also urban-based (81% versus 65%; Table 2). Most respondents (75%) reported that community-based lactation support providers had some formal training ([Supplemental Table 10](#)). Sites that received CAPC funds were less likely to offer IBCLCs (29% versus 38%) or support from another community-based provider (66% versus 86%), but more likely to provide peer support programming (56% versus 46%; Table 2). Among sites that offered breastfeeding peer support programming, this was usually led by a CPNP staff member (> 80%) and could be in a group or one-on-one ([Supplemental Table 10](#)).

During the COVID-19 pandemic, fewer survey respondents reported being able to offer personalized lactation support compared to pre-pandemic, although coverage was expected to return to pre-pandemic levels (Table 4). Among CPNP sites that continued to offer personalized lactation support, providing support virtually increased ([Supplemental Table 10](#)). More virtual service integration was planned post-pandemic relative to pre-pandemic, although not to the same extent as during the pandemic. For breastfeeding peer support, there was

also a loss of group sessions during the pandemic.

Among CPNP sites that provided personalized lactation support, there was a decrease in public health nurse and/or community member engagement reported during the pandemic ([Supplemental Table 10](#)). IBCLC access was the least offered lactation support overall, and among sites that reported offering IBCLCs, this continued more often during the pandemic at sites with CAPC or a breastfeeding clinic ([Supplemental Tables 6 and 8](#)). However, among sites that offered support from another community-based lactation support provider during the pandemic, this was less often offered at sites with CAPC, a breastfeeding clinic, or primary healthcare facility compared to pre-pandemic ([Supplemental Tables 7, 8 and 9](#)). Alternatively, among sites offering peer support programming, those with CAPC, a breastfeeding clinic, or a primary healthcare facility more often continued providing peer support programming during the pandemic ([Supplemental Tables 7, 8 and 9](#)).

Breast pumps

Among CPNP sites offering breast pumps, electric or manual models were most common, with 53% reporting that all registered CPNP participants could access pumps and 48% reporting that pumps were available upon request ([Supplemental Table 11](#)). Pumps were usually donated (53%) or loaned (43%) to CPNP participants, and most sites (81%) provided user guidance. Pumps were more often provided by rural sites (78% versus 65%) and lead agencies with a breastfeeding clinic (76% versus 66%), and less often provided by sites with CAPC funding (63% versus 72%) or an on-site primary healthcare facility (59% versus 70%; Table 2).

Among CPNP sites offering breast pumps, access decreased slightly during the COVID-19 pandemic (pre-pandemic: 64%, during pandemic: 58%; Table 4). This decrease was observed among urban sites, sites without CAPC, and sites with a breastfeeding clinic ([Supplemental Table 5, 7, and 8](#)). Similar to other lactation support modalities, there was an increase in virtual guidance on how to use a pump ([Supplemental Table 11](#)).

Funding of lactation supports

To provide lactation supports, most survey respondents reported requiring resources

beyond CPNP core funds (Table 5). While more non-CPNP funding was required to offer IBCLCs, another community-based provider, or breast pumps, more CPNP sites reported funding breastfeeding peer support programming using CPNP funds only. Urban sites more often reported using funds outside of CPNP core funds for all supports except education ([Supplemental Table 12](#)). Compared to sites with CAPC, sites without CAPC more often reported using non-CPNP funds only to offer live education sessions, IBCLCs, another lactation support provider, or breast pumps ([Supplemental Table 12](#)). Sites that offered a breastfeeding clinic more often reported using non-CPNP funds to offer these four types of lactation support.

Additional desired lactation support

Eighty-three CPNP sites (91%) responded to optional questions about additional desired lactation supports. If sustainable funds were available, 81% wanted to offer additional lactation supports, including skilled lactation support (indicated by 54%; e.g. specialized lactation or IBCLC training for staff, improved accessibility to existing supports) and support for breast-milk expression (indicated by 42%; e.g. breast pumps and hand expression kits), lactation education for staff (14%), other lactation supplies (12%; e.g. breast pads, nipple cream, milk storage bags), lactation education for CPNP participants (11%; e.g. guest speakers, teaching tools, community elders), and peer support programming (8%).

Discussion

Promoting and supporting lactation is a stated goal of CPNP programming. Offered in both official languages, this survey is the first to document what and how lactation supports are implemented within CPNP programming. While lactation educational materials and community referrals were offered universally, providing lactation supports that required additional human resource capacity or additional materials varied. With the onset of the COVID-19 pandemic, sites continued to deliver lactation supports; however, they faced challenges in adapting service provision (e.g. shift to virtual programming, loss of personalized lactation support, loss of public health support). To provide lactation supports to CPNP participants, most sites relied heavily on resources beyond CPNP core funds.

TABLE 5
Sources of funding reported by survey respondents to be able to provide lactation supports within their CPNP programming^a

Source of funding	Educational materials	Live education sessions	Board-certified lactation professional (IBCLC)	Other lactation support provider	Breastfeeding peer support programming	Breast pumps
CPNP funds only ^b	28%	28%	23%	17%	43%	37%
CPNP and other funds ^{b,c}	50%	46%	19%	32%	38%	24%
Other funds ^c only	22%	26%	58%	51%	18%	39%

Abbreviations: CPNP, Canada Prenatal Nutrition Program; IBCLC, International Board-Certified Lactation Consultant; PHAC, Public Health Agency of Canada.

^a All %s are averages, calculated from the data across the three reference periods.

^b CPNP funds refers to the core funds provided by PHAC to agencies to implement CPNP programming.

^c Other funds included any funding from a lead agency's own funds, in-kind donations, other government funds and/or charitable funds to be able to provide a type of lactation support offered within CPNP programming.

The variation in lactation supports and delivery methods across CPNP sites reflects the intended flexibility of the CPNP delivery model. This allows for programming adaptation to reflect community preferences and best meet participants' needs, in contrast with other countries' more structured, entitlement-based programming, such as Women, Infants, and Children (WIC) in the United States.^{13,20} Within WIC, increasing the number of lactation supports available has been associated with increased breastfeeding likelihood.²¹ However, access to lactation supports and supplies could differ by CPNP site characteristics: urban sites offered more types of lactation supports than rural; sites within a lead agency with an on-site breastfeeding clinic or primary healthcare facility more often offered support from an IBCLC; and sites that received both CPNP and CAPC funding continued to provide multiple types of lactation support (live educational sessions, breastfeeding peer support programming, trained lactation support, and breast pumps) during the pandemic more often than those without CAPC, potentially because CAPC funds could be leveraged to offer protective benefits. Collectively, this demonstrates that without adequate, designated core resources, there is precarity in lactation support availability for CPNP participants. This leads to disparities between CPNP sites.

CPNP sites were resilient during the COVID-19 pandemic. CPNP programming was affected by the pandemic and resulting public health restrictions, including changes in social interactions, disruptions to service delivery, and public health redeployment. Despite restrictions and

shutdowns to core public services and healthcare, CPNP sites adapted (e.g. virtual program integration) and continued to offer perinatal services. There was a noted drop in public health-led lactation supports, particularly affecting urban CPNP sites. However, lactation support delivery continued at most sites, often with CPNP personnel assuming the additional workload where possible. The needs and challenges CPNP participants face had become increasingly complex before the pandemic, and the pandemic amplified these challenges.^{13,14} For example, Canadian mothers of young children, especially those socially and/or economically vulnerable, increased their use of mental health services during the pandemic, indicating heightened exposure to stressors.²² The increase in workload and complexity of factors experienced by CPNP participants created additional stress on personnel implementing the already constrained CPNP model.^{13,23}

Regardless of the lactation support considered, most survey respondents reported that resources beyond CPNP core funds were required to offer services. Furthermore, accessing more personalized lactation supports (e.g. IBCLC, another community-based lactation support provider) was largely financed using non-CPNP funds. Although the CPNP is meant to build on community-based partnerships, no increase in core funds since the 1990s presents a clear challenge in service level continuity. Compared to the 1990s, CPNP sites are estimated to have 33% less purchasing power in 2019, after adjusting for inflation.¹³ Service provision has continued without increased financial support, suggesting additional costs are shouldered by

the lead agencies implementing CPNP programming. This highlights the strain on the current CPNP service delivery model. Providing CPNP-based lactation supports is considered a programmatic strength, and CPNP participants widely report increased breastfeeding knowledge and skills because of programming.¹³ Evidence from Ontario indicates that increasing exclusive breastfeeding would yield substantial short- and long-term healthcare and economic benefits,²⁴ which supports scale-up of existing evidence-based interventions.²⁵ Our research with one CPNP site offering enhanced lactation support through external funding showed high value and uptake of this service, and high breastfeeding rates.^{26,27} Strengthening CPNP funding could bolster program capacity to improve breastfeeding, thereby advancing maternal and child health and contributing to healthcare and economic gains.⁴

With sustainable funding, expanding access to skilled lactation providers was identified as a desired way to strengthen CPNP lactation supports. This included supporting CPNP personnel to receive formal lactation training. This highlights the importance of lactation support within the CPNP and aligns with global recommendations for universal access to skilled, personalized lactation support.²⁸ However, IBCLCs were the least provided lactation support, and, along with other skilled providers, depended heavily on non-CPNP funding and were less available at rural sites.

Strengths and limitations

This study was strengthened by CPNP site participation across all invited Canadian

provinces and territories, and the availability of the survey in both national languages. Advisory Group guidance was a strength of the study, although it was based on an open call and sites with greater capacity or institutional support may have been over-represented. Participating sites' general characteristics reflected those of CPNP sites in Canada (e.g. proportion urban/rural, receive CAPC funding, Indigenous-led), although the response rate may limit generalizability and subgroup analyses were exploratory due to power limitations.¹³ Data were not collected on survey non-respondents, including why the survey was not completed; sites with fewer resources (e.g. time, capacity, Internet access) may not have participated. Despite aligning survey questions with PHAC documentation wherever possible, findings should be interpreted in the context of potential recall bias and self-reported data.

Conclusion

This national survey found that lactation education and community referrals were commonly offered at CPNP sites, but that availability of other lactation supports requiring more resources and/or non-CPNP funds varied. This led to inequities between CPNP sites. These findings suggest a need for PHAC to identify and support a core package of lactation supports that should be universally available across CPNP sites, alongside relevant monitoring and evaluation measures, while maintaining flexibility for local adaptation. Increased and sustained investment in core lactation supports within the CPNP may help reduce inequities in availability across Canada. To contextualize findings on lactation supports, future research should assess the fidelity and nuances of CPNP lactation support programming and examine participants' breastfeeding outcomes and experiences regarding service quality, adequacy, and appropriateness.

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Agency of Canada personnel who shared the survey with CPNP sites.

Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

JABB: Conceptualization, methodology, data curation, formal analysis, project administration, writing—original draft, writing—review and editing.

AM: Conceptualization, methodology, formal analysis, project administration, writing—review and editing.

JF: Conceptualization, methodology, formal analysis, project administration, writing—review and editing.

DWS: Conceptualization, methodology, supervision, writing—review and editing.

DLO: Conceptualization, methodology, supervision, writing—review and editing.

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Original quantitative research

Physical activity among children and youth in Canada living with disabilities

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Abstract

Introduction: Limited evidence exists on physical activity (PA) participation among children and youth living with disabilities (CYLWD) in Canada. CYLWD may experience barriers and inequitable access to PA opportunities that differ by disability type. This study provides national-level estimates for PA participation among CYLWD.

Methods: Using data from the 2019 Canadian Health Survey on Children and Youth (CHSCY), we identified children and youth with various physical, cognitive, and behavioural disabilities using the Washington Group/UNICEF Child Functioning Module. We examined a comprehensive set of PA measures (average minutes of moderate-to-vigorous PA per day; meeting moderate-to-vigorous PA recommendations; organized sport; outdoor PA/play; indoor PA; walking to school) for children aged 5 to 11 years (N = 16 694) and youth aged 12 to 17 years (N = 11 077). We employed linear and logistic regression adjusted for age group and sex to assess disparities in PA between CYLWD and those without.

Results: CYLWD were 26% to 52% less likely to meet PA recommendations and 27% to 64% less likely to participate in organized sport than those without, with the greatest disparities among those with mobility limitations. Outdoor PA/play was less likely among those with physical disabilities and diagnosed with autism, while indoor non-organized PA was less likely among youth with cognitive, behavioural, or mobility-related disabilities, or a neurodevelopmental disorder.

Conclusion: While overall, CYLWD in Canada engage in less PA than those without disability, participation differs by disability type. Improved PA data that are specific to the realities of CYLWD is needed to strengthen the evidence base and inform policy and program development to promote PA.

Keywords: disabled persons, exercise, child, adolescent, Canada, mobility limitation

Introduction

Regular physical activity (PA) has crucial benefits for the growth and development of children and youth, as well as mental and psychosocial health.^{1,2} Physical inactivity is a key modifiable risk factor for chronic disease,^{3,4} and large-scale studies show that PA during childhood tracks into

adulthood.^{5,6} As such, the equitable promotion of PA among all children and youth is an important goal for population health.

The *Canadian 24-Hour Movement Guidelines for Children and Youth (5 to 17 years)* recommend at least 60 minutes of moderate-to-vigorous PA (MVPA) per day, with at

least three days per week of vigorous PA and muscle and bone strengthening activities, and several hours of structured and unstructured light PA per day.⁷ These recommendations are based on studies that excluded individuals with diagnosed medical

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Highlights

- Disparities exist in meeting PA recommendations and organized sport participation among children and youth living with and without disabilities, regardless of disability type.
- Children and youth living with disabilities (except hearing) showed lower adherence to PA recommendations compared to the total population, with disparities ranging from 4.2 to 14.0 percentage points, and achieved an average of 5 to 20 fewer minutes of moderate-to-vigorous physical activity per day.
- Participation in non-organized PA varied by disability type. Children and youth with physical disabilities were more likely to participate in outdoor non-organized PA while youth with cognitive or behavioural disabilities were more likely to participate in indoor non-organized PA.

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conditions,⁸ and preliminary research suggests the recommendations are not perceived to be inclusive or compatible with the experiences of this population.⁹ Although the evidence on the health benefits of at least 60 minutes/day of MVPA for children and youth living with disabilities (CYLWD) is not conclusive;¹⁰ some amount of MVPA is still beneficial,¹¹ and in the absence of disability-specific evidence, this benchmark is believed to be useful to identify disparities in PA.

CYLWD experience barriers and inequitable access to PA opportunities that limit their PA levels.¹²⁻¹⁵ Organized PA and sport are not always adapted to those with disabilities. Large-scale surveys in Europe and the U.S. have suggested that CYLWD are less likely to meet PA recommendations and participate in sports compared to those without disabilities.¹⁶⁻¹⁹ Surveys have also suggested that CYLWD have less access to physical education classes at school globally.¹¹ Few studies have examined population-level disparities in PA among children and youth in Canada, and none in recent years. The 2001–2002 Health Behaviour in School-Age Children study found that children and youth achieved at least 60 minutes of MVPA on a similar number of days per week regardless of disability status.²⁰ The 2006–2007 Canadian National Longitudinal Survey of Children and Youth found that children with selected neurodevelopmental disorders (i.e. epilepsy, cerebral palsy and intellectual and learning disabilities) were less likely to participate in organized sports, but as likely to engage in non-organized PA.²¹

CYLWD may have different experiences and barriers with PA depending on disability type. National-level evidence on PA for CYLWD is needed to develop targeted strategies to promote PA for these subpopulations. The objective of this study is to examine PA participation among CYLWD in Canada, and to assess disparities compared to those without disabilities. Based on previous studies,¹⁶⁻¹⁹ we hypothesize that CYLWD report lower levels of PA than their counterparts.

Methods

Data source

We analyzed data from the 2019 Canadian Health Survey on Children and Youth (CHSCY), a national cross-sectional survey

administered by Statistics Canada. The CHSCY collects health-related information among children and youth aged 1 to 17 years. Its sampling frame consists of beneficiaries of the Canada Child Benefit (CCB) and excludes those living on First Nation reserves and other Aboriginal settlements, or in foster homes and institutions. The CCB covers 98% of the Canadian population aged 1 to 17 in all provinces and 96% in all territories.

Data were collected by electronic questionnaire or telephone interview between February 2019 to August 2019. Questionnaires for children ages 1 to 11 were administered to the person-most-knowledgeable (PMK; most often a parent), whereas questionnaires for youth ages 12 to 17 were administered to the PMK or youth depending on the module. This study focusses on children aged 5 to 11 years and youth aged 12 to 17 years. The CHSCY is conducted under the authority of the *Statistics Act*, and the use of these data for research purposes does not require research ethics board review.

Response rates for the 2019 CHSCY were 57.8% among children and 41.3% among youth.²² In total, the PMK of 16 694 children and 11 077 youth agreed to share their responses with the Public Health Agency of Canada (82.4% shared rate). These Share data files, which include survey weights adjusted specifically for the Share file, contain responses from all participants who consented to have their data shared with CHSCY's designated partners. Data were accessed through the Public Health Agency of Canada secure network that ensures data are protected in accordance with data privacy and data security requirements.

We employed pairwise deletion, where respondents with missing data for a specific disability or PA measure were only excluded from analyses involving those specific measures. The number of respondents with missing data ranged from 6 to 416 for disability measures, and from 156 to 1953 for PA measures. Data on indoor PA (youth-only) had 23 missing responses.

Disability measures

Washington Group/UNICEF Child Functioning Module

The Washington Group/UNICEF Child Functioning Module (WG/UNICEF-CFM) is a validated, PMK-reported module that

assesses difficulties in functional domains as measures of disability.²³⁻²⁵ For ages 5 to 17 years, these domains include vision, hearing, walking, communication/comprehension, behaviour, learning, self-care, remembering, concentrating, and coping with change, relationships, and emotions.²³ Following a Likert response scale, the module allows for identification of those with mild, moderate, or severe levels of disability,^{24,25} and those requiring assistive devices.²⁶

PMKs reported whether their child had “no difficulty,” “some difficulty,” “a lot of difficulty,” or “cannot do at all” for tasks within each domain. To increase statistical power and the ability to detect PA disparities among CYLWD, domains were grouped as: (1) physical disabilities; (2) cognitive disabilities; or (3) behavioural disabilities.²⁵ Emotional functional difficulties (i.e. anxiety and depression) were outside the study scope. Some individuals reported difficulties across multiple domains and are represented across more than one functional limitation or disability group.

Physical disabilities

Walking, seeing, hearing, and self-care were considered physical domains. Those with “some difficulty,” “a lot of difficulty,” or “cannot do at all” were identified as having a functional difficulty, as any physical limitation may greatly impact PA. Given the differences in experiences across these domains, they were assessed separately and under an overall measure of “any physical disabilities.”

Cognitive or behavioural disabilities

The validity of the WG/UNICEF-CFM to capture cognitive and behavioural functional difficulties at the population level in Canada was recently assessed.²⁵ Communication/comprehension, learning, remembering, and concentrating were considered cognitive domains, while coping with change, controlling behaviour, and making friends were considered behavioural. Those with “a lot of difficulty” or “cannot do at all” were identified as having a functional difficulty within each domain. Those with “some difficulty” were not considered as having a functional difficulty given the large percentage of participants in this category (~50% of children). Given the overlap between the different cognitive and behavioural functional domains, these were assessed under two overall measures of “any cognitive disabilities” and “any behavioural disabilities.”

Use of assistive devices and assistance

PMKs reported whether their child used a walking aid or received assistance for walking. Although PMKs also reported on the use of glasses or contact lenses and hearing aids, these were outside the study scope.

Neurodevelopmental disorders

PMKs were asked whether their child had been diagnosed with a learning disability or disorder, attention-deficit/hyperactivity disorder (ADD/ADHD), autism (also known as autism spectrum disorder), and fetal alcohol spectrum disorder (FASD). These reported diagnoses were assessed separately and grouped together.

Physical activity measures

Moderate-to-vigorous physical activity (MVPA)

Average minutes of MVPA per day

Youth self-reported, and PMKs reported for their child, the total time they participated in any PA that made them sweat at least a little or breathe harder in each day over the past 7 days, excluding during school for children. Total minutes of MVPA were divided by 7 to obtain the average minutes of MVPA per day.

Meeting PA recommendations

Individuals were identified as “meeting PA recommendations” if they averaged at least 60 minutes of MVPA per day.

Organized sport participation

Youth self-reported and PMKs reported for their child, the time spent participating in sports or PA with a coach or instructor in the past 7 days, excluding during school for children. Individuals were identified as “participating in organized sports” if they spent any amount of time participating in organized sports or PA in the past 7 days.

Outdoor non-organized physical activity/play

PMKs reported the time their child spent playing outside in the past 7 days in their free time, while youth self-reported the time they spent participating in outdoor physical activities in their free time, excluding organized activities. Response options were “less than 1 hour,” “1 hour to less than 3 hours,” “3 hours to less than 7 hours,” “7 hours to less than 14 hours,” and “14 hours or more.” Individuals were identified as “participating in outdoor

non-organized PA” if they spent at least 3 hours participating in outdoor play/PA in the past 7 days. This threshold is in line with published indicators of outdoor active play.^{27,28}

Indoor non-organized physical activity

Youth self-reported the time they spent participating in indoor physical activities in their free time (e.g. playing at an indoor play centre, working out at home or in a gym) in the past 7 days. Data were not collected for children aged 5 to 11 years. Youth were identified as “participating in indoor non-organized PA” if they spent any amount of time in indoor PA in the past 7 days.

Walking to school

Youth self-reported and PMKs reported whether their child walked to get to school in the past 7 days. Children and youth who did any walking to school were identified as “walking to school.” Although the 2019 CHSCY collected information on the use of cycling and other active ways to get to school, they were not examined due to the low frequency among CYLWD.

Statistical analyses

We calculated descriptive statistics for disability and PA measures overall and stratified by age group (children 5–11 years/youth 12–17 years). We conducted logistic regressions with each binary PA measure as the outcome and each disability type as the exposure, adjusting for age group and sex, to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for the likelihood of meeting each PA measure, comparing those with and without each disability type. We similarly conducted linear regressions for the outcome of average minutes of MVPA per day to estimate adjusted mean differences, comparing those with and without each disability type. We identified significant differences where the 95% CI for an aOR or mean difference excluded the null values of 1.0 and 0 respectively. We conducted subgroup analyses by disability severity by estimating separate aORs for those with “some difficulty” and “a lot of difficulty or cannot do at all” with “no difficulty” as the reference group. All estimates were calculated using survey weights specific to the CHSCY 2019 Share files supplied by Statistics Canada to account for sampling and non-response and generate population-level

estimates. Bootstrap weights supplied by Statistics Canada were applied to calculate 95% CIs accounting for the survey sampling method. Analyses were conducted in SAS Enterprise Guide version 7.1 (SAS Institute Inc., Cary, NC, US).

Results

Table 1 presents the prevalence of disabilities among children and youth in Canada. Physical disabilities were prevalent in 15.8% of children and youth. The most prevalent were difficulties seeing (6.5%) and walking (6.4%), followed by self-care (3.7%) and hearing (2.2%). Difficulties seeing were more prevalent among youth than children, while difficulties walking and with self-care were more prevalent among children. Cognitive disabilities were reported in 4.6% of children and youth, while behavioural disabilities were reported in 7.8% of this population. Cognitive and behavioural disabilities were more prevalent among children than youth. Overall, 14.3% of children and youth were diagnosed with a neurodevelopmental disorder, with a higher prevalence among males and youth. The most prevalent neurodevelopmental disorders were learning disabilities (8.5%) and ADD/ADHD (8.7%).

Descriptive statistics for each PA measure overall and by disability type are presented in Table 2. Descriptive statistics disaggregated by age and sex are available in [Supplementary Tables S1 to S6](#). Within the total population, 31.6% met PA recommendations, averaging 46.8 minutes of MVPA per day. Around half of children and youth in Canada participated in organized sports and PA (54.5%) and achieved at least 3 hours of outdoor PA/play (50.2%) in the past week, while 28.6% used any walking to get to school. Among youth, 53.0% participated in any indoor non-organized PA.

Across all disability types (except hearing), prevalences for meeting PA recommendations were lower than the overall population, with the lowest prevalences among those who used a walking aid or assistance (17.6%) or had difficulty walking (19.4%). Average minutes of MVPA were lowest among those using a walking aid or assistance (28.7 minutes/day) or with difficulty walking (32.2 minutes/day), as well as those with autism (32.8 minutes/day). Sport participation prevalences were lower than the overall population for all disability types, and particularly low

TABLE 1
Percentage of children aged 5 to 11 years and youth aged 12 to 17 years with different types of disabilities in Canada

Type of disability (unweighted sample size) ^b	Percentage (95% CI) ^a								
	Children and youth, both sexes (n = 27 771)	Children and youth, male (n = 14 056)	Children and youth, female (n = 13 715)	Children (n = 16 694)	Youth (n = 11 077)	Male children (n = 8599)	Female children (n = 8095)	Male youth (n = 5457)	Female youth (n = 5620)
Physical disabilities									
Any physical functional difficulty (n = 27 369)	15.8 (15.2, 16.4)	15.6 (14.8, 16.5)	15.9 (15.1, 16.8)	16.2 (15.4, 17.0)	15.3 (14.4, 16.3)	17.8 (16.7, 19.1)	14.4 (13.3, 15.5)	13.0 (11.8, 14.2)	17.8 (16.4, 19.2)
Difficulty walking (n = 27 451)	6.4 (6.0, 6.8)	6.0 (5.5, 6.6)	6.7 (6.2, 7.3)	7.4 (6.9, 8.0)	5.1 (4.5, 5.6)	7.5 (6.8, 8.4)	7.4 (6.6, 8.2)	4.2 (3.5, 4.9)	6.0 (5.2, 6.8)
Difficulty seeing (n = 27 715)	6.5 (6.1, 7.0)	5.6 (5.1, 6.1)	7.5 (6.9, 8.2)	4.7 (4.2, 5.1)	8.8 (8.1, 9.6)	4.3 (3.7, 4.9)	5.0 (4.4, 5.7)	7.1 (6.2, 8.1)	10.6 (9.5, 11.7)
Difficulty hearing (n = 27 726)	2.2 (2.0, 2.5)	2.3 (2.0, 2.7)	2.2 (1.8, 2.5)	2.3 (2.0, 2.7)	2.1 (1.8, 2.5)	2.8 (2.3, 3.3)	1.9 (1.5, 2.3)	1.8 (1.4, 2.2)	2.5 (2.0, 3.1)
Difficulty with self-care (n = 27 643)	3.7 (3.4, 4.0)	5.0 (4.5, 5.5)	2.3 (2.0, 2.7)	5.2 (4.7, 5.8)	1.8 (1.5, 2.2)	7.2 (6.4, 8.1)	3.1 (2.6, 3.7)	2.2 (1.7, 2.8)	1.4 (1.0, 1.9)
Use of walking aid or assistance (n = 27 764)	0.5 (0.3, 0.6)	0.5 (0.3, 0.7) ^E	0.4 (0.3, 0.6) ^E	0.5 (0.4, 0.7) ^E	0.4 (0.2, 0.5) ^E	0.6 (0.4, 1.0) ^E	0.5 (0.3, 0.7) ^E	0.4 (0.2, 0.7) ^E	0.3 (0.2, 0.6) ^E
Cognitive or behavioural disabilities									
Any cognitive disability (n = 27 355)	4.6 (4.2, 4.9)	5.6 (5.1, 6.2)	3.5 (3.1, 4.0)	5.2 (4.7, 5.7)	3.9 (3.4, 4.3)	6.6 (5.8, 7.3)	3.7 (3.1, 4.4)	4.5 (3.8, 5.2)	3.2 (2.6, 3.9)
Any behavioural disability (n = 27 524)	7.8 (7.4, 8.3)	9.8 (9.1, 10.4)	5.8 (5.3, 6.4)	8.5 (7.9, 9.2)	7.0 (6.4, 7.6)	11.6 (10.6, 12.6)	5.3 (4.6, 6.1)	7.6 (6.7, 8.5)	6.4 (5.5, 7.3)
Any of the four neurodevelopmental disorders (n = 27 695)	14.3 (13.7, 14.9)	18.7 (17.8, 19.6)	9.7 (8.9, 10.4)	12.7 (11.9, 13.4)	16.2 (15.3, 17.2)	17.2 (16.1, 18.4)	7.9 (7.0, 8.8)	20.4 (19.1, 21.9)	11.8 (10.6, 13.0)
Learning disability (n = 27 701)	8.5 (8.0, 9.0)	10.6 (10.0, 11.4)	6.2 (5.6, 6.8)	7.1 (6.6, 7.7)	10.1 (9.3, 10.9)	9.1 (8.2, 10.1)	5.1 (4.3, 5.8)	12.5 (11.4, 13.7)	7.6 (6.6, 8.6)
ADD/ADHD (n = 27 762)	8.7 (8.3, 9.2)	12.1 (11.3, 12.9)	5.2 (4.7, 5.9)	7.6 (7.0, 8.2)	10.1 (9.3, 11.0)	10.8 (9.8, 11.8)	4.3 (3.6, 5.0)	13.7 (12.5, 15.0)	6.4 (5.4, 7.5)
Autism (n = 27 765)	2.2 (2.0, 2.5)	3.5 (3.1, 3.9)	0.9 (0.7, 1.2)	2.5 (2.2, 2.9)	1.9 (1.6, 2.3)	3.9 (3.4, 4.6)	1.0 (0.7, 1.4) ^E	3.0 (2.5, 3.6)	0.8 (0.5, 1.2) ^E
FASD (n = 27 762)	0.2 (0.1, 0.3) ^E	0.2 (0.1, 0.3) ^E	0.2 (0.1, 0.3) ^E	0.1 (0.1, 0.3) ^E	0.2 (0.1, 0.4) ^E	^F	^F	0.2 (0.1, 0.5) ^E	^F

Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; FASD, fetal alcohol spectrum disorder.

^a Percentage estimates are weighted using survey weights provided by Statistics Canada.

^b Analytic sample sizes varied across estimates due to pairwise deletion and subgroup-specific missing data.

^E Estimates should be interpreted with caution due to high sampling variability.

^F Estimates are unreportable due to high sampling variability.

among those using a walking aid or assistance (31.2%), and for individuals diagnosed with FASD (30.1%) or autism (32.2%). Outdoor PA prevalences were lowest among individuals with difficulty seeing (37.5%). Indoor PA prevalences were lowest among youth diagnosed with autism (30.9%), who had difficulties with self-care (35.3%), and with cognitive disabilities (35.9%). Prevalences for walking to school were lowest among individuals who had difficulties with self-care (22.8%).

After adjustment for age and sex, the likelihood of meeting PA recommendations was lower among all disability types, except hearing, compared to those without disabilities (Figure 1). Individuals with mobility, seeing, self-care limitations or using walking aids or assistance were 26% to 57% less likely to meet PA recommendations, while individuals with cognitive disabilities, behavioural disabilities and any of the four neurodevelopmental disorders were 24% to 49% less likely to

meet PA recommendations. Average minutes of MVPA per day were lower by 5 to 20 minutes/day among all disability types except hearing after adjustment for age and sex compared to those without disabilities (Figure 2). The largest differences were for those using a walking aid or assistance (19.5 fewer minutes/day), diagnosed with autism (17.6 fewer minutes/day), and experiencing difficulties walking (16.3 fewer minutes/day) or with self-care (13.5 fewer minutes/day).

TABLE 2
Physical activity measures among children and youth in Canada ages 5 to 17 years overall and by disability type

Type of disability (unweighted sample size) ^b	Percentage (95% CI) ^a					Average minutes of MVPA per day (95% CI; n = 22 563) ^a
	Meeting PA recommendations (n = 22 563)	Sport participation (n = 27 615)	Outdoor PA (n = 27 676)	Indoor PA ^c (n = 11 054)	Walking to school (n = 25 818)	
Total population	31.6 (30.8, 32.5)	54.5 (53.7, 55.3)	50.2 (49.5, 51.0)	53.0 (51.7, 54.3)	28.6 (27.8, 29.4)	46.8 (45.9, 47.6)
Physical disabilities						
Any physical functional difficulty (n = 27 369)	24.8 (22.9, 26.7)	44.4 (42.4, 46.5)	44.1 (42.1, 46.1)	47.8 (44.5, 51.1)	28.3 (26.3, 30.3)	39.4 (37.3, 41.4)
Difficulty walking (n = 27 451)	19.4 (16.9, 22.1)	41.3 (38.2, 44.5)	41.3 (38.2, 44.4)	42.6 (37.2, 48.2)	30.7 (27.6, 33.9)	32.2 (29.5, 35.0)
Difficulty seeing (n = 27 715)	24.6 (21.6, 27.8)	45.8 (42.4, 49.2)	37.5 (34.4, 40.7)	50.7 (46.2, 55.1)	28.6 (25.5, 31.9)	40.4 (37.2, 43.7)
Difficulty hearing (n = 27 726)	32.8 (27.7, 38.2)	46.4 (41.3, 51.7)	51.7 (46.6, 56.8)	50.5 (43.0, 58.0)	28.4 (23.7, 33.5)	47.6 (42.2, 53.1)
Difficulty with self-care (n = 27 643)	24.3 (20.4, 28.5)	40.2 (35.9, 44.5)	53.3 (48.9, 57.8)	35.3 (26.5, 44.9) ^E	22.8 (19.1, 26.9)	37.4 (32.6, 42.2)
Use of walking aid or assistance (n = 27 764)	17.6 (9.5, 28.8) ^E	31.2 (19.7, 44.7) ^E	50.8 (37.2, 64.3) ^E	48.2 (28.7, 68.0) ^E	25.4 (15.8, 37.1) ^E	28.7 (20.7, 36.6)
Cognitive or behavioural disabilities						
Any cognitive disability (n = 27 355)	27.1 (23.5, 31.0)	37.1 (33.4, 40.9)	55.7 (51.8, 59.6)	35.7 (29.7, 41.9)	27.4 (24.0, 31.0)	40.3 (36.2, 44.4)
Any behavioural disability (n = 27 524)	27.3 (24.4, 30.3)	39.7 (36.8, 42.7)	51.4 (48.3, 54.4)	42.5 (37.5, 47.6)	27.6 (24.9, 30.4)	40.5 (37.7, 43.3)
Any of the four neurodevelopmental disorders (n = 27 695)	26.6 (24.3, 28.9)	42.5 (40.3, 44.7)	49.2 (47.0, 51.4)	42.4 (39.1, 45.9)	27.2 (25.2, 29.3)	41.2 (38.8, 43.6)
Learning disability (n = 27 701)	25.7 (23.0, 28.5)	42.2 (39.3, 45.1)	50.0 (47.1, 53.0)	41.3 (37.3, 45.3)	26.1 (23.6, 28.7)	40.9 (37.8, 44.1)
ADD/ADHD (n = 27 762)	27.4 (24.4, 30.5)	41.9 (39.0, 44.9)	50.7 (47.6, 53.7)	43.1 (38.7, 47.6)	28.0 (25.3, 30.8)	42.7 (39.3, 46.1)
Autism (n = 27 765)	21.4 (16.8, 26.7)	32.2 (27.4, 37.3)	45.0 (39.6, 50.4)	30.9 (23.1, 39.5)	25.6 (20.7, 31.2)	32.8 (27.5, 38.1)
FASD (n = 27 762)	^F	30.1 (14.1, 50.5) ^E	59.0 (39.2, 77.0) ^E	^F	44.3 (25.3, 64.5) ^E	40.6 (26.2, 54.9) ^E

Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; FASD, fetal alcohol spectrum disorder; MVPA, moderate-to-vigorous physical activity; PA, physical activity.

^a Percentage and average minutes estimates are weighted using survey weights provided by Statistics Canada.

^b Analytic sample sizes varied across estimates due to pairwise deletion and subgroup-specific missing data.

^c Indoor PA was only assessed for youth aged 12 to 17 years.

^E Estimates should be interpreted with caution due to high sampling variability.

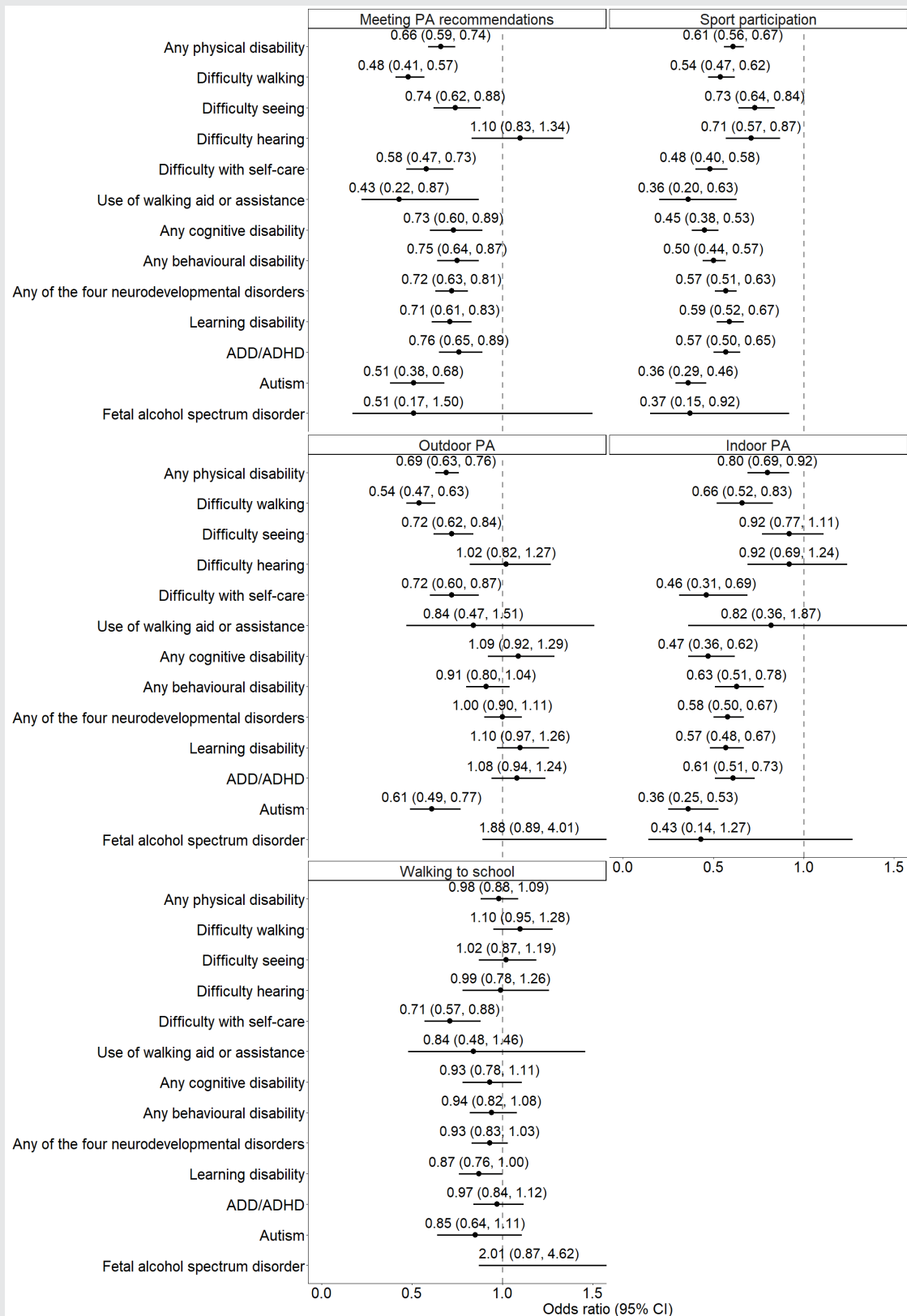
^F Estimates are unreportable due to high sampling variability.

Children and youth with physical disabilities or using walking aids or assistance were 27% to 64% less likely to participate in organized sports, while those with cognitive or behavioural disabilities and any of the four neurodevelopmental disorders were 41% to 63% less likely to participate in organized sports compared to those without these disabilities (Figure 1). Whereas individuals with

physical disabilities or using walking aids or assistance, except for hearing, were 16% to 46% less likely to participate in outdoor PA. Individuals with cognitive as well as behavioural disabilities were as likely to participate in outdoor PA as those without, except for children and youth with autism (39% less likely). Indoor PA was only assessed for youth. Youth with difficulties walking or with self-care were

34% to 54% less likely to participate in indoor PA, while youth with other physical disabilities were as likely to participate in indoor PA as those without. Youth with cognitive or behavioural disabilities, as well as any of the four neurodevelopmental disorders were 37% to 64% less likely to participate in indoor PA. Individuals with self-care difficulties were 29% less likely to use walking to get to school, with

FIGURE 1
Odds ratios for the likelihood of meeting different physical activity measures comparing Canadian children and youth living with and without different types of disability

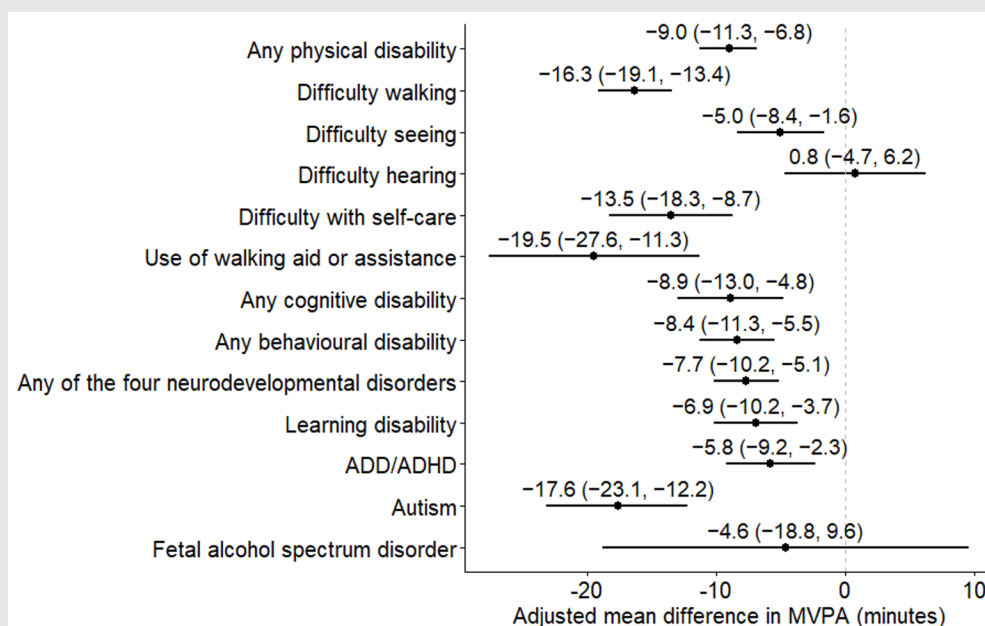


Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; CI, confidence interval; PA, physical activity.

Notes: For each analysis, participants without the disability type of interest were used as the reference group.

Odds ratios are adjusted for age group (children/youth) and sex. Indoor PA analyses are limited to youth due to data availability for children.

FIGURE 2
Mean differences in minutes of moderate-to-vigorous physical activity per day comparing Canadian children and youth living with and without different types of disability



Abbreviations: ADD/ADHD, attention-deficit/hyperactivity disorder; MVPA, moderate-to-vigorous physical activity.

Notes: For each analysis, participants without the disability type of interest were used as the reference group. Mean differences are adjusted for age group (children/youth) and sex.

no significant disparities for other disability types.

Although subgroup analyses were not sufficiently powered to detect differences by functional difficulty severity, there appeared to be gradient effects where children and youth with severe difficulties (“a lot of difficulty or cannot do at all”) were less likely to engage in PA across all measures than those with “some difficulty” (Figure 3). This was most evident for sport participation, where the likelihood of participating in organized sports was significantly lower among individuals with severe walking, self-care, cognitive, and behavioural functional difficulties. The likelihood of indoor PA participation among youth with severe cognitive functional difficulties was also significantly lower than youth with less severe cognitive functional difficulties.

Discussion

CYLWD in Canada achieved less MVPA and were less likely to meet PA recommendations than those without. CYLWD were also markedly less likely to participate in organized sports. Children and youth with physical disabilities were less

likely to participate in outdoor non-organized PA, while youth with cognitive or behavioural disabilities as well as any of the four neurodevelopmental disorders were less likely to participate in indoor non-organized PA. Prevalences of walking to school were similar regardless of disability, with the exception of individuals with self-care difficulties. These findings underscore the importance for greater attention and support to increase PA participation among CYLWD living in Canada.

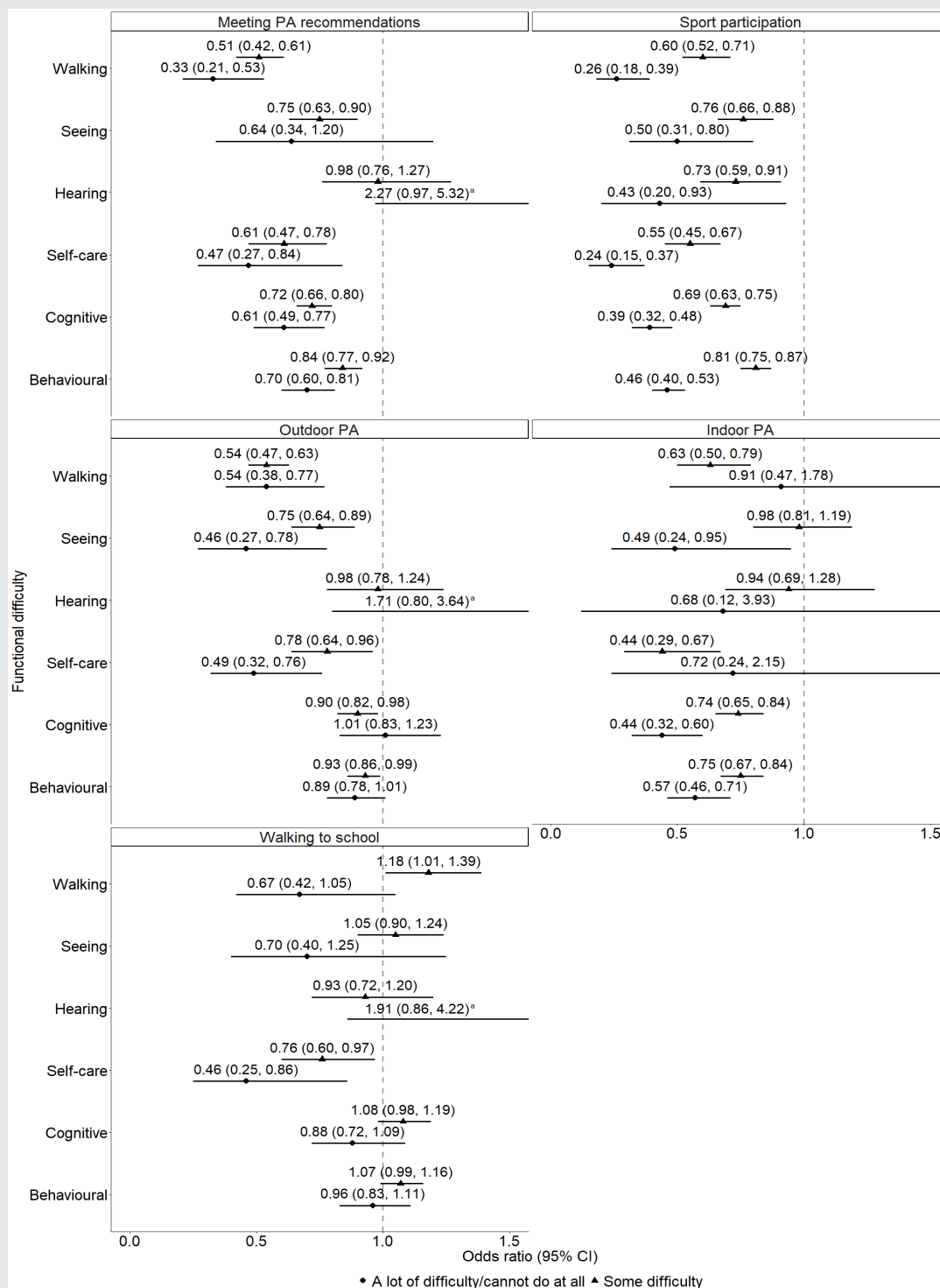
We found that CYLWD in Canada, with the exception of hearing difficulties, were 24% to 57% less likely to meet PA recommendations than those without disabilities. While particularly large disparities exist for those with mobility limitations as well as those diagnosed with autism, others such as those with ADD/ADHD and learning disabilities were less likely to meet PA recommendations. Our findings are in line with literature from other countries indicating lower levels of MVPA among CYLWD,^{11,29-31} but contrast from previous Canadian studies conducted over a decade ago that found similar levels of MVPA for CYLWD.^{20,21}

Similar to the U.S.,¹⁷ there were clear disparities in organized sport participation

for all disability types. Considerable research has been conducted regarding barriers and facilitators to sport participation and other modes of PA for CYLWD,^{14,32-34} and federal and provincial policies exist to promote organized sports in these populations.³⁵ Despite these efforts, more work needs to be done to implement policies and programs to address these disparities within Canada, including ensuring that CYLWD are afforded with quality participation experiences in sport and non-organized PA.³⁶

Children and youth with difficulties walking, seeing, and self-care were less likely to engage in outdoor non-organized PA/play, as well as those diagnosed with autism. Outdoor facilities such as playgrounds and parks have been recognized as having social and physical barriers that may limit opportunities for outdoor play or PA for CYLWD.³⁷⁻⁴⁰ Youth participation in indoor non-organized PA was less likely across all cognitive and behavioural disabilities and any of the four neurodevelopmental disorders, as well as youth with difficulties walking and with self-care, and particularly for those with severe functional difficulties. Accessibility issues and social factors such as stigma and lack of

FIGURE 3
Odds ratios for the likelihood of meeting physical activity measures comparing children and youth in Canada with versus without different types of functional difficulty by severity



Abbreviations: CI, confidence interval; PA, physical activity.

Notes: For each analysis, participants without the disability type of interest were used as the reference group.

Odds ratios are adjusted for age group (children/youth) and sex. Indoor PA analyses are limited to youth due to data availability for children.

^a Data point out of range.

peer support have been noted as barriers to gyms and fitness centres among adults with physical disabilities,^{41,42} and similar barriers likely exist for youth. Similarly, feelings of shame regarding physical capabilities have been reported as barriers for going to the gym for youth with intellectual disabilities.⁴³ Altogether, these findings suggest that individuals with different disabilities experience different barriers and preferences regarding non-organized PA in outdoor versus indoor settings.

Walking to school was less likely among children and youth with self-care difficulties, and among those with severe difficulties walking and seeing (with uncertainty). Our data source did not include information on wheelchair use as a mode of active transportation. Nonetheless, walking and wheeling in a wheelchair has been described in the literature as an approach to increase PA among people living with disabilities.⁴⁴ There is limited evidence on the use of active transportation to school and its barriers and facilitators among CYLWD, and a systematic review pointed to diverse experiences of children living with different disabilities.⁴⁵ While walking to school may be a practical way through which CYLWD can obtain PA, there may be barriers to non-active modes of transportation to school (e.g. public transit) that result in increased active transportation.⁴⁶

Strengths and limitations

This study is the first to our knowledge to examine PA levels among CYLWD in Canada and to identify disparities compared to those without disabilities using national-level data. We examined a comprehensive set of PA measures across an array of disability measures, encompassing physical, cognitive, behavioural disabilities and selected neurodevelopmental disorders. Our findings fill a gap in reporting on PA among CYLWD in Canada.

Nevertheless, this study has several limitations. PA measures were self-reported for youth and PMK-reported for children, which may be subject to recall bias and may not correlate well with objective measures.⁴⁷ The use of PMK-reported PA for children may have also resulted in an inaccurate representation of children's PA levels, and our measures excluded PA during school time. The survey response rates were low, further affected by the share rates. While the survey sampling weights provided by Statistics Canada were used

in our analyses to account for sampling as well as non-response and share rates, sample and non-response bias could still have affected the representativeness of the results.

Our sample size was insufficient to examine how PA participation varied by age, sex, or other sociodemographic characteristics. Similarly, we could not draw definitive conclusions about differences in PA by severity levels due to insufficient statistical power. We pooled the study sample for regression analyses rather than stratifying by age group to increase power. Children and youth may experience differences in PA patterns, social support, and PA opportunities and barriers across these groups, and the use of a pooled analysis limits our ability to assess differences between age groups.

We used dichotomized measures to assess sport participation, outdoor and indoor non-organized PA, and walking to school. There are no established thresholds for these measures, and examining them as continuous (i.e. amount of time spent in each type of PA) could provide further insight into PA disparities between CYLWD and without. Additionally, the data used in this study were collected prior to the COVID-19 pandemic. Given the potential impact of the pandemic on PA participation,⁴⁸ future research using newly available data is important to investigate whether disparities in PA have shifted.

In general, greater efforts to collect data on PA specific to CYLWD are needed to strengthen the evidence base and inform policy development.¹¹ Given the heterogeneity of the disabilities examined, further research is warranted to investigate in more depth the potential barriers to PA associated with each disability type.

Conclusion

CYLWD in Canada achieved less MVPA and were less likely to meet PA recommendations and participate in organized sports than those without disability. Participation in outdoor and indoor non-organized PA was also less likely for certain disability types. Efforts to improve and expand population-level data collected on PA among CYLWD would better inform the development of targeted policies and programs to promote PA within these subpopulations.

Conflicts of interest

The authors declare no conflicts of interest.

Authors' contributions and statement

KCR, MTB and CW conceptualized the study. CW and MTB designed the study and analytical approach and conducted the statistical analyses. CW, MTB and KCR interpreted the results. CW and MTB drafted the initial manuscript. All authors (CW, MTB, KCR, KMG, KAN) contributed to reviewing and editing the manuscript.

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

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Original quantitative research

Risk and protective factors of solitary cannabis use among Canadian secondary school students: findings from the COMPASS study

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Abstract

Introduction: Solitary cannabis use has become increasingly prevalent among youth in Canada and is linked to both mental and behavioural concerns. This study seeks to fill current gaps in the literature by examining the factors associated with solitary cannabis use to understand the complexities of specific contexts in which use occurs and improve prevention efforts targeted towards behaviours that are associated with greater health impacts and riskier behaviours.

Methods: This study examined solitary cannabis use among a cross-sectional sample ($n = 2899$) of Canadian youth (11–18 years) who reported past 30-day cannabis use and participated in the COMPASS study in 2020–21. Using a stepwise approach, generalized linear mixed models were run to examine risk and protective factors associated with solitary use. A Bayesian imputation framework was used to address missing data.

Results: Sixty-six percent of students reported having used cannabis alone in the past 30 days. All substance use variables examined were strongly associated with solitary use. A preliminary interaction between school connectedness and flourishing was observed, suggesting school connectedness may offer modest protection against solitary cannabis use and vary across flourishing scores.

Conclusion: Solitary cannabis use is common among Canadian youth and is associated with several other risk factors examined. These findings suggest that comprehensive prevention strategies that promote both flourishing and equitable school environments may be relevant to reduce solitary cannabis use and its associated risks. Future research should explore how behaviours may cluster with solitary use and employ longitudinal designs to understand how behaviours change over time.

Keywords: *cannabis, substance use, youth, mental health, school health services*

Introduction

Cannabis use among Canadian youth is widespread and has become increasingly normalized since the federal legalization of cannabis (the *Cannabis Act*) in 2018.¹ Adolescents are uniquely vulnerable to cannabis-related harms, and such behaviours,

including frequent use, early initiation, poly-use, and consumption context, have been linked to greater risks of problematic substance use, dependency, and negative psychosocial outcomes.^{2,3} One risk behaviour that has become increasingly prevalent among North American youth is solitary cannabis use (i.e. using cannabis

alone rather than in a social context).^{4,5} In Canada, it has been estimated that over one-third of youth who have used cannabis in the past year use alone.⁶ Solitary cannabis use (SCU) may pose its own risks due to fewer social precautions or be an important proxy for evaluating related risk. Reflecting on Cooper's motivational model of substance use, non-social use is often internally driven and coping-motivated,⁷ aligning with problematic use patterns and maladaptive regulation. Beyond coping motives, solitary substance

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Highlights

- Solitary cannabis use is prevalent among Canadian youth who use cannabis.
- Additional research on solitary cannabis use among youth is needed.
- The majority of those who report current cannabis use report frequent solitary use.
- Solitary use is strongly associated with other substance use and risky behaviours.
- School connectedness may vary in its protective effect by flourishing level.

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use has also been linked to poorer mental health, other risky substance use indicators, and sustained substance use problems into adulthood.⁸⁻¹⁶ Recent literature examining cannabis use disorder risk among young adults in Canada found that participants at high-risk for cannabis use disorder had particularly elevated SCU prevalence rates compared to low-risk participants.¹⁷ While various risks and long-term health outcomes have been identified, research on youth SCU remains extremely limited.

Social factors have a central role in influencing adolescent cannabis use and function across various levels of influence. A systematic review examining the multi-level influences of cannabis demonstrates that peer disapproval and parental monitoring emerged as strong protective factors, while peer norms and parental acceptance of use were associated with increased risk of cannabis use; similarly, school connectedness served as a protective factor.¹⁸ However, COVID-19-related restrictions in 2020–2021, specifically school closures, altered how youth interacted with their home and school environments. Notably, social and environmental supports that youth typically rely on, including friends, teachers, and school programs, were disrupted, resulting in increased internalizing symptoms and substance use reported by youth.¹⁹ As cannabis is typically consumed in social settings or at school,¹ using alone deviates from more typical or experimental patterns seen in adolescence, representing a fundamentally different behavioural pattern. The extent to which these social influences similarly shape non-social use remains poorly understood. Therefore, characterizing SCU is critical to informing future research and surveillance initiatives, as well as targeted approaches to mitigate related risks, especially for vulnerable populations such as youth.

Since the enactment of the *Cannabis Act*, Canadian youth have reported increased normalization of cannabis, greater access, and reduced risk perceptions.^{1,20} Further, COVID-19-related restrictions introduced additional contextual and social changes that may have influenced youth substance use behaviours. While research indicates the prevalence of cannabis use remained stable during COVID-19,²¹ youth more commonly reported using cannabis to

cope and manage their mental health,^{22,23} suggesting that self-isolation may have had an impact on how and why youth consume cannabis. The COMPASS study (COMPASS)²⁴ is a prospective cohort study (2012–2027) that collects longitudinal health behaviour data from Canadian secondary school students, and was designed to evaluate ongoing real-world changes in programs, policies, and resources for schools, communities, and provinces. Using cross-sectional data from COMPASS, this study examined SCU and associated risk and protective factors among a large sample of Canadian secondary school students during the COVID-19-related school closures. Specifically, the objectives were to 1) estimate the prevalence of SCU among participating youth who reported cannabis use in the prior 30 days; and 2) examine the demographic, psychological, behavioural, and social support correlates of SCU.

Methods

Study design

COMPASS collects data annually from a rolling cohort of students attending a convenience sample of secondary schools in Alberta, British Columbia, Ontario, and Quebec, Canada. Ethical approval was obtained from the University of Waterloo Human Research Ethics Committee (ORE#30118), Brock University Research Ethics Committee (REB#23-087), CIUSSS de la Capitale-Nationale–Université Laval (#MP-13-2017-1264), University of Alberta Research Ethics Office (Project #00040729), University of British Columbia (H17-00167), and participating school boards. This study utilized cross-sectional student data from the 2020–21 wave of COMPASS (2020–21 host sample: $n = 45\,329$).²⁴ Student questionnaires were administered online with an initial survey link and one reminder emailed by school administrators. All students were invited to participate using active-information passive-consent parental permission protocols²⁵ and could decline or withdraw at any time (student response rate: 58%).

Study sample

Secondary school students (11–18 years) reporting past-month cannabis use during the 2020–21 school year were included. This subsampling is necessary as SCU was assessed based on past 30-day cannabis

use ($N = 3153$). Students with undefined data were removed, including those unsure about solitary cannabis use ($N = 159$), those who declined to report their gender ($N = 64$), and Quebec students who were in non-traditional academic streams ($N = 48$). The final analytical sample size was 2899 students.

Study measures

Dependent variable

To measure SCU, students were asked: “In the last 30 days, how many times have you: Used marijuana or cannabis when you were all by yourself?” with response options of “never,” “once,” “twice,” “three or more times,” and “I don’t know.” Given the low proportion of students who used solitary “once” or “twice,” a binary measure of SCU was used based on students reporting having used alone at least once in the past 30 days (yes = 1) or “never” (no = 0). Students reporting “I don’t know” were removed from the analytical sample ($n = 159$).

Independent variables

Independent variables were examined for their association with SCU. Variables were selected based on existing literature examining youth cannabis use^{6,18,26-29} and organized hierarchically based on multi-level behavioural frameworks.³⁰

Sociodemographic characteristics

Sociodemographic characteristics included in the analyses are as follows: gender (“female,” “male,” “I describe my gender in a different way,” or “I prefer not to say”), grade (9,10,11,12, and “Secondary I–V” and “other” [for schools in Quebec only; Secondary I and II are equivalents to Ontario Grades 7 and 8, “other” represents students who fall within a class with no official grade equivalent]), and, race (White, Black, Asian, First Nations (status and non-status), Métis, Inuit, Latin American or Hispanic, and/or “other”), and perceived family affluence compared to their peers (“more comfortable,” “as comfortable,” and “less comfortable”) as a proxy for socioeconomic status (SES).

Within the analytical models, province was excluded due to being highly correlated with grade (e.g. Secondary I–II is unique to Quebec) and students who described their gender “in a different way” were excluded due to small cell counts. Race was recoded into racialized

(e.g. Black, Asian, Indigenous, Latin American, other) vs. non-racialized (White).

Psychological characteristics

Depressive symptoms were assessed using the Centre for Epidemiologic Studies Depression Scale (Revised)-10 (CESD-R10;³¹). Students responded to questions about depressive symptoms such as feelings of sadness, loss of interest, and difficulties sleeping over the past week.³¹⁻³³ Anxiety symptoms were measured using the Generalized Anxiety Disorder 7-item Scale (GAD-7;³⁴). Students responded to questions about having symptoms of anxiety such as feelings of worry, fear, and irritability over the past 2-week period. Scores for CESD-R-10 and GAD-7 ranged from 0 to 30 and 0 to 21, respectively, where higher sum scores indicated greater frequency of symptoms. Consistent with other research, this study used scores greater than or equal to 10 for both depression³³ and anxiety³⁴ scales to indicate clinically relevant symptoms. Shortened versions of the depression³³ and anxiety³⁴ scales have been validated against the original scales for use in adolescent populations. Internal consistency of the CESD-R-10 ($\alpha = 0.99$) and GAD-7 ($\alpha = 0.98$) scales were high.

Student psychosocial well-being was assessed using Diener's Flourishing Scale.^{35,36} Students were asked to report on their perceived successes in various areas of psychosocial well-being. The revised and validated³⁷ five-point response scale from strongly disagree to strongly agree was used to rate perceived psychosocial strengths and resources for support, with higher sum scores (range: 8–40) indicating greater flourishing.³⁶ Internal consistency of the Flourishing Scale was high ($\alpha = 0.98$).

Emotional dysfunction was assessed using a shortened version of the Difficulties in Emotion Regulation Scale (DERS).³⁸ Students were asked to report on their perceived emotional regulation on six items, including one item from each subscale: nonacceptance of difficult emotions, difficulties engaging in goal-directed behaviours, impulse control difficulties, emotional awareness, access to emotion regulation strategies, and emotional clarity. A five-point Likert scale from strongly disagree to strongly agree was used to rate perceived emotional dysregulation with

higher sum scores (range: 6–30) indicating greater emotional dysfunction.³⁷ Internal consistency of the DERS was high ($\alpha = 0.99$).

Substance use characteristics

To measure cannabis use frequency, students were asked: "In the last 12 months, how often did you use marijuana or cannabis? (a joint, pot, weed, hash)." Response options appropriate for this study included: "once a month," "2 or 3 times a week," "4 to 6 times a week," and "every day." The frequency of use among students who report current cannabis use was assessed as "monthly," "weekly," and "daily" use.

To measure increases in cannabis use during COVID-19, students were asked: "How has your life changed because of COVID-19? My cannabis use has..." where the response options included: "increased," "stayed the same/not applicable," and "decreased." Increased cannabis use due to COVID-19 was assessed as a binary measure [increased = 1, not increased = 0].

To measure mode of cannabis use, students were asked: "If you have used marijuana or cannabis in the last 12 months, how did you use it?" Response options included: "I have used it by smoking it," "I have used it by vaping it," and "I have used it by eating or drinking it." Students were asked to select all that applied. All three modes of use were examined as separate binary variables (i.e. mode of use [smoking, vaping, eating [yes = 1, no = 0]).

To measure binge drinking, students were asked to answer: "In the last 12 months, how often did you have 5 drinks of alcohol or more on one occasion?" Response options ranged from "never" to "daily or almost daily." Student responses were assessed as a binary measure based on past-30-day binge drinking [yes = 1, no = 0].

To measure solitary alcohol use, students were asked: "In the last 30 days, how many times have you: Drank alcohol when you were all by yourself?" with response options of "never, once, twice, three or more times, and I don't know." Student responses were coded as a binary measure based on past-30-day solitary alcohol use [yes = 1, or no = 0] and "I don't know" was categorized with missing data.

Driving under the influence (of alcohol and/or cannabis) was assessed with two questions about riding in a vehicle in the past 30 days with a driver (self or others) who had used alcohol or cannabis. Responses ("never" to "three or more times" or "I don't know") were coded as: 1 = yes to either substance, 0 = no to both, and 2 = mixed/uncertain responses (including "I don't know").

Social characteristics

A six-item version of the National Longitudinal Study of Adolescent Health School Connectedness Scale was used to assess student-perceived school connectedness.^{39,40} Students were asked to report their perceived connection to school (e.g. feeling close to people at school, membership, feeling happy and safe at school). A four-point Likert scale from strongly disagree to strongly agree was used to rate perceived school connectedness, with higher sum scores (range: 6–24) indicating stronger school connectedness.³⁹ Internal consistency of the School Connectedness Scale was high ($\alpha = 0.99$).

Two items from the Multidimensional Scale of Perceived Social Support and an additional item to assess the home environment were used to examine the self-perceived adequacy of supportive relationships and home environment.⁴¹ Students were asked to report agreement with the following statements? "I can talk about my problems with my family," "I can talk about my problems with my friends," and "I have a happy home life" on a five-point Likert scale from strongly disagree to strongly agree. Responses were dichotomized (agree = 0, disagree = 1). Students reporting neutrality were categorized as "agree" to reduce potential misclassification and to err on the side of inclusion, as research on Likert scales suggests that neutral responses reflect a lack of strong feeling in either direction, rather than the absence of the attribute being measured.⁴²

Analysis

Descriptive statistics were used to estimate the proportion of students who reported SCU. Univariate tests (chi-square and one-way ANOVA) were used to examine differences in SCU by student sociodemographic, psychological, behavioural, and social characteristics. Using a stepwise approach, four generalized linear mixed

models were run with random intercepts at the school-level. Model 1 examined the association between sociodemographic characteristics (gender, grade, ethnicity, SES) and SCU. The following models involved the stepwise addition of psychological (Model 2), behavioural (Model 3), and social (Model 4) characteristics. This approach demonstrated the evolution of associations between variables as new variables were added, and changes in strength and statistical significance. Post-hoc testing for product-term interactions was conducted based on Model 4 results, and a significant interaction was observed, resulting in a final interaction model, Model 5. Data cleaning and formatting were completed in SAS Studio.⁴³ Generalized linear mixed models were run within a Bayesian imputation framework⁴⁴ in R Studio⁴⁵ using the JointAI package,⁴⁶ and imputed missing data on dependent and independent variables. Sample sizes between Table 1 and Table 2 are discordant, as descriptive results utilized a complete case sample ($n = 2822$), and linear models used imputation ($n = 2899$).

Results

Sample descriptives and SCU

Within the analytic sample of 108 participating schools, 2822 students reported using cannabis in the past month, and 1853 of these students (66%) reported SCU. Half of the students identified as female, the majority were non-racialized (71%), and reported being as financially comfortable compared to the average student in their class (59%). The largest proportion of students (48%) resided in Ontario. The intraclass correlation coefficient (ICC) for SCU (ICC: 4.8%) suggests low between-school variation in student SCU.

Of students reporting SCU, 30% reported having used alone once or twice in the past 30 days ($n = 552$), while 70% reported having used alone three or more times ($n = 1303$). Student characteristics by SCU were examined descriptively (Table 1). The proportion of students reporting SCU increased with grade. Among students reporting solitary use, 50% were female, 40% were male, and 10% described their gender differently. Thirty-three percent of people who used cannabis alone were racialized, while 68% were non-racialized. SCU was most common among students

with perceived average SES (58%), compared to those with perceived higher SES (24%) and lower SES (18%).

Students who reported SCU demonstrated worse psychological characteristics compared to students who did not report SCU across all measures. Compared to students who did not report SCU, a greater proportion of students who reported SCU indicated clinically relevant depression scores (71.8% vs. 60.2%) and anxiety scores (53.5% vs. 42.5%), as well as lower mean flourishing (27.5 vs. 30.1) and higher emotional dysregulation (18.0 vs. 16.7). These unadjusted differences were statistically significant across all psychological characteristics. Related to other substance use behaviours, 40% of students who reported SCU also used cannabis on a weekly basis, 34% reported daily use, and 73% reported increased cannabis use during COVID-19. Students reporting SCU also reported high rates of solitary alcohol use (61%), driving under the influence of cannabis and/or alcohol (46%), and cannabis consumption by smoking (90%), vaping (49%), and eating/drinking (50%).

Students who reported SCU had poorer perceptions of the various social supports available across all measures. Mean school connectedness was notably lower among students reporting SCU (15.8 vs. 17.4) and were also more likely to disagree that they had a happy home life (20.0% vs. 12.9%), report lacking family support (38.0% vs. 30.2%) and insufficient peer support (16.0% vs. 9.4%), compared to students who did not report SCU.

Model results

Stepwise model results predicting students' SCU are presented in Table 2. In the final model (Model 5), students in Secondary I and II (OR: 0.50 [95% CI: 0.33–0.77]) had a lower likelihood of SCU (due to inclusion of Secondary I and II, the Quebec sample is younger compared to other provinces). Gender-diverse students had a higher likelihood of SCU than females (OR: 2.08 [1.26–3.50]), and racialized students had a higher likelihood of SCU (OR: 1.43 [1.13–1.81]) compared to non-racialized students. Students who reported being as financially comfortable (OR: 1.27 [1.02–1.59]) or less financially comfortable (OR: 1.55 [1.10–2.19]) had a higher likelihood of SCU compared to their peers

who were more financially comfortable. All substance use variables were strongly and positively associated with SCU, except for binge drinking. None of the mental health variables examined were independently associated with SCU in the final model (Model 5). An interaction between flourishing and school connectedness was selected for post-hoc exploration based on both theoretical and empirical grounds. Theoretically, flourishing and school connectedness represent complementary protective influences, suggesting a plausible moderating relationship, which was further supported by the diminished effect size of flourishing after school connectedness was added in Model 4. A small but significant interaction was observed between flourishing and school connectedness (OR: 1.00 [0.99–1.00]) (Figure 1). Figure 1 demonstrates that higher school connectedness is linked to a lower likelihood of SCU, varying by flourishing quantiles. The negative estimate ($\beta_{\text{FLRSH*SCU}} = -.00431$) implies that as flourishing increases, the slope of school connectedness becomes more negative, resulting in a greater reduction of SCU probability. Flourishing and school connectedness were moderately and positively correlated ($r = 0.54$, 95% CI [0.51, 0.56], $p < .001$). While effects were significant, the correlation between both variables may explain the small effect size observed.

Discussion

This study found that, during COVID-19 and related school closures, SCU was highly prevalent among Canadian secondary school students who reported past-30-day cannabis use. Notably, 64% of students in this sample reported engaging in SCU, which is consistent with existing literature.^{6,8,9} During this time, nearly three-quarters of students who reported SCU reported that they had used cannabis alone three times or more in the last month, indicating a higher frequency pattern of use in isolation. Substance use behaviours examined in this study were consistently and strongly associated with SCU. Preliminary evidence for a moderating effect of flourishing on the protective relationship between school connectedness and SCU was observed, despite the unique context of school closures, where conditions may have been conducive to diminished connection and solitary use. These findings fill a gap in current research, reinforcing the importance of schools even

TABLE 1
Sample characteristics of Canadian secondary school students participating in
the 2020–21 wave of the COMPASS study who reported past-month cannabis use^a

	Cannabis use			Chi-square/one-way ANOVA
	No solitary use N = 969 % (n)	Solitary use N = 1853 % (n)	Total sample N = 2968 ^b % (n)	
Province				86.1 (< .0001)
Ontario [ref.]	37.5 (363)	53.2 (986)	47.9 (1421)	
Quebec	52.1 (505)	34.3 (635)	40.3 (1197)	
Alberta	7.2 (70)	9.1 (169)	8.5 (251)	
British Columbia	3.2 (31)	3.4 (63)	3.3 (99)	
Gender				56.7 (< .0001)
Female [ref.]	52.9 (512)	50.1 (927)	50.2 (1487)	
Male	44.1 (427)	40.6 (751)	42.6 (1263)	
Describe differently	3.0 (29)	9.5 (173)	7.3 (215)	
Grade				45.0 (< .0001)
Secondary I and II	9.9 (96)	5.9 (110)	7.46 (221)	
Grade 9 [ref.]	16.0 (155)	17.0 (314)	16.6 (493)	
Grade 10	29.9 (289)	23.4 (433)	25.6 (760)	
Grade 11	28.8 (279)	30.7 (569)	29.9 (887)	
Grade 12	15.4 (149)	23.0 (425)	20.3 (603)	
Ethno-racial identity				39.4 (< .0001)
Non-racialized [ref.]	78.7 (760)	67.5 (1246)	71.2 (2103)	
Racialized	21.3 (206)	32.5 (599)	28.8 (852)	
Socioeconomic status (SES)				35.5 (< .0001)
More comfortable [ref.]	30.0 (290)	23.9 (442)	25.8 (765)	
As comfortable	59.8 (578)	58.0 (1073)	58.8 (1741)	
Less comfortable	10.2 (99)	18.1 (334)	15.4 (456)	
Psychological characteristics				
Depression				38.7 (< .0001)
Low scores (< 10)	39.8 (354)	28.2 (476)	32.5 (880)	
Clinically relevant scores (≥ 10)	60.2 (535)	71.8 (1214)	67.5 (1827)	
Anxiety				31.1 (< .0001)
Low scores (< 10)	57.5 (529)	46.5 (809)	50.6 (1415)	
Clinically relevant scores (≥ 10)	42.50 (391)	53.5 (930)	49.4 (1380)	
Flourishing (mean, [SD])	30.1 (6.6)	27.5 (7.1)	28.4 (7.1)	43.2 (< .0001)
Emotional dysregulation (mean, [SD])	16.7 (5.6)	18.0 (5.5)	17.5 (5.6)	18.6 (< .0001)
Substance use characteristics				
Frequency of cannabis use				575.1 (< .0001)
Monthly [ref.]	71.8 (696)	26.8 (497)	41.4 (1230)	
Weekly	21.1 (204)	39.5 (731)	33.3 (987)	
Daily	7.1 (69)	33.7 (625)	25.3 (751)	

Continued on the next page

TABLE 1 (continued)
Sample characteristics of Canadian secondary school students participating in the 2020–21 wave of the COMPASS study who reported past-month cannabis use^a

	Cannabis use			Chi-square/one-way ANOVA
	No solitary use N = 969 % (n)	Solitary use N = 1853 % (n)	Total sample N = 2968 ^b % (n)	
Increased cannabis use since COVID-19				245.6 (< .0001)
Stayed same/decreased [ref.]	58.5 (535)	27.5 (472)	38.7 (1069)	
Increased	41.5 (379)	72.5 (1245)	61.4 (1697)	
Binge drinking				10.6 (0.0049)
No [ref.]	18.9 (182)	18.8 (348)	19.4 (572)	
Yes	81.1 (782)	81.2 (1501)	80.5 (2381)	
Solitary alcohol use				149.2 (< .0001)
No [ref.]	63.5 (568)	38.7 (663)	47.6 (1282)	
Yes	36.5 (326)	61.3 (1050)	52.4 (1413)	
Driving under the influence				269.4 (< .0001)
No [ref.]	67.0 (646)	44.6 (823)	52.1 (1539)	
Yes	29.7 (286)	49.9 (921)	42.4 (1253)	
I don't know	3.3 (32)	5.5 (101)	5.5 (162)	
Mode of use: vaping				39.4 (< .0001)
No [ref.]	63.1 (599)	51.3 (943)	55.8 (1633)	
Yes	36.9 (350)	48.7 (894)	44.2 (1295)	
Mode of use: eating				61.4 (< .0001)
No [ref.]	64.7 (614)	50.0 (919)	55.6 (1627)	
Yes	35.3 (335)	50.0 (918)	44.4 (1301)	
Mode of use: smoking				6.9 (0.032)
No [ref.]	12.4 (118)	10.5 (192)	11.4 (334)	
Yes	87.6 (831)	90.0 (1645)	88.6 (2594)	
Social characteristics				
School connectedness (mean [SD])	17.4 (3.6)	15.8 (3.9)	16.3 (3.9)	49.0 (< .0001)
Happy home life				22.1 (< .0001)
Agree/neutral [ref.]	87.1 (883)	80.0 (1462)	82.5 (2415)	
Disagree	12.9 (123)	20.0 (365)	17.5 (512)	
Family support				17.0 (0.0002)
Agree/neutral [ref.]	69.8 (670)	62.0 (1127)	64.7 (1891)	
Disagree	30.2 (290)	38.0 (692)	35.3 (1031)	
Peer support				22.9 (< .0001)
Agree/neutral [ref.]	90.5 (868)	84.0 (1530)	86.1 (2516)	
Disagree	9.4 (91)	16.0 (291)	13.9 (405)	

Abbreviations: ref., referent category; SD, standard deviation; SES, socioeconomic status.

^a Percentages may not add to 100 due to rounding.

^b Counts may not add to 100% due to missing data; within this study sample, there was some non-mutually exclusive item nonresponse; 3% of students (n = 77) were missing data on SCU, 6–11% were missing data on mental health variables, 3–10% were missing data on substance use behaviours, 4–7% were missing data on perceived social supports, and 3% were missing for all demographic variables.

TABLE 2
Stepwise mixed models examining factors associated with solitary cannabis use among Canadian secondary school students participating in the 2020–21 wave of the COMPASS study who reported past-month cannabis use (n = 2899)

	Model 1	Model 2	Model 3	Model 4	Model 5
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Demographic variables					
Gender					
Female	–	–	–	–	–
Male	0.98 (0.83, 1.16)	1.19 (0.99, 1.42)	0.99 (0.79, 1.22)	0.99 (0.8, 1.24)	1.00 (0.81, 1.24)
Gender diverse	2.89 (1.91, 4.49)**	2.82 (1.83, 4.42)**	2.02 (1.23, 3.39)**	1.98 (1.20, 3.34)**	2.08 (1.26, 3.50)**
Grade					
Grade 9	–	–	–	–	–
Grade 10	0.75 (0.58, 0.97)*	0.78 (0.60, 1.01)	0.92 (0.68, 1.26)	0.91 (0.67, 1.23)	0.89 (0.66, 1.20)
Grade 11	1.07 (0.84, 1.38)	1.19 (0.92, 1.55)	1.55 (1.14, 2.11)**	1.53 (1.13, 2.07)**	1.50 (1.11, 2.03)**
Grade 12	1.34 (1.00, 1.78)	1.55 (1.15, 2.08)**	1.70 (1.20, 2.39)**	1.68 (1.19, 2.36)**	1.64 (1.17, 2.29)**
Secondary I and II	0.59 (0.41, 0.85)**	0.60 (0.42, 0.87)**	0.51 (0.33, 0.78)**	0.51 (0.33, 0.77)**	0.50 (0.33, 0.77)**
Ethnicity					
Non-racialized	–	–	–	–	–
Racialized	1.47 (1.21, 1.79)**	1.41 (1.16, 1.73)**	1.43 (1.13, 1.80)**	1.42 (1.13, 1.780)**	1.43 (1.13, 1.81)**
Socioeconomic status (SES)					
More comfortable	–	–	–	–	–
As comfortable	1.28 (1.06, 1.53)**	1.19 (0.98, 1.44)	1.30 (1.04, 1.63)*	1.30 (1.03, 1.62)*	1.27 (1.02, 1.59)*
Less comfortable	2.12 (1.61, 2.81)**	1.70 (1.28, 2.27)**	1.58 (1.13, 2.22)**	1.57 (1.11, 2.21)**	1.55 (1.10, 2.19)*
Psychological variables					
Depression					
No depression	–	–	–	–	–
Depression	–	1.25 (0.98, 1.58)	1.07 (0.81, 1.41)	1.05 (0.79, 1.38)	1.00 (0.75, 1.33)
Anxiety					
No anxiety	–	–	–	–	–
Anxiety	–	1.05 (0.84, 1.3)	1.02 (0.78, 1.31)	1.01 (0.79, 1.31)	1.01 (0.78, 1.31)
Flourishing	–	0.96 (0.95, 0.98)**	0.97 (0.95, 0.99)**	0.98 (0.96, 1.00)*	1.05 (0.99, 1.11)
Emotional regulation	–	1.01 (0.99, 1.03)	1.01 (0.98, 1.03)	1.01 (0.98, 1.03)	1.01 (0.98, 1.03)
Substance use variables					
Frequency of cannabis use					
Monthly	–	–	–	–	–
Weekly	–	–	4.51 (3.61, 5.62)**	4.44 (3.56, 5.54)**	4.43 (3.6, 5.54)**
Daily	–	–	9.95 (7.33, 13.64)**	9.72 (7.16, 13.32)**	9.79 (7.18, 13.44)**
COVID-related cannabis changes					
Same/decrease	–	–	–	–	–
Increased	–	–	2.69 (2.20, 3.31)**	2.72 (2.21, 3.35)**	2.74 (2.23, 3.37)**
Binge drinking					
No	–	–	–	–	–
Yes	–	–	0.75 (0.58, 0.98)*	0.76 (0.59, 0.99)*	0.77 (0.59, 0.99)*
Solitary alcohol use					
No	–	–	–	–	–
Yes	–	–	3.07 (2.47, 3.82)**	3.06 (2.46, 3.81)**	3.06 (2.47, 3.82)**

Continued on the next page

TABLE 2 (continued)
Stepwise mixed models examining factors associated with solitary cannabis use among Canadian secondary school students participating in the 2020–21 wave of the COMPASS study who reported past-month cannabis use (n = 2899)

	Model 1	Model 2	Model 3	Model 4	Model 5
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Drive under the influence					
No			—	—	—
Yes			1.65 (1.33, 2.04)**	1.63 (1.32, 2.02)**	1.65 (1.33, 2.03)**
I don't know			1.93 (1.17, 3.23)**	1.89 (1.14, 3.16)*	1.92 (1.16, 3.20)**
Mode of use					
Vaping					
No			—	—	—
Yes			1.27 (1.03, 1.57)*	1.28 (1.04, 1.57)*	1.27 (1.03, 1.57)*
Eating					
No [ref.]			—	—	—
Yes			1.36 (1.10, 1.67)**	1.36 (1.10, 1.68)**	1.37 (1.11, 1.69)**
Smoking					
No [ref.]			—	—	—
Yes			1.06 (0.78, 1.45)	1.03 (0.75, 1.40)	1.02 (0.75, 1.39)
Social support variables					
School connectedness				0.96 (0.93, 0.99)*	1.10 (0.99, 1.22)
Happy home life					
Agree/neutral				—	—
Disagree				0.87 (0.64, 1.19)	0.89 (0.66, 1.22)
Parent support					
Agree/neutral				—	—
Disagree				0.93 (0.74, 1.18)	0.93 (0.73, 1.17)
Peer support					
Agree/neutral				—	—
Disagree				1.13 (0.81, 1.57)	1.15 (0.83, 1.60)
Interaction term					
Flourishing ^a school connectedness					1.00 (0.99, 1.00)*

Abbreviations: CI, confidence interval; OR, odds ratio; ref., referent category.

* $p \leq 0.05$.

** $p \leq 0.01$.

during COVID-19-related restrictions, and warrant the need for future research to move beyond general cannabis use patterns among adolescents and examine the specific contexts in which use occurs, especially those that are associated with greater health impacts and riskier behaviours.

Who is at risk of SCU?

Consistent with existing research, SCU clustered with other substance use behaviours, indicating broader patterns of risk.^{5,9,15,47} SCU was more likely among students who increased their cannabis use during COVID-19, reflecting how social

isolation, school closures and disrupted routines may influence substance use. Prior research has highlighted the protective role of structured environments,⁴⁸ and these findings are aligned in demonstrating that stronger school connectedness is associated with reduced SCU. These findings are particularly relevant given that school closures may have altered student connectedness that would typically be protective against risky substance use behaviours, possibly influencing SCU observed in this study.

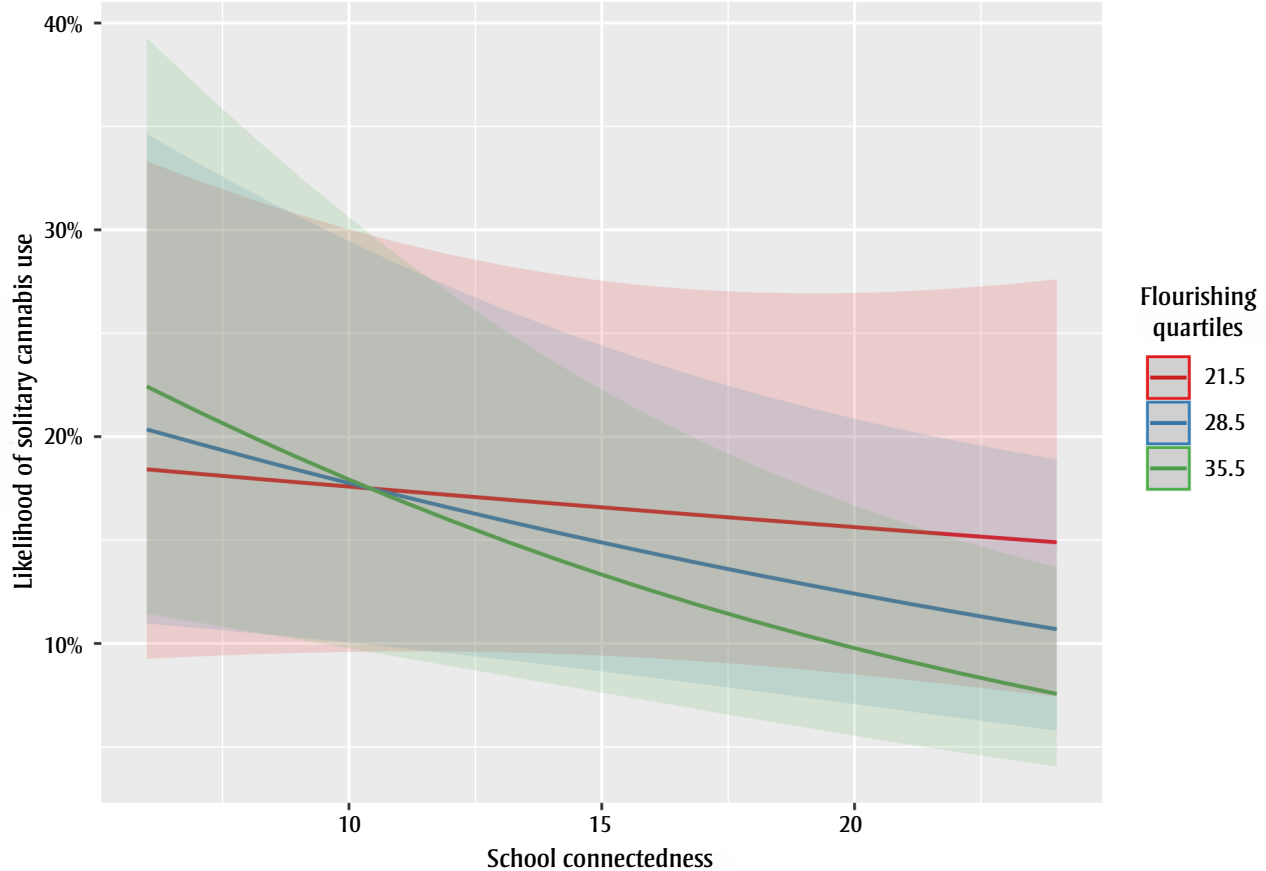
SCU was more prevalent among marginalized youth—specifically racialized students,

gender-diverse students, and those with perceived lower SES—highlighting important equity considerations in school-based substance use protection strategies. These populations have historically faced exclusion from supportive school environments, which may compound their risk for solitary and problematic cannabis use.⁴⁹ These findings reinforce the importance of equity-informed approaches when implementing prevention/intervention strategies.⁵⁰

What is protective against SCU?

These findings point to a potentially nuanced but protective relationship between school

FIGURE 1
Interaction between flourishing scores and school connectedness and the likelihood of solitary cannabis use among students participating in the 2020–21 wave of the COMPASS study



Note: Figure 1 was created for illustrative purposes, where values are based on a complete case analysis and not the imputed values reported in Table 2, Model 5. However, the direction and strength of association are consistent between both outputs.

connectedness, flourishing, and SCU. Students with higher levels of flourishing experienced stronger protective effects from school connectedness, with the steepest decline in solitary use observed in the top quartile of flourishing scores. This suggests that students who report higher flourishing may receive greater benefits from the positive social and relational aspects of school environments, and in turn are less likely to use cannabis alone. Importantly, these preliminary findings suggest that the protective association between school connectedness and SCU may vary by flourishing level, and interventions that solely focus on increasing school connectedness may be insufficient for some youth. Instead, integrated approaches, such as school-based well-being programs, may be necessary to support these students and reduce SCU. This interaction offers preliminary evidence of

a complex interplay between individual, interpersonal, and environmental factors in shaping youth substance use behaviour, and indicates a need for further research to clarify the nature and magnitude of these relationships.

Non-predictive correlates of SCU

Contrary to previous research,^{10–12,16} SCU was not independently significantly associated with symptoms of depression or anxiety. These null findings may suggest that generalized measures of depression, anxiety, and emotional regulation may not adequately capture the motivations or psychosocial contexts that underlie SCU. In contrast, flourishing, was predictive in earlier models and significantly interacted with school connectedness. This aligns with prior research in the present sample, demonstrating that positive well-being

measures are more closely associated with youth substance use behaviours compared to traditional mental illness scales.⁵¹ Future SCU research should incorporate more targeted mental health measures (e.g. social anxiety, coping motives) to better understand unique drivers that may explain these behaviours and motivations more clearly.

Recommendations for future research and prevention

Consistent with existing research,⁵² our findings suggest that school connectedness can mitigate health risks during adolescence and appears most impactful for vulnerable students (e.g. less resourced/unsupportive home environments). Yet, these same populations often report feeling less connected to their schools, highlighting a critical gap for equitable prevention

strategies. While enhancing school connectedness is necessary, it is insufficient to reduce SCU on its own; comprehensive approaches that support student well-being and flourishing, especially for marginalized or at-risk youth, are essential.^{53,54}

From a population-health lens, the ICC (4.84%) indicates school-level factors play a small but meaningful role in shaping SCU patterns. Where data is available, future research may explore specific school-level characteristics, such as inclusivity policies, staff-student relationships, extra-curricular offerings, or available supports, to explain possible between-school differences in student SCU. Additionally, longitudinal research is needed to understand how SCU patterns evolve, and if the frequency of using cannabis alone presents with different risk factors, especially in response to COVID-related restrictions and changes in students' perceived connection with their school and substance use behaviours over time. Given that SCU behaviours may be partially driven by isolating conditions of COVID-19, it remains unclear whether SCU prevalence and associated characteristics observed in this study reflect a behavioural pattern that will persist in post-COVID-19 conditions, or if results are shaped by these unique circumstances. As such, continued monitoring and surveillance for these high-risk behaviours is required in a post-pandemic era.

Strengths and limitations

A key strength of this study is the use of a large, population-based sample that enabled robust analysis of multiple risk and protective factors for SCU. The breadth of the dataset also allowed for consideration of equity-relevant variables and complex interactions between student characteristics and school environment. Further, this study managed missing data using a Bayesian imputation framework to mitigate biases common in complete case analyses.

However, limitations remain. SCU data were unavailable for the period immediately before COVID-19, and SCU was dichotomized due to response distributions; future research may consider how predictors of SCU vary by frequency where data are available. Additionally, COMPASS does not collect information on

intentions or motivations for using alone, nor the context of isolation (e.g. with friends online). These data challenges are especially relevant for students reporting "I don't know" to SCU, potentially reflecting uncertainty about product content (e.g. tetrahydrocannabinol [THC]/cannabinol [CBD]) or ambiguity in interpreting the question. Focus group interviews would help clarify participant understanding, reasons for response, and inform improvements to this measure for future use. Notably, data were collected during COVID-19, when social restrictions and school closures may have structurally changed the way in which youth used cannabis; SCU patterns observed in this study may be a result of mandated isolation, thus limiting the generalizability of these findings to non-pandemic contexts.

Because these data are cross-sectional, directionality between SCU and correlates cannot be inferred. However, the current cross-sectional data from COMPASS (2020–21) represent the first wave of SCU available from the full sample of COMPASS students. This study had a response rate of 58%, which may be due to data collection challenges during COVID-19, when school-based research participation rates declined. Nevertheless, selection bias is possible as non-responding students may differ systematically from respondents on key variables such as school connectedness and cannabis use. Results from this exploratory cross-sectional study identify the variables associated with SCU and provide a foundation for future longitudinal research. These findings are not generalizable to all Canadian youth, although it is worth noting that COMPASS was not designed to be nationally representative, and evidence suggests its large convenience sample aligns with other similar nationally representative data.⁵⁵

Conclusion

This study, which takes place during the COVID-19-mandated school closures, highlights the prevalence of SCU among Canadian secondary school students, with the majority of those who report current use reporting frequent SCU. Solitary use was more common among students engaging in other risky behaviours, those who increased use during COVID-19, and marginalized youth. Further, school connectedness emerged as a key protective

factor and appeared to vary across flourishing levels. These findings highlight the potential value of considering comprehensive prevention strategies and warrant the need for additional research on interventions that promote both flourishing and equitable school environments for reducing SCU and its associated risks.

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Conflicts of interest

None.

Authors' contributions and statement

AB: Conceptualization, methodology, writing—original draft, review and editing, formal analysis.

AD: Writing—review and editing, formal analysis.

KS: Writing—review and editing.

KAP: Writing—review and editing, funding acquisition.

CP: Writing—review and editing.

SL: Writing—review and editing, supervision, investigation, funding acquisition, data curation.

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