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Original quantitative research

The association of school connectedness and bullying involvement with multiple screen-time behaviours among youth in two Canadian provinces: a COMPASS study

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Abstract

Introduction: Screen time, a proxy for sedentary behaviours, has emerged as a critical health determinant among youth in contemporary societies, where most aspects of youth life involve access to screen-time devices. An understudied approach to reducing screen time among youth is bullying reduction. This study aims to understand the association between bullying perpetration, victimization, youth perception of the school environment and multiple screen-time behaviours.

Methods: A total of 44,861 youth aged between 13 and 18 years in two Canadian provinces completed a validated questionnaire that collected student data on health behaviours and outcomes, including multiple screen-time behaviours, bullying perpetration and victimization, and school connectedness. The outcome variables were total screen time, time spent watching television, playing video games, internet surfing, and communication-based screen-time behaviours. Using a random intercept, the final models were built using PROC MIXED in SAS 9.4. These models were adjusted for age, ethnicity, weekly disposable income, daylight hours, and weather variables.

Results: Compared to youth who reported non-involvement in bullying, youth who were bullies, victims, or both bullies and victims spent on average more minutes per day in front of screens across all screen time categories. Youth who felt happy and safe at school, and who perceived their teachers as being fair, reported lower levels of multiple screen-time behaviours.

Conclusion: With non-involvement in bullying showing a strong negative association with multiple screen-time behaviours, school policies to address bullying and screen time through school connectedness could offer a novel approach in minimizing these harmful behaviours.

Keywords: *youth health, school connectedness, bullying, screen time, TV, internet surfing, texting, video games*

Highlights

- Bullying perpetration, victimization, or both are associated with increased multiple screen-time behaviours among youth.
- Non-involvement in bullying is associated with decreased multiple screen-time behaviours among youth.
- Positive perception of the school environment and enhanced school connectedness could play an important role in minimizing screen time among youth.
- Strategies to minimize screen time among youth should move beyond limiting access to screen-time devices.
- School policies should target both bullying and screen time to maximize the reduction of these complex harmful behaviours.

Introduction

Screen time (ST), a proxy for sedentary behaviours, has emerged as a critical determinant of health among youth in contemporary societies,[1,2] where most aspects of youth life involve digital media.[3,4] ST is associated with a wide range of poor health outcomes, including obesity, metabolic syndrome, anxiety and depression, poor vision, and multiple risk behaviours such as smoking and other illicit drug use.[5-9]

Evidence also suggests that time spent using computers and playing video games is associated with physical violence,[10] as well as increased loneliness, risk of online victimization,[11] and various functional problems such as peer-related issues and

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hyperactivity.[12,13] An important yet understudied avenue for reducing ST in youth may involve targeting negative social factors in their environment, such as bullying.

Bullying is a heterogeneous concept that refers to a wide array of repeated behaviours, including physical and verbal aggressions, intended to harm or intimidate individuals who are perceived as less powerful.[14] Bullying affects between 6 and 40 per cent of youth annually (youth sample consisted of ages 11, 13, and 15 years)[15,16] and has been linked to various poor health outcomes, such as depression, suicidal ideation, and physical inactivity.[17-19] Cyber-bullying is a special cause for concern as it is not confined to social settings and can occur anytime and anywhere through electronic devices. Online communication is also faster, more widespread, and sometimes anonymous with limited accountability, which can create disinhibition and distance from the victim that may prompt more severe aggressions[20] and lead to worse outcomes compared to other types of bullying (e.g., suicide attempts that need medical attention, heavier substance use).[21, 22]

Drawing upon existing literature on bullying interventions, school strategies such as environmental supervision (e.g., playground supervision) and educating school staff about appropriate strategies for intervening are somewhat effective in reducing aggressions and victimization among youth.[15,20] The effectiveness of anti-bullying endeavours may, however, be contingent upon students' perceptions of school connectedness and environment. Rates of bullying are lower when students perceive their school environment as supportive and safe, the school climate is positive (e.g., staff/teachers provide caring atmosphere that promotes autonomy), and when students have positive relationships with teachers.[23,24]

This study is based on the hypothesis that involvement in bullying (either perpetration, victimization, or both) and negative perceptions of the school environment and school connectedness are associated with increased ST in youth. The study aims to understand the association between bullying perpetration, victimization, and youth perception of the school environment and school connectedness on different types of ST behaviours after controlling for weather variation (a perennial factor that is known to influence sedentary behaviours) in two geographically and climatically distinct provinces in Canada (Ontario and Alberta).[25-27]

Methods

Design

COMPASS (2012-2021) is a cohort study collecting data from a focussed sample of secondary school students (grades 9 through 12) and the schools they attend in Ontario (n = 79) and Alberta (n = 10).[28] This study uses secondary cross-sectional student- and school-level data from Year 2 (2013-2014) of the COMPASS cohort. Year 2 data were used because Year 1 data consisted of a smaller sample of schools (www.compass.uwaterloo.ca).[28]

Participants

Parents or guardians of eligible students were mailed an information letter or received an automated call about the COMPASS study and were asked to contact the COMPASS recruitment coordinator using a toll-free phone number or email address if they did not want their child to participate. Students whose parents or guardians did not contact the COMPASS team to withdraw their child were deemed eligible to participate. Students could also withdraw themselves and decline participation at any time. All procedures were approved by the University of Waterloo Office of Research Ethics and participating School Boards. In Ontario, out of a total 52,529 students enrolled in grades 9 to 12, 80.1% (N = 41 734) students completed the student-level COMPASS questionnaire (Cq)[28]; in Alberta, out of a total of 4,700 students enrolled in grades 9 to 12, 77.1% (N = 3564) of students completed the Cq in class time on the day of their schools' scheduled data collection.

Data collection tools

The Cq collects individual student data pertaining to demographic variables (e.g., age, ethnicity, disposable income) and health behaviours, including physical activity, ST-based sedentary behaviour, bullying, and school connectedness. Items measured on the Cq were based on national standards or current national public health guidelines.[28] To account for weather variation, weather and daylight data were obtained for each COMPASS school through the Environment Canada website's Climate database.[29]

Policies and programs related to physical activity and bullying were measured using the School Policies and Practices Questionnaire, a paper-based survey completed by the administrator most knowledgeable about the school's program, practice, and policy environment. This survey measured the presence or absence of relevant programs and policies, as well as changes to school programs, policies, or resources, that are related to student health.

Measures

Student-level measures

Students were asked to report, via four individual items on the Cq, the average amount of time per day they had spent in each type of ST behaviour for the past 7 days: (1) watching/streaming TV shows or movies; (2) playing video/computer games; (3) surfing the internet; and (4) texting, messaging, and emailing. Total ST was measured as the sum of minutes for these four activities. Reported ST was not context-specific (e.g., school, home). Previous research found that the test re-test reliability for these individual items ranged from fair (TV: ICC = 0.56) to moderate (playing video or computer games: ICC = 0.65; surfing the internet: ICC = 0.71) to substantial (texting, messaging, emailing: ICC = 0.86).[30,31]

Students reported their experience related to bullying by answering the following question: "In the last 30 days, in what ways were you bullied by other students?" with response options of "I did not get bullied by other students"; physical attacks, verbal attacks, or cyber-attacks; and stealing. They were also asked: "In the last 30 days, in what ways did you bully other students?" with response options of "I did not bully other students"; physical attacks, verbal attacks, or cyber-attacks; and stealing. Perception of school environment and school connectedness was measured by asking students to strongly agree, agree, disagree, or strongly disagree with the following statements: "I feel close to people at my school," "I feel I am a part of my school," "I am happy to be at my school," "I feel the teachers at my school treat me fairly," "I feel safe in my school," and "getting good grades is important to me."

School-level measures

School level variables of interest for this study included policies to address bullying and enhance physical activity. Bullying policy questions for school administrators included examples such as, "Is bullying a problem in your school?" (Yes/No); "Does your school have any policies to address bullying?" (Yes/No. If yes, "Please list them" (Table 1).

Weather and daylight data

All weather data were for the seven days prior to the Cq data collection date to match ST recall data. Data on maximum temperature (degrees Celsius [°C]), total rainfall (millimetres [mm]), and total daylight hours (sunrise to sunset) were collected.

Analyses

All the analyses were carried out in SAS 9.4. The sample was divided into four groups (Ontario males and females, Alberta males and females) to develop five random-intercept linear regression models for each of the five outcomes. Random-intercept models were chosen because they account for the effects of clustering of children within each school. The primary assumption of these models is that the mean outcome for each school varies around a grand mean of the outcome for all schools. The estimated coefficients in the models are indicative of the amount of increase in the ST minutes associated with one-unit increase in the independent variables, holding other covariates fixed. The five outcomes were average minutes/day of total ST, and individual ST behaviours (television viewing, internet surfing, video gaming, communication-based ST). The models were adjusted for age, ethnicity, weekly disposable income, daylight hours, and weather variables.

Results

As shown in Table 2 total ST (min/day) was similar among females (Ontario: mean = 473.7 ± 318.7; Alberta: 459.9 ± 325.0) and males (Ontario: mean = 481.5 ± 332; Alberta: 476.9 ± 340.5) in both provinces, with a major proportion of youth (41%) accumulating more than 7.5 hours of ST per day. Males in both Ontario and Alberta spent significantly more minutes per day playing video games than females (< 0.0001), whereas females spent significantly more minutes per day in communication-based ST behaviours and internet surfing (< 0.0001) (Table 2). Time spent watching TV was similar between females and males in both provinces.

The prevalence of reported bullying victimization and perpetration was similar across the two provinces. In both provinces, the proportion of females who reported being bullied in the past 30 days was significantly higher than males (< 0.0001) (Table 2). In contrast, in both provinces, the proportion of males who reported bullying others in the past 30 days was significantly higher than females (< 0.0001) (Table 2). In both provinces, males reported being victims of significantly more physical attacks (< 0.0001) and females reported being victims of significantly more verbal and cyber-attacks (< 0.0001). Figures 1 and 2 show that in both Ontario and Alberta, youth who reported involvement in bullying, both as perpetrators and victims, also reported significantly higher ST in comparison with youth who reported being only perpetrators or only victims and youth who reported non-involvement (< 0.0001).

Separate random-intercept linear effects models for males in Ontario, females in Ontario, and total youth (males and females) in Alberta examined the associations between youth perception of the school environment, school connectedness, and bullying involvement (perpetration, victimization) and non-involvement (i.e., those who were neither bullied nor bully others) with multiple ST behaviours (Tables 3, 4, 5 and 6). Overall, higher perceived school connectedness was associated with lower ST across all groups (i.e., Ontario males, Ontario females, and total youth in Alberta). On the other hand, involvement in bullying, whether perpetration, victimization, or both, was associated with higher ST across all groups.

Ontario males

Among males in Ontario, feeling happy and safe at school and perceiving teachers as fair was associated with significantly lower total ST. Males who felt safe at school reported lower TV viewing time and males who felt like they were part of their school reported less time playing video games and surfing the Internet.

TABLE 1
Description of school-level bullying policies and within-province, between-school differences in total screen time/day based on presence or absence of policies/programs

School-level questions	School-level outcomes (Yes/No)	Total daily screen time in minutes					
		Alberta		*p*-value	Ontario		*p*-value
		Yes	No		Yes	No	
Does your school have written policies on the following? e.g., bullying	Alberta (yes=2, no=7) Ontario (yes=3, no=73)	440.2	477.3	0.0023	489.7	475.3	0.1615
In which fields does your school receive support from your school's local Public Health Unit? (Check all that apply) e.g., bullying	Alberta (yes=1, blank=9), Ontario (yes =27, blank=52)	535.2	461.4	0.0009	476.5	478.4	0.5492
Is bullying a problem at your school?	Alberta (yes=8, no=2), Ontario (yes=45, no=30)	477.0	441.9	0.0050	475.4	478.9	0.3060
Does your school have any programs that address bullying?	Alberta (yes=7, no=3) Ontario (yes=74, no=5)	481.4	443.6	0.0014	477.3	482.3	0.4618

Notes: *p*-values are based on ANOVA and show the differences between within-province total screen-time behaviours/day based on the presence or absence of policies/programs (yes/no).

Only variables that were statistically significant following backward stepwise elimination were included in the models.

TABLE 2
Demographic and screen time characteristics for students participating in Y2 of the COMPASS study in Ontario and Alberta, Canada, 2013-2014

Descriptive category	ON (N = 41 324)				AB (N = 3537)			
	Female (n = 20 388)	Male (n = 20 936)	DF	*p*-value	Female (n = 1761)	Male (n = 1776)	DF	*p*-value
Grade (%; n)								
9	26.7 (5445)	27.5 (5742)	3	0.027	15.0 (264)	15.4 (274)	3	0.6978
10	26.2 (5344)	25.3 (5277)			33.0 (582)	31.3 (556)		
11	24.9 (5062)	24.4 (5099)			28.3 (499)	28.5 (505)		
12	22.2 (4511)	22.9 (4777)			23.6 (416)	24.8 (440)		
Age (%; n)								
13	1.1 (229)	1.2 (250)	5	< .0001	0.4 (7)	0.6 (10)	5	0.0214
14	21.6 (4405)	21.6 (4517)			13.0 (229)	11.5 (204)		
15	25.9 (5284)	24.8 (5176)			29.4 (517)	26.8 (475)		
16	25.3 (5155)	24.5 (5129)			30.2 (531)	29.4 (522)		
17	20.2 (4119)	20.6 (4307)			22.2 (391)	24.8 (440)		
18	5.8 (1179)	7.3 (1528)			4.9 (86)	6.9 (123)		
Ethnicity (%; n)								
White	75.3 (15342)	73.2 (15315)	5	< .0001	74.2 (1307)	72.6 (1290)	5	0.0067
Black	3.2 (657)	4.9 (1033)			1.2 (21)	2.8 (50)		
Asian	5.2 (1068)	5.2 (1082)			3.4 (60)	4.4 (78)		
Aboriginal	3.0 (613)	2.8 (591)			11.1 (195)	10.2 (182)		
Hispanic	1.9 (386)	2.2 (453)			0.5 (8)	0.2 (4)		
Other/Mixed	11.4 (2322)	11.8 (2462)			9.7 (170)	9.7 (172)		
BMI categories (%; n)								
Underweight	1.4 (282)	1.7 (350)	4	< .0001	1.4 (25)	1.8 (32)	4	< .0001
Healthy weight	61.7 (12574)	52.6 (11021)			58.0 (1022)	50.0 (888)		
Overweight	11.4 (2332)	16.7 (3493)			11.8 (208)	16.9 (300)		
Obese	4.1 (838)	8.3 (1734)			6.0 (105)	10.1 (180)		
Not Stated	21.4 (4362)	20.7 (4338)			22.8 (401)	21.2 (376)		
Weekly disposable income (%; n)								
Zero	15.3 (3127)	16.8 (3513)	7	< .0001	13.9 (245)	14.3 (254)		< .0001
$1 to $5	7.0 (1428)	6.4 (1331)			3.8 (67)	3.4 (61)		
$6 to $10	8.1 (1650)	7.9 (1658)			6.0 (105)	4.1 (72)		
$11 to $20	14.8 (3016)	14.8 (3105)			10.3 (181)	9.6 (170)		
$21 to $40	13.1 (2676)	12.3 (2584)			12.6 (222)	12.4 (221)		
$41 to $100	14.9 (3037)	12.4 (2600)			17.2 (303)	15.0 (266)		
More than $100	13.7 (2787)	17.2 (3591)			17.5 (309)	27.7 (492)		
DK/Missing	13.1 (2667)	12.2 (2554)			18.7 (329)	13.5 (240)		
Bullying victimization and perpetration (%; n)								
Victims of bullying	23.9 (4867)	19.7 (4120)			30.8 (542)	22.1 (392)		
Victims of physical attacks	1.8 (358)	3.7 (775)	1	< .0001	2.6 (46)	5.3 (95)	1	< .0001
Victims of verbal attacks	17.5 (3562)	11.8 (2463)	1	< .0001	24.9 (438)	13.6 (241)	1	< .0001
Victims of cyber-attacks	8.2 (1671)	2.9 (600)	1	< .0001	10.2 (179)	2.9 (52)	1	< .0001

Continued on the following page

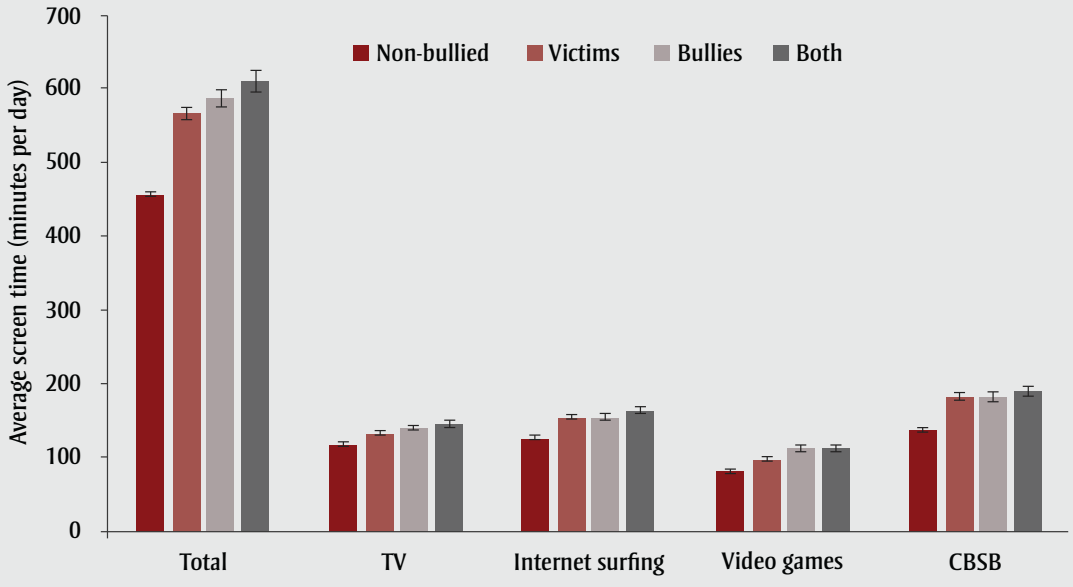
TABLE 2 (continued)
Demographic and screen time characteristics for students participating in Y2 of the COMPASS study in Ontario and Alberta, Canada, 2013-2014

Descriptive category	ON (N = 41 324)				AB (N = 3537)			
	Female (n = 20 388)	Male (n = 20 936)	DF	*p*-value	Female (n = 1761)	Male (n = 1776)	DF	*p*-value
Bullying victimization and perpetration (%; n) (continued)								
Victims of property damage and theft	2.6 (526)	3.4 (702)	1	< .0001	3.6 (63)	4.3 (77)	1	0.2476
Perpetrators of bullying	10.3 (2102)	15.9 (3338)			11.9 (209)	18.0 (319)		
Perpetrators of physical attacks	0.9 (187)	3.3 (681)	1	< .0001	0.4 (7)	4.7 (83)	1	< .0001
Perpetrators of verbal attacks	6.6 (1353)	9.5 (1984)	1	< .0001	9.3 (163)	11.7 (208)	1	0.0172
Perpetrators of cyber-attacks	2.1 (438)	1.8 (370)	1	0.0052	1.3 (23)	2.0 (36)	1	0.0941
Perpetrators of theft and property damage	0.6 (118)	1.6 (328)	1	< .0001	0.3 (6)	1.7 (31)	1	< .0001
Non-involvement in bullying (%; n)								
Did not bully others	89.7 (18286)	84.1 (17598)	1	< .0001	88.1 (1552)	82.0 (1457)	1	< .0001
Did not get bullied	76.1 (15521)	80.3 (16816)	1	< .0001	69.2 (1219)	77.9 (1384)	1	< .0001
Multiple screen-time behaviours (mean minutes/day; SD)								
Total screen time	473.7 (318.7)	481.5 (332.0)		0.0153	459.9 (325.0)	476.9 (340.5)		0.1295
TV	122.6 (92.1)	120.4 (96.0)		0.0147	115.3 (89.1)	119.4 (98.1)		0.1945
Internet surfing	143.0 (129.7)	117.3 (120.7)		< .0001	128.6 (133.8)	104.8 (118.5)		< .0001
Video games	38.4 (81.4)	126.0 (128.4)		< .0001	43.7 (83.8)	125.4 (127.0)		< .0001
Communication-based screen-time behaviours	169.7 (165.3)	117.9 (145.3)		< .0001	172.2 (169.2)	127.2 (154.7)		< .0001

Abbreviations: BMI, body mass index; DF, degrees of freedom; SD, standard deviation.

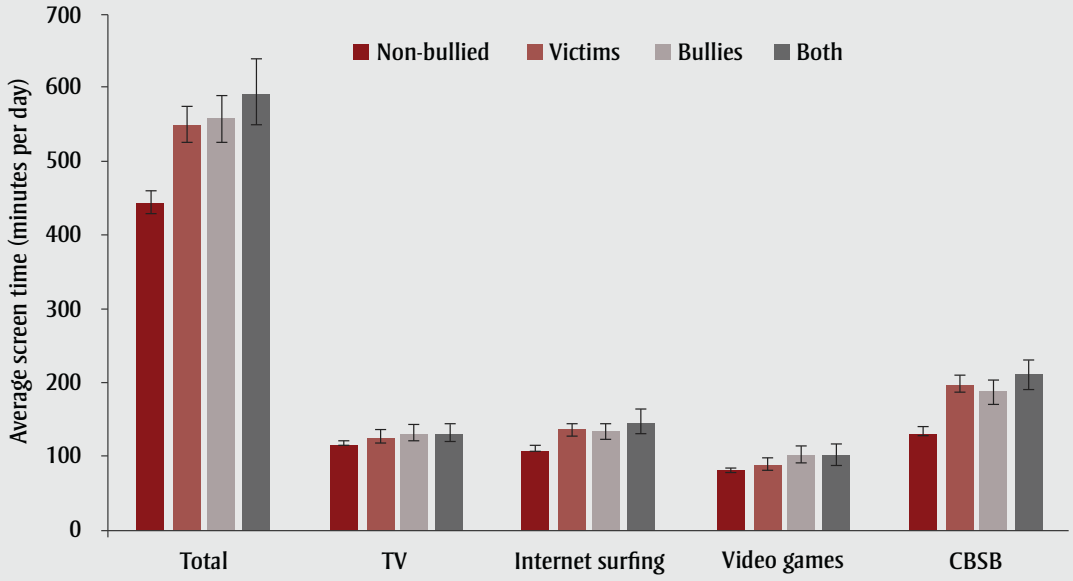
Note: Only variables that were statistically significant following backward stepwise elimination were included in the models.

FIGURE 1
Average screen-time behaviours across the distribution of bullying perpetration, victimization, both perpetration/victimization, and non-involvement in Ontario, Canada, COMPASS Study (2013-2014)



Abbreviation: CBSB, communication-based screen-time behaviours.

FIGURE 2
Average screen-time behaviours per day across the distribution of bullying perpetration, victimization, both perpetration/victimization, and non-involvement in bullying in Alberta, Canada, COMPASS Study (2013-2014)



Abbreviation: CBSB, communication-based screen-time behaviours.

However, males who reported being close to people in their school spent more time in communication-based ST behaviours and accumulated more total ST.

Males who reported being attacked physically had significantly more TV viewing time and accumulated more total ST. Males who bullied others on the Internet and those who were responsible for damaging property or theft spent more time playing video games. Males who reported that they had engaged in verbal attacks against others spent significantly less time in communication-based ST behaviours. Males who were not bullied in any form reported significantly less time playing video games.

Ontario females

Among females in Ontario, feeling happy and safe at schools and perceiving teachers as fair was associated with significantly lower total ST. Females in Ontario who felt safe and part of their school reported lower TV viewing time. Females who reported being happy and safe at school reported less time surfing the internet. Feeling happy and safe at school and perceiving teachers as fair was further associated with fewer minutes per day spent in communication-based ST behaviours. Moreover, similar to the findings among males, feeling close to people at school was associated with significantly more communication-based ST behaviours and more total ST among females.

Females who reported cyber-attacks spent more time surfing the internet and in communication-based ST behaviours. Females who reported bullying others online also had significantly more communication-based ST behaviours. On the other hand, females who reported non-involvement in bullying (i.e., those who did not bully or get bullied) reported significantly lower ST. Females who reported that they did not bully spent less time surfing the internet, in communication-based ST behaviours, and accumulated lower total ST. Females who reported not being victims of bullying reported less time spent in communication-based ST behaviours and accumulated lower total ST.

Alberta youth

Females in Alberta who felt being part of their school reported significantly less time playing video games. Both females and males who reported cyber-attacks spent more time in communication-based ST behaviours, with females who reported cyber-attacks also accumulating more total ST. Females and males who reported that they had not bullied others spent significantly less time in communication-based ST behaviours. Females and males who were not bullied spent significantly less time surfing the Internet and accumulated lower total ST, with females who were not bullied also spending less time in communication-based ST behaviours

Discussion

The purpose of this study was to examine the association between perception of school environment, school connectedness, and involvement in bullying with multiple ST behaviours among youth in a large sample spread across two Canadian provinces. Our hypothesis that involvement in bullying and negative perceptions of school environment and school connectedness are associated with higher ST was supported.

Average ST reported among youth in both provinces was more than 7.5 hours per day, which corroborates a nationally representative sample of youth in Canada.[32] The high ST accumulation among youth is attributed to constant access and exposure to diverse ST devices, both at school and at home.[33] Thus, it is essential that studies capture the entire range of ST behaviours. Males spent significantly more time playing video games than females, whereas females spent significantly more time in communication-based ST behaviours and surfing the internet. These findings highlight the need for gendered interventions in reducing ST among youth.[33]

TABLE 3
Random-intercept linear regression model showing the relationship between perception of school environment and school connectedness, and involvement in bullying with multiple and total screen-time behaviours among boys in Ontario, Canada, COMPASS Study (2013-2014)

	Ontario males									
	TV		Video games		Internet surfing		Communication-based screen time		Total screen time	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
School connectedness										
Close to people							0.19	0.14 to 0.23	0.05	0.01 to 0.09
Part of school			−0.10	−0.13 to −0.06	−0.08	0.02 to −0.12				
Happy at school							−0.08	−0.13 to −0.04	−0.06	−0.10 to −0.02
Fair teachers							−0.19	−0.24 to −0.15	−0.10	−0.14 to −0.06
Safe at school	−0.06	−0.09 to −0.03							−0.07	−0.12 to −0.02
Victims of bullying										
Physical attacks	0.25	0.14 to 0.35							0.33	0.19 to 0.48
Verbal attacks										
Cyber-attacks					0.45	0.31 to 0.60	0.61	0.45 to 0.78	0.45	0.29 to 0.61
Bullying perpetrators										
Verbal attacks							−0.24	−0.41 to −0.06		
Cyber-attacks			0.25	0.03 to 0.46						
Property damage			0.18	−0.07 to 0.43						
Non-involvement in bullying										
Did not get bullied			−0.14	−0.20 to −0.08						
Did not bully										

Abbreviations: CI, confidence interval; Est., estimate.

Note: Only variables that were statistically significant following backward stepwise elimination were included in the models.

Females in Ontario who felt like they were part of their school spent less time on average watching TV. Previous research suggests that time spent watching TV is associated with loneliness and lower social engagement.[34,35] Youth who report feeling integrated in their school may be more likely to be actively involved in school activities and thus have higher social engagement and lower TV time.

However, feeling close to people at school was associated with more communication-based ST behaviours, and higher total ST among both males and females in Ontario. These findings are in line with previous research that shows that communication-based ST behaviours (e.g., short messaging services, instant messages) have become the primary and preferred method of interpersonal communication among youth and are associated with efforts to enhance belonging.[36,37] This increase in communication-based ST behaviours could explain higher total ST among youth who feel closer to people at school. There appear to be obvious trade-offs in terms of various aspects of school connectedness and their relationship with different ST behaviours. Nevertheless, our models showed that both Ontario males and females who felt happy and safe at school and who perceived their teachers as being fair reported lower levels of multiple ST behaviours. This reiterates the point that a positive perception of the school environment and enhanced school connectedness could play an important role in minimizing ST among youth.

Bullying perpetration and victimization were both associated with increased ST among youth. Compared to youth who reported non-involvement in bullying, youth who were bullies, victims, and both bullies and victims spent on average more minutes per day in front of screens across all ST categories.

Prevalence of past-month involvement in bullying was approximately 20% among both females and males in Alberta and Ontario, which is similar to previously reported prevalence rates of bullying involvement in Canada.[38] Involvement in bullying differed between males and females by type of bullying behaviours. More males reported being victims and perpetrators of physical violence, perpetrators of verbal attacks, and perpetrators of property damage or theft. More females reported being victims of verbal attacks,

TABLE 4
Random-intercept linear regression model showing the relationship between perception of school environment and school connectedness, and involvement in bullying with multiple and total screen-time behaviours among girls in Ontario, Canada, COMPASS Study (2013-2014)

	Ontario females									
	TV		Video games		Internet surfing		Communication-based screen time		Total screen time	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
School connectedness										
Close to people							0.12	0.08 to 0.16	0.06	0.03 to 0.10
Part of school	−0.06	−0.09 to −0.03								
Happy at school					−0.12	−0.16 to −0.09	−0.08	−0.13 to −0.04	−0.13	−0.17 to −0.09
Fair teachers							−0.19	−0.24 to −0.14	−0.13	−0.17 to −0.09
Safe at school	−0.07	−0.10 to −0.03			−0.09	−0.14 to −0.05	−0.12	−0.17 to −0.06	−0.14	−0.19 to −0.09
Victims of bullying										
Cyber-attacks					0.21	0.12 to 0.29	0.49	0.37 to 0.61		
Bullying perpetrators										
Cyber-attacks							0.39	0.19 to 0.60		
Non-involvement in bullying										
Did not get bullied							−0.19	−0.27 to −0.11	−0.17	−0.25 to −0.10
Did not bully					−0.20	−0.28 to −0.13	−0.21	−0.31 to −0.10	−0.30	−0.39 to −0.21

Abbreviations: CI, confidence interval; Est., estimate.

Note: Only variables that were statistically significant following backward stepwise elimination were included in the models.

and both victims and perpetrators of cyber-bullying. This evidence reiterates existing literature that suggests that males are more likely to engage in physical aggressions, whereas females tend to engage in bullying perpetration through social aggression.[38]

One consistent pattern was that the victims of cyber-attacks were associated with more communication-based ST in all four cohorts. However, cyber-bullying perpetrators among Ontario females also had higher communication-based ST, which could potentially be explained by the evidence that females predominantly engage in bullying perpetration through social manipulation.[39]

Females in both Ontario and Alberta spent significantly more time than males surfing the internet and in communication-based

TABLE 5
Random-intercept linear regression model showing the relationship between perception of school environment and school connectedness, and involvement in bullying with multiple and total screen-time behaviours among boys in Alberta, Canada, COMPASS Study (2013-2014)

	Alberta males									
	TV		Video games		Internet surfing		Communication-based screen time		Total screen time	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
Victims of bullying										
Cyber-attacks							1.35	0.76 to 1.94		
Non-involvement in bullying										
Did not get bullied					−0.37	−0.56 to −0.17			−0.25	−0.48 to −0.02
Did not bully							−0.48	−0.75 to −0.21		

Abbreviations: CI, confidence interval; Est., estimate.

Note: Only variables that were statistically significant following backward stepwise elimination were included in the models.

TABLE 6
Random-intercept linear regression model showing the relationship between perception of school environment and school connectedness, and involvement in bullying with multiple and total screen-time behaviours among girls in Alberta, Canada, COMPASS Study (2013-2014)

	Alberta females									
	TV		Video games		Internet surfing		Communication-based screen time		Total screen time	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
School connectedness										
Part of school			−0.24	−0.37 to −0.10						
Victims of bullying										
Cyber-attacks							0.38	0.05 to 0.72	0.52	0.19 to 0.84
Non-involvement in bullying										
Did not get bullied					−0.17	−0.34 to −0.00	−0.45	−0.69 to −0.21	−0.28	−0.50 to −0.07
Did not bully							−0.32	−0.60 to −0.03		

Abbreviations: CI, confidence interval; Est., estimate.

Note: Only variables that were statistically significant following backward stepwise elimination were included in the models.

ST behaviour. Previous studies have also found that risk of cyber-bullying victimization is higher with more time spent on the internet, including more "chatting online."[10,11] Cyber-bullying is different from other types of bullying in that it can occur anytime and anywhere through multiple digital devices. In addition, youth that engage in cyber-bullying perpetration are more likely to be involved in school bullying, either as a perpetrator or a victim.[11]

Bullying perpetration through property damage and theft was associated with more time spent playing video games for males in Ontario. These findings are in line with Janssen et al.'s[10] prospective cohort study that found that video game use predicted physical violence among high school students.

Perhaps the most conclusive evidence of the strong association between bullying perpetration/victimization and ST behaviours is shown by the findings that among all four cohorts, non-involvement in bullying (i.e., youth who were not bullied or who did not bully) was associated with lower accumulation of multiple ST behaviours. ST behaviours are complex not only because they are enabled by a constant access to a range of multiple digital media devices (e.g., TV, desktop/laptop computers, tablets), but also because of the varied impact of each ST behaviour. For instance, both TV viewing and playing video games are associated with increased loneliness and poor social engagement,[13,32,33] with video games also being connected to physical violence[10] and TV viewing to poor nutritional choices associated with obesity.[40,41]

Communication-based ST behaviours are more complicated because although they correlate with social engagement and connections,[36] they are also associated with cyber-bullying.[10,11] Furthermore, there is gendered variation in ST behaviours, with males spending significantly more time playing video games and females spending significantly more time accumulating communication-based ST behaviours.

With consistently increasing dependence on the use of multiple ST devices among youth,[32] restricting access to ST devices is becoming exceedingly difficult. Different types of ST behaviours can be accumulated via access to various devices. For example, youth can watch TV, play video games, surf the internet, and communicate via texts, online messaging, or emails using laptops, desktops, tablets, and even smartphones – sometimes simultaneously. In this scenario, strategies to minimize ST should move beyond limiting access to ST devices.

It is theoretically difficult to argue a linear, unidirectional relationship between multiple ST behaviours and bullying, especially with evidence from a cross-sectional study. ST and bullying are complex behaviours that need to be studied with more robust study designs, and a systems science perspective to delineate if their relationship is causal or more complex.[42-44] Nevertheless, the evidence of an association between bullying, school connectedness, and ST, has policy implications for schools to address bullying perpetration and the prevalence of multiple screen-time behaviours.

With non-involvement in bullying showing a strong negative association with multiple ST behaviours, school policies to address both bullying and screen time could offer a novel approach in reducing harmful behaviours among youth. However, school policies should focus on improving youth perception of school environment and connectedness as this could enable pathways to prevent bullying and reduce ST.

Strengths and limitations

The major strength of the study is the sample size of schools and distribution of participants across two Canadian provinces who reported multiple ST behaviours. However, the modeling of multiple ST behaviours and the depiction as well as the interpretation of results can be challenging due to the large number of independent factors that need to be tested across different ST behaviours. Potential under reporting, recall bias, and missing data are the primary limitations of the

study due to its reliance on self-reported surveys. Nevertheless, COMPASS survey measures specific to this study have previously demonstrated satisfactory reliability and validity.[29] Another limitation is the lack of context in terms of ST behaviours because we do not know the type of digital devices that youth were using to accumulate different types of ST behaviours and where they are using these devices (e.g., home, school). It is important to understand the nuances and distribution of ST behaviours across different devices and physical contexts to tailor ST reduction policy interventions.

Adapted ST surveys that capture the variation of ST behaviours accumulated over different types of screens or devices and ecological momentary assessments deployed through smartphones could provide the device and physical context lacking in current evidence.[45] Smartphone-based studies could also reduce recall bias and measure objective smartphone ST behaviour.[46] Finally, since this study is cross-sectional in nature, causal inferences cannot be made and there may be pathways through which more ST could result in greater exposure to bullying, especially when it comes to the association of computer usage and video games with physical violence[10] and the risk of online victimization.[11]

Conclusion

This study is the first to simultaneously examine the association between involvement in bullying, youth perception of school environment/school connectedness, and multiple ST behaviours. Our findings suggest that school policies should focus on improving school connectedness and target both bullying and screen time to maximize the reduction of these complex harmful behaviours.

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Conflicts of interest

Apart from Dr. Leatherdale being the CIHR-PHAC Chair in Applied Public Health Research, and an Associate Scientific Editor with *Health Promotion and Chronic Disease Prevention in Canada: Research, Policy and Practice*, we declare that no other conflicts of interest exist.

Authors' contributions and statement

TRK conceptualized the study, interpreted the data and drafted the paper. AST and RL interpreted the data and drafted the paper. WQ analyzed the data and drafted the paper. STL designed the study, and acquired and interpreted the data. All authors revised the paper and approved its final version.

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