Suicide on the Toronto Transit Commission subway system in Canada (1998–2021): a time-series analysis

Selina Chow,[a,b] Vera Yu Men,[a,b] Rabia Zaheer,[a,b] Ayal Schaffer,[a,b] Christine Triggs,[c] Matthew J. Spittal,[d] Maureen Elliott,[e] Dalia Schaffer,[a,b] Mathavan Vije,[a,b] Navitha Jayakumar,[a,b] and Mark Sinyor[a,b,]*

[a]Department of Psychiatry, Sunnybrook Health Sciences Centre, Toronto, Canada
[b]Department of Psychiatry, University of Toronto, Toronto, Canada
[c]Safety & Environment Department, Toronto Transit Commission, Toronto, Canada
[d]Melbourne School of Population and Global Health, The University of Melbourne, Melbourne, Australia
[e]Distress Centres of Greater Toronto, Toronto, Canada

Summary

Background The Toronto Transit Commission (TTC) operates the public transit system in Toronto, Canada. From 1954 to 1980, there were 430 suicide deaths/attempts on the TTC subway system. In 2011, TTC implemented Crisis Link, a suicide helpline to connect subway passengers with counsellors. Upstream factors such as media reporting about suicide incidents may also influence suicidal behaviour. Our objectives were to investigate how Crisis Link and media reports about TTC suicide incidents influenced suicide rates.

Methods Suicide data were obtained from the TTC and Coroner, with Crisis Link data provided by Distress Centres of Greater Toronto (1998–2021). Media articles were identified through a database search of Toronto media publications. Interrupted time-series analysis investigated the association between Crisis Link calls, media articles, and quarterly suicide rates on the subway system.

Findings There were 302 suicides on TTC's subway system from 1998 to 2021. The introduction of Crisis Link was associated with a large but non-significant decrease in TTC-related suicide rate in the same quarter (IRR = 0.64, 95% CI = 0.36–1.12). Each subsequent post-Crisis-Link quarter experienced an average 2% increase in suicide rate (IRR = 1.02, 95% CI = 1.004–1.04). Furthermore, for each TTC-related media article in the previous quarter, the suicide rate on the TTC increased by 2% (IRR = 1.02, 95% CI = 1.004–1.04).

Interpretation The Crisis Link helpline was associated with a large but non-significant short-term decrease in suicide rates. However, this outcome was not sustained; this may, in part, be attributable to media reporting which was associated with increased suicides. This should inform suicide prevention policies in Canada and worldwide.

Funding No funding.

Introduction

Suicides on subway systems are an important public health issue—impacting not only the individual, but also their loved ones, traumatized witnesses, and commuters who experience subsequent transit delays.[1,2] In 1954, Canada's first subway was built by the Toronto Transit Commission (TTC) in Toronto—today, Canada's most populous city.[3,4] In 2017, the TTC was ranked as North America's third largest transit system by ridership, following New York City and Mexico City.[5] In 2020, TTC's subway system counted 84,605,245 rides, equivalent to over 230,000 passengers daily.[6]

Johnston and Waddell published the trends in suicide deaths (N = 207) and attempts (N = 223) on the TTC subway system from its inception in 1954 until 1980.[7] Among all suicides in Toronto in 1979, death by subway represented 5.5% of fatalities.[7] Suicides on the TTC gradually increased over the 26 years following the subway's opening, which was consistent with national suicide statistics.[7] TTC-related suicides were most

*Corresponding author. Department of Psychiatry, Sunnybrook Health Sciences Centre, 2075 Bayview Avenue, Room FG22b, Toronto, ON M4N 3M5, Canada.
E-mail address: mark.sinyor@sunnybrook.ca (M. Sinyor).

Research in context

Evidence before this study

A literature search in Ovid MEDLINE, Ovid EMBASE, and APA PsycINFO was conducted in November 2023 with the aim of identifying prior published literature on suicide on subway systems in general and the Toronto Transit Commission (TTC) subway system specifically. Search results were not limited by publication date or language. First, we searched for evidence on suicide telephone helplines for subway systems—("railroad trains" OR "railroads" OR "railway" OR "subway" OR "public transportation") AND ("suicide") AND ("hotlines" OR "helpline" OR "phone line" OR "crisis intervention"). There is limited literature on this topic; only one study conducted in Denmark evaluated the outcomes of implementing signs on subway platforms to encourage individuals in crisis to call a suicide helpline. Secondly, we searched the literature regarding the influence of media reporting and suicides —("railroad trains" OR "railroads" OR "railway" OR "subway" OR "public transportation") AND ("suicide") AND ("media" OR "news" OR "report"). There is substantial evidence that media reporting about suicide has been associated with subsequent increases in suicide by the same method. Finally, we searched specifically for articles about suicide on the TTC subway system in Toronto, Canada—("Toronto" OR "Greater Toronto Area" OR "Toronto Transit Commission" OR "TTC") AND ("railroad trains" OR "railway" OR "subway" OR "public transportation"). The literature search identified three relevant studies, which describe 1) deaths by suicide from 1954 to 1980, 2) injury patterns from 2010 to 2018, and 3) TTC's gatekeeper suicide prevention initiative.

Added value of this study

To our knowledge, this is the first study to comprehensively analyze recent suicide trends on Toronto's subway system from 1998 to 2021, to study the impact of the Crisis Link helpline, and to assess for any association between media reporting about TTC suicide incidents and subsequent suicide rates. The introduction of Crisis Link on all subway platforms in 2011 was associated with an immediate decrease in suicide rates on the TTC. However, this outcome was not sustained in the long-term; this may, in part, be attributable to the presence of media reporting about TTC suicide incidents which was associated with increased suicides. Furthermore, the demographic trends suggest that adult men with serious mental illness, those with prior suicide attempts, and those who are single and live alone—are at higher risk of dying by suicide on the subway.

Implications of all the available evidence

These results point to the utility of suicide helplines on subways, but also, the potential for negative impacts of media reporting about a high-lethality suicide method. This should inform suicide prevention policies in Canada and around the world. Specifically, interventions such as Crisis Link may need to be augmented over time to sustain effectiveness. The results also underscore the importance of responsible media reporting. Lastly, to identify unique risk factors for subway-related suicide, future studies can compare these characteristics to those of people who died by other suicide methods.

prevalent mid-day (10 am–5 pm), in November and December, and at older subway stations, transfer stations, and stations located near psychiatric institutions.[7] From 1954 to 1980, individuals involved in TTC suicide incidents were often female, aged 20–30, and had a history of psychiatric illness.[7] Those who survived their suicide attempt subsequently stayed in hospital for ~15 weeks, with a high incidence of traumatic amputation.[7] A recent retrospective cohort study characterized the injury patterns and outcomes of patients presenting with subway-related trauma at a level 1 adult trauma centre in Toronto from 2010 to 2018.[8] Among these patients, overall fatality rate was 29% and severe injuries were commonly sustained to the head, thorax, and lower extremities.[8] Most recently, during 2020, a media article reported that suicides on the TTC increased during the COVID-19 pandemic.[9]

To prevent suicides, the TTC has developed several initiatives (Supplementary Table S1). A 2011 study evaluated the TTC's gatekeeper program; it found that suicide prevention training for TTC employees improved their knowledge of suicide and intervention skills to help a suicidal individual on the subway system.[10] In 2011, the TTC also partnered with Distress Centres of Greater Toronto and Bell Canada to implement Crisis Link—the first public/private/not-for-profit partnership in the world to develop a suicide helpline on the subway.[11] All platforms were equipped with posters and payphones, which encourage anyone contemplating suicide to call Crisis Link for free.[11] Crisis Link connects callers with a trained counsellor, who assesses their suicide risk.[11] Counsellors provide de-escalation and safety planning if the caller is at low risk of harm.[11] If there are imminent safety concerns, counsellors liaise with TTC Transit Control to slow or stop trains.[11]

Whereas Crisis Link supports individuals in crisis, there are many upstream factors which may also influence suicidality. One population-level factor is media reporting about suicide using specific methods, which has been associated with subsequent increases in suicide by the same method.[12–18] This phenomenon of imitative suicide, known as the Werther effect, is especially pronounced with media reports of celebrity suicides—with an associated 30% increase in deaths by the same method in the following 14–60 days.[18] The

Werther effect is attributed to social learning, where individuals who are already susceptible relate to someone in a news story who has attempted or died by suicide.[16] When news reports portray a simplified storyline such as a cause and effect relationship between a stressful life event and suicide, this may cause harm by: 1) failing to communicate the complexity of suicide risk factors (e.g. family history, early life experiences, mental illness), 2) positioning suicide as an inevitable outcome, and 3) omitting information on how to overcome suicidal crises.[16] Responsible media reporting guidelines have been developed in an attempt to minimize Werther effects; they generally ask journalists not to report on suicide methods.[19–22]

The primary objective of this study was to investigate how suicide rates on the TTC subway system have changed over the period of data availability (1998–2021) and, specifically, whether they changed after Crisis Link was introduced in 2011. The secondary objective was to determine whether media reporting about TTC suicide incidents was associated with changes in TTC-related suicide rates. Lastly, our exploratory objectives were to describe the characteristics of individuals a) who are involved in suicide incidents and b) who seek help via Crisis Link.

Methods
The present study adhered to the STROBE reporting criteria for observational cross-sectional studies (Supplementary Table S2).[23] The following outcomes, exposure, and confounding variables were collected (Fig. 1). Any missing information in the below datasets were recorded as unknown or not available.

Outcome variables
The outcome of interest was quarterly suicide counts. The Office of the Chief Coroner of Ontario granted access to records for suicides in the Greater Toronto Area from 1998 to 2021. We collected detailed data about suicides on the TTC, and aggregate counts of suicides in Toronto by other methods to examine overall trends. Data collected for each suicide included: demographic data (i.e. age, gender, marital status, living situation), history of mental and/or medical illness, recent stressors (i.e. personal, medical, or criminal justice involvement), and details of the suicide (i.e. location of incident, time of day, witnesses, location of death).

The TTC provided information on non-fatal suicide attempts on the subway. This data was only available from 2004 to 2021. A suicide attempt was defined as a non-fatal self-directed behaviour with an intent to die. However, there were some changes in the TTC's definition of "suicide attempt" over the years. The TTC broadened its reporting of suicide attempts in 2014 to also include attempts that did not contact the train, and later in 2017, individuals who reach track level and are apprehended under the Mental Health Act (MHA). For each attempt, we collected the date, gender and age of the individual, whether a call to Crisis Link had been made, and whether the individual was physically contacted by the train.

The TTC also provided data on MHA apprehensions (i.e. date, intervenor, age and gender of individual). Once again, this data was not available for the entire study period; only from 2011 to 2021. An apprehension followed when Crisis Link, TTC employees, Toronto Police Service, TTC Special Constables, or another customer intervened before there was an attempt; police and/or special constables subsequently apprehended the individual. In these cases, an individual was classified as having suicidal intent and, in the judgment of authorities, had taken action to put themselves in harm's way (e.g. was located on the platform), but was not at track level yet.

Exposure variables
The exposure of interest was implementation of Crisis Link. For Crisis Link data, the Distress Centres of
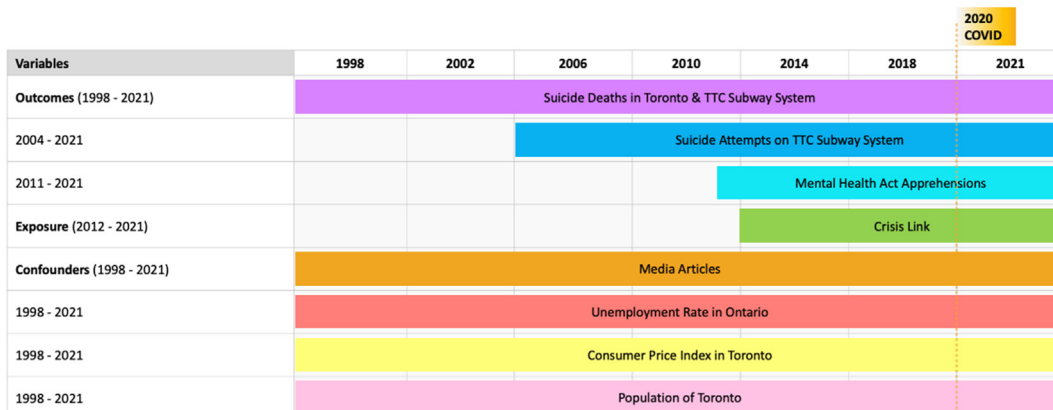

Fig. 1: Timeline of study outcomes, exposure, and confounding variables. TTC—Toronto Transit Commission.

Greater Toronto provided the number of calls, age and gender of each caller, and types of interventions made since its inception in 2011. Thus, Crisis Link data was obtained from December 2012 to 2021.

Confounding variables

To investigate the association between TTC-related media coverage and suicide rates, we searched our database of all media articles related to suicide published in the Toronto press between 1998 and 2021. The following search terms were used to identify relevant articles: subway, train, platform, rail, transit, station, track, TTC, line, Crisis Link. To be included, an article must have reported on specific suicide(s) occurring on the TTC. Media guidelines discourage journalists from reporting on suicide methods.[19] Note that we did not perform a content analysis of the media articles collected for this study; however, all of them, by definition, included potentially problematic content that is discouraged by media guidelines. Trained coders read the full text of identified articles to determine their eligibility. The date of included articles was retrieved, and quarterly counts of TTC-related media articles was calculated.

Finally, we collected control variables for our analysis. The monthly unemployment rate in Ontario and Consumer Price Index (CPI) in Toronto between 1998 and 2021 were obtained from Statistics Canada.[24,25] Quarterly data was calculated by taking the three-month average, which we then used to construct variables representing the change in CPI from the previous quarter and the change unemployment. The population of Toronto was retrieved from the 1996, 2001, 2006, 2011, 2016, and 2021 Canadian census.[26–30] We assumed linear growth within each 5-year census period to estimate the quarterly population during non-census years.

Statistical analysis

Quarterly counts of deaths by suicide on the TTC and by other methods were calculated. Interrupted time-series analysis using Poisson regression with a logarithm link function was performed to investigate the association between Crisis Link and quarterly suicide rates. The over-dispersion assumption for Poisson regressions and the autocorrelation assumption for time-series analysis were assessed.

The dependent (outcome) variable was quarterly counts of suicides on the subway system. The independent (exposure) variable was the implementation of Crisis Link (April 2011). An interaction term between linear time trend and the intervention (time*Crisis Link) was input into the model to depict the trend in suicide rates after the introduction of Crisis Link. The lagged-term count of suicide cases on the TTC system (–1 quarter) was input into the model to account for temporal dependence. The number of TTC-related media articles in the past quarter was added to the model, as were other potential confounders—including the number of suicides by other methods in the same quarter, quarterly change in the unemployment rate in Ontario, quarterly change in CPI in Toronto, seasonal variation (four quarters per year), and COVID-19 pandemic (binary variable, positively coded starting from April 2020). The confounders were selected based on variables identified as factors associated with suicide in the literature and those that also relate to the implementation of Crisis Link.[31–34] All met the modified disjunctive cause criteria for inclusion in our study.[35] The log of Toronto's population in the corresponding quarter was included in the model as the offset variable.

To interpret the association between time and suicide rate in the post-intervention period, the linear combination of the time trend and intervention*time coefficients was calculated. Results were presented as incidence rate ratios (IRRs) and 95% confidence intervals (CIs) for suicide on the TTC. We also estimated the relative risk, a recently developed estimate for quantifying effect sizes in the interrupted time-series context for count outcomes,[36,37] and we plotted the model's fitted and counterfactual values. We undertook several sensitivity analyses to test the robustness of our main result to different assumptions. We examined whether time should be entered as a non-linear effect by comparing our primary model with the best fitting model identified from fitting a series of fractional polynomials to the data with up to 2 powers (using the default values in Stata, from –2 to 3); we tested if excluding the COVID-19 period (April 2020 onwards) altered the results; and we examined the results over a shorter window of time (2005–2016).

For our exploratory objective, we compared the distribution of gender between the three groups (i.e. MHA apprehensions for suicidal behaviour, non-fatal suicide attempts, suicide deaths) using a Chi-square (χ^2) test. Type I error was pre-specified as 0.05. Analyses were conducted using Stata/SE 16.1 and R, version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria). This study was approved by Sunnybrook Health Sciences Centre research ethics board (REB Pin No.199-2012).

Role of the funding source

This study was not funded.

Results

There were 302 deaths by suicide on the TTC subway system from 1998 to 2021, 258 non-fatal attempts from 2004 to 2021, and 473 MHA apprehensions for suicidal behaviour from 2011 to 2021. Of the 302 fatalities, 278 (92%) died on the scene, 21 (7%) died in hospital, one (0.3%) died at home, and the location of death was unknown for two cases (0.7%). Among all suicide

methods, death by subway represented less than 10% of total suicides in Toronto annually (Fig. 2).

Fig. 3 illustrates the trend of annual suicide rates on the subway between 1998 and 2021. Suicide rates were higher during the early years, recorded at 0.74 and 0.93 per 100,000 population in 1999 and 2000 respectively. However, a decline occurred in 2011 when Crisis Link was introduced (0.31 per 100,000 population). Suicide rates remained relatively steady until 2013. Since then, they gradually increased to 0.40 and 0.83 per 100,000 population in 2019 and 2020. There was a large drop in suicide rates in 2021.

In total, 255 TTC-related media articles were identified during the study period (Fig. 3). There were spikes in TTC-related articles in July–September 2000 (N = 37), October 2009–March 2010 (N = 42) and April–September 2018 (N = 29). There was also a positive association between suicide rates on the subway and the number of TTC-related media articles in the preceding quarter. For each additional media article, the suicide rate for the subsequent quarter increased by 2% (IRR = 1.02, 95% CI = 1.004–1.04). No significant association was found with the other control variables.

Table 1 summarizes the interrupted time-series analysis after adjustment for covariates. Time was not associated with a change in TTC-related suicide rate before the intervention period (IRR = 0.99, 95% CI = 0.98–1.001). The implementation of Crisis Link was associated with a large but non-significant decrease in the suicide rate in that same quarter (IRR = 0.64, 95% CI = 0.36–1.12). However, each subsequent quarter after this then experienced an average 2% increase in the suicide rate (IRR = 1.02, 95% CI = 1.004–1.04). These findings are plotted in Fig. 4. This figure shows a line of best fit that includes the effect of covariates on the prediction and a line of best fit that isolates the time effects (i.e. by averaging the covariates before generating

the prediction). The relative risk effect size was 1.35 (95% CI = 0.76–2.37). The model's fitted and counterfactual values are contained in Supplementary Fig. S1. The relative risk effect size estimate and the counterfactual analysis indicate that if Crisis Link had not been implemented, the suicide rate on the TTC system would have shown a decreasing trend, noting that the confidence intervals include the null value of 1.00. The model assumptions of autocorrelation ($p = 0.20$) and over-dispersion ($p = 0.25$) were not violated.

A sensitivity analysis testing whether time should instead be entered as a non-linear term using fractional polynomials suggested that a better fitting model ($p = 0.009$) was one where time was transformed to the powers of −2 and −1 (Supplementary Fig. S2). While there were differences between the primary model and this model in the pre-intervention trend, the post-intervention trend was essentially flat and followed the same trajectory as the primary model. A second sensitivity analysis excluding the COVID-19 period from the data also resulted in a similar set of results (Supplementary Table S3), with the main difference being a reduction in suicides the quarter the intervention was implemented (IRR = 0.53, 95% CI = 0.29–0.95). Finally, the results for the sensitivity analysis with a shorter study window showed no evidence of a change in suicides after implementation of Crisis Link (IRR = 0.54, 95% CI = 0.24–1.22) (Supplementary Table S3).

Demographics: Crisis Link callers

From its inception in 2011 to 2021, there were 243 calls to Crisis Link. Among all calls, 175 (72%) callers were deemed to be low-risk and managed by de-escalation and safety planning. Six (3%) of the 175 low-risk calls were made by a third party. There were 38 (16%) callers at medium-risk for imminent harm, which prompted
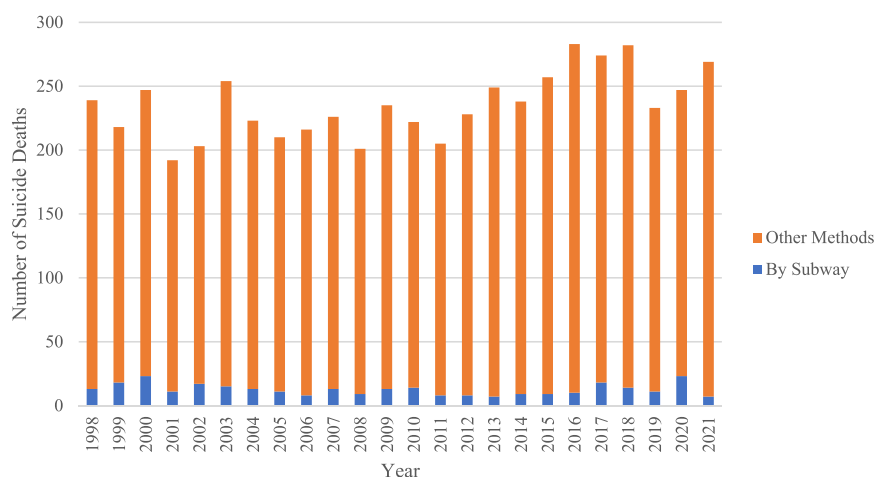

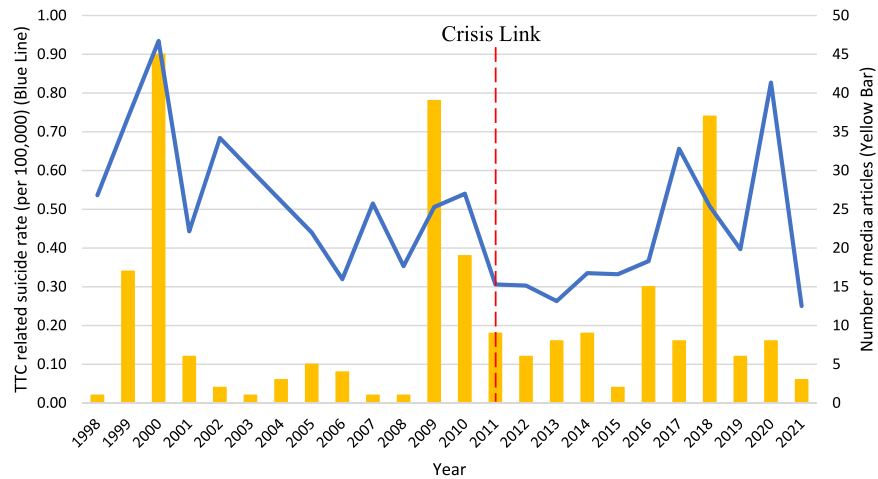Fig. 2: Suicide deaths in Toronto from 1998 to 2021.

Fig. 3: Annual TTC-related suicide rates in Toronto and the number of media articles, 1998 to 2021. TTC—Toronto Transit Commission.

Crisis Link to liaise with TTC Transit Control to slow subway trains. Thirty (12%) callers were assessed to be at high-risk of suicide; Crisis Link subsequently contacted TTC Transit Control to stop the trains. Most individuals seeking help from Crisis Link were female (62% low-, 76% medium-, 57% high-risk calls) (Table 2).

Demographics: fatal suicide incidents

When comparing individuals who were apprehended for suicidal behaviour, who survived a suicide attempt, and those who died by suicide on the TTC, there were differences in gender and age. Individuals who died were predominantly male compared to both other groups

(OR = 2.26, 95% CI = 1.69–3.01), and older (mean age = 41 ± 17 years for suicide deaths, vs. 32 ± 12 years for MHA apprehensions, vs. 39 ± 17 years for suicide attempts). The majority (71%) of the deceased were adults, followed by youth under 25 (17%) and older adults above 65 (13%). Of all fatalities, 83% were witnessed by the subway operator and 60% by passengers (Table 3).

Coroner's records contained demographics of those who died by suicide on the TTC (Table 4). Most individuals were single (74%) and lived alone (56%). Some had a history of psychiatric illness(es)—most commonly depression (35%), schizophrenia (14%), or substance abuse (11%). A subset (11%) of individuals were seen by

	Incidence rate ratio (95% CI)	p-value
Step change (intervention-Crisis Link)	0.64 (0.36–1.12)	0.11
Pre-intervention trend (linear time in quarters)	0.99 (0.98–1.001)	0.071
Post-intervention trend (intervention*time in quarters)	1.03 (1.01–1.06)	0.0043
Effect of time in the post-intervention period	1.02 (1.004–1.04)[a]	0.020
Control variables:		
Number of TTC-related suicide case in the past quarter	0.99 (0.93–1.07)	0.84
Number of suicide cases using other methods in the same quarter	0.99 (0.98–1.01)	0.38
Quarterly change in unemployment rate	1.02 (0.86–1.20)	0.86
Quarterly change in CPI	0.90 (0.70–1.15)	0.39
COVID pandemic	0.78 (0.43–1.42)	0.19
Number of TTC-related suicide media articles in the past quarter	1.02 (0.004–1.04)	0.019
Seasonal variation		
Quarter 1 (Jan–Mar)	Reference	
Quarter 2 (Apr–Jun)	1.15 (0.79–1.67)	0.47
Quarter 3 (Jul–Sep)	1.16 (0.79–1.68)	0.45
Quarter 4 (Oct–Dec)	1.13 (0.80–1.62)	0.48

TTC—Toronto Transit Commission. CI—Confidence interval. CPI—Consumer price index. [a]The effect of time in the post-intervention period was calculated by the linear combination of the linear time trend and the intervention*time coefficients.

Table 1: Association between the implementation of Crisis Link with TTC-related suicide rates in Toronto, 1998 to 2021.
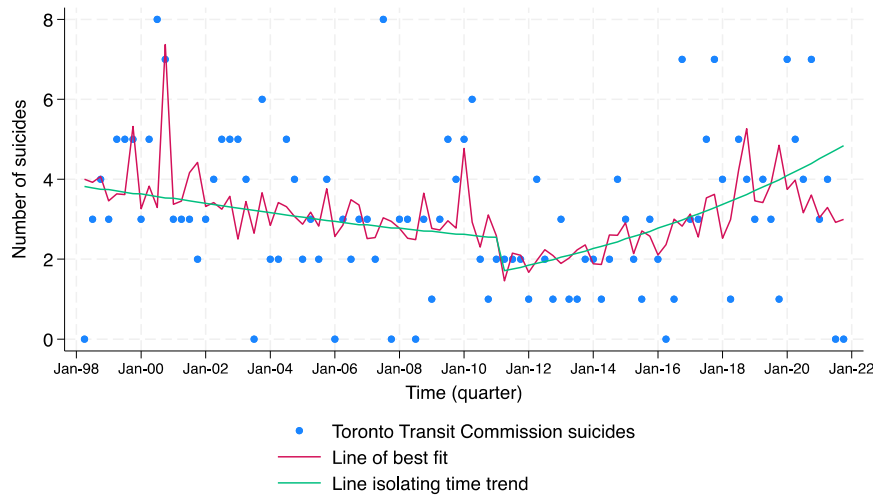
Fig. 4: **Association of Crisis Link with TTC-related suicide rates in Toronto, 1998 to 2021.** TTC—Toronto Transit Commission.

a psychiatrist or in the emergency room the week prior to their passing. There were 21% who had a known history of previous suicide attempt(s). A suicide note was left in 11% of cases.

Demographics: non-fatal suicide incidents

Of the 473 MHA apprehensions from 2011 to 2021, 49% were male, 42% female, and gender was unknown for the remaining 9%. Toronto Police Service and Special Constables intervened in 70% of cases, followed by TTC employees (16%), TTC customers (9%), and Crisis Link (6%) (Table 3).

Among 258 people with non-fatal suicide attempts from 2004 to 2021, there were more males (58%) than females (42%) involved. Nearly half (49%) of the suicide attempt group were adults, followed by a smaller proportion of youth (11%) and older adults (6%). Since

Variable	Low-risk: de-escalation (N = 175)	Medium-risk: slow subway trains (N = 38)	High-risk: stop subway trains (N = 30)
Gender			
Male	64 (37%)	9 (24%)	13 (43%)
Female	108 (62%)	29 (76%)	17 (57%)
Not Available	3 (2%)	0 (0%)	0 (0%)
Age groups			
Youth (<25 years)	25 (14%)	6 (16%)	0 (0%)
Adult (25–64 years)	74 (42%)	10 (26%)	8 (27%)
Older adult (≥65 years)	2 (1%)	1 (3%)	0 (0%)
Unknown	74 (42%)	21 (55%)	22 (73%)

Table 2: **Demographics of individuals who called Crisis Link from 2012 to 2021 according to assessed risk level.**

Crisis Link's 2011 inception, there was only one known instance where an individual called Crisis Link and then went on to attempt suicide on the TTC (Table 3).

Discussion

To our knowledge, this is the first study to comprehensively analyze recent suicide trends on Toronto's subway system from 1998 to 2021, to study the impact of the Crisis Link helpline, and to assess for any association between media reporting about TTC suicide incidents and subsequent suicide rates. The introduction of Crisis Link on all subway platforms in 2011 was associated with a large but non-significant 36% decrease in the suicide rate in that same quarter. However, this decrease waned over time, with each following quarter then experiencing an average 2% increase in suicide rate.

This conclusion was reinforced by the three sensitivity analyses. First, the primary model used time as a linear variable. When testing whether non-linear transformations of time would result in a better fitting model, the suicide trend after Crisis Link implementation did not differ from the primary model. Secondly, when the COVID-19 period was excluded from the dataset, the sensitivity analysis confirmed there was a reduction in suicides during the same quarter that Crisis Link was initiated. Lastly, when shortening the study window to 2005 to 2016, there was no evidence of a change in suicide rates after implementation of Crisis Link. This suggests that the observed increase in suicide may only be apparent when looking at long-term trends.

Based on the relative risk effect size, there was some evidence that the net effect of Crisis Link was an increase in suicides on the subway. However, there is considerable uncertainty in this estimate and the range included values that are indicative of no net change. Similarly, while our counterfactual analysis indicated

Variable	Mental Health Act apprehensions from 2011 to 2021 (N = 473)	Non-fatal suicide attempts from 2004 to 2021 (N = 258)	Suicide deaths from 1998 to 2021 (N = 302)
Gender[b]			
Male	230 (48.6%)	149 (57.8%)	214 (70.9%)
Female	198 (41.9%)	109 (42.3%)	87 (28.8%)
Not available	45 (9.5%)	0 (0%)	1 (0.3%)
Age (years)			
Mean (SD)	32 (12)	39 (17)	41 (17)
Age groups			
Youth (<25 years)	41 (8.7%)	29 (11.2%)	50 (16.6%)
Adult (25–64 years)	90 (19.0%)	125 (48.5%)	213 (70.5%)
Older adult (≥65 years)	0 (0%)	15 (5.8%)	38 (12.6%)
Unknown	342 (72.3%)	89 (34.5%)	1 (0.3%)
Intervenor for apprehensions			
Crisis Link	28 (5.9%)	–	–
TTC employee	75 (15.9%)	–	–
Toronto Police Service/Special Constables	330 (69.8%)	–	–
Customer	40 (8.5%)	–	–
Crisis Link involvement			
Yes	–	1 (0.4%)	–
No	–	184 (71.3%)	–
Unknown	–	12 (4.7%)	–
Not available before 2011	–	61 (23.6%)	–
Suicide attempt			
Contacted	–	157 (60.9%)	–
Not contacted	–	18 (7.0%)	–
Not available before 2014	–	83 (32.2%)	–
Witnesses			
Subway operator	–	–	250 (82.8%)
Passengers	–	–	180 (59.6%)

SD—standard deviation. TTC—Toronto Transit Commission. [a]p-value < 0.0001. [b]Note that data for non-fatal suicide attempts and Mental Health Act apprehensions were only available from 2004 to 2011 onwards respectively.

Table 3: **Demographics of individuals with Mental Health Act apprehensions, non-fatal suicide attempts, or deaths on the TTC subway system (1998 to 2021).**[a]

Variable (N = 302)	
Marital status	
Single or none listed	223 (73.8%)
Divorced/separated	20 (6.6%)
Married	53 (17.6%)
Widowed	5 (1.7%)
Divorced & widowed	0 (0%)
Unknown	1 (0.3%)
Living circumstance	
Alone	168 (55.6%)
With others	133 (44.0%)
Unknown	1 (0.3%)
Bereavement in past year	
No	291 (96.4%)
Yes	10 (3.3%)
Unknown	1 (0.3%)
Employment/financial stress	
No	275 (91.0%)
Yes	26 (8.6%)
Unknown	1 (0.3%)
Intimate relationship breakup	
No	292 (96.7%)
Yes	9 (3.0%)
Unknown	1 (0.3%)
Interpersonal conflict stressor	
No	279 (92.4%)
Yes	22 (7.3%)
Unknown	1 (0.3%)
Recent medical/health stressor	
No	287 (95.0%)
Yes	14 (4.6%)
Unknown	1 (0.3%)
Police/legal stressor	
No	286 (94.7%)
Yes	15 (5.0%)
Unknown	1 (0.3%)
Offense	
No	283 (93.7%)
Yes	12 (4.0%)
Unknown	7 (2.3%)
Immigrant status	
No	288 (95.4%)
Yes	2 (0.7%)
Unknown	12 (4.0%)
Past suicide attempts	
No or not reported	225 (74.5%)
At least one	34 (11.3%)
Multiple	30 (9.9%)
Unknown	13 (4.3%)
Suicide note left	
No	258 (85.4%)
Yes	32 (10.6%)
Unknown	12 (4.0%)
	(Table 4 continues on next page)

that suicide may have declined in the absence of the intervention, this is based entirely on a prediction from the model, not from observations from a comparison group. This prediction could be influenced by unmeasured confounding and is therefore not a strong test of what would have happened in the absence of the intervention.

Additionally, each media article about TTC suicide incidents was associated with a 2% increase in the suicide rate of the next quarter. These results provide insight into the potential benefits of Crisis Link for suicide prevention, as well as concerns about media coverage of suicides on subways.

Lastly, there was some year-to-year variability of suicide rates on the TTC. For example, 2020 had the

Variable (N = 302)	
(Continued from previous page)	
Psychiatry or emergency room in past week	
No	254 (84.1%)
Yes	33 (10.9%)
Unknown	15 (5.0%)
Mental health condition	
Depression	106 (35.1%)
Schizophrenia	41 (13.6%)
Substance abuse	34 (11.3%)
Bipolar	17 (5.6%)
Anxiety	14 (4.6%)
Other	107 (35.4%)
Physical health condition	50 (16.6%)
Toxicology completed	
No	270 (89.4%)
Yes	32 (10.6%)
Drugs detected	24 (8.0%)
Psychiatric drug present	14 (4.6%)
Intoxicated with alcohol at death	6 (2.0%)
Intoxicated with illegal drug at death	5 (1.7%)

Table 4: Detailed demographics of individuals who died by suicide on Toronto's subway system from 1998 to 2021.

second highest rate of any year in our study while 2021 had the lowest rate. The reasons for these observations are unclear, but future work could investigate the relationship with factors associated with the COVID-19 pandemic such as timing of lockdowns.

Crisis Link

The short-lived decrease in suicide rates following implementation of Crisis Link is consistent with evaluations of other suicide prevention strategies—including gatekeeper training,[38,39] means restriction for charcoal burning suicide,[40] and crisis line services.[41] In each case, a short-term effect was prominent, but effectiveness appeared to decrease with time. It is possible that Crisis Link was effective initially, but only transiently, at raising people's awareness and promoting help-seeking behaviours. It is also possible that Crisis Link's impact was obscured or undermined over time due to confounders including media reporting (see below) or others we did not have access to or account for. For instance, suicides at the Skyway Bridge in the USA greatly increased in the 13 years following the implementation of six crisis telephones in 1999.[42,43] This was attributed to a popular website sharing information about suicides on the bridge, among other distressing content which may have inspired imitative behaviours.[42,43] We are not aware if similar external factors diminished the benefits of Crisis Link.

There is limited literature on suicide helplines specifically for subway systems. Most recently, a pilot study from Denmark implemented an intervention similar to

Crisis Link.[44] In December 2019, 12 posters were placed at one Danish railway station, consisting of "Is life difficult? We are here to help", followed by the national suicide helpline and emergency service phone numbers.[44] From January 2020 to April 2021, there were no deaths by suicide (compared to 1.5 deaths/year pre-intervention) and one suicide attempt; however, this follow-up period was not long enough to conclusively evaluate efficacy.[44] During the same time, the suicide helpline received 14 calls who reported they had seen the posters encouraging help-seeking.[44] However, an additional two individuals found the signs distressing and expressed concern that it could trigger suicidal ideation in themselves.[44] To address this issue, suicide prevention campaigns should consult mental health experts and individuals with lived experience.[44]

Media reporting

The results also identified a positive association between the number of TTC-related media articles and suicides in the subsequent quarter. This is consistent with previous findings that media reporting of suicide was related to increased suicide by the same method in the following period.[12–18] For this reason, guidelines on suicide reporting have been developed in Canada and other countries worldwide.[16] Most notably in Austria, the introduction of media guidelines in 1987 resulted in a significant decrease ($p < 0.008$) in the number of headlines containing "suicide" and "self-murder".[45] Within the same year, a moratorium on reporting suicides on the Austrian subway system resulted in a decrease from 18 media articles in the year before, to only seven articles over the next 18 years.[45] In the first year after the media guidelines and moratorium (1987–1988), there was a significant annual decrease of 81 suicides (95% CI = −149 to −13) in Austria overall and ten suicides on the subway system (95% CI = −15.1 to −5.4).[45] Subsequently, there was a sustained reduction of 3.4 suicides (95% CI = −5.0 to −1.8) on the subway annually until the study ended in 2005.[45] Austria provides strong evidence that adherence to responsible media guidelines about suicide can impact suicide incidence and the quality and quantity of reporting.[45]

Canada can learn from Austria's example and should aim to increase education for media about the importance to avoid promulgating suicide locations and methods such as the subway. For media recommendations to be effective, there must be robust uptake by journalists. Notably, at Canada's first media forum for suicide prevention in 2015, some journalists were skeptical about whether media reporting is linked with increased suicides.[16] Our present study addresses this issue, demonstrating that media reports of TTC-related suicides were indeed associated with a subsequent increase in suicides. Journalists further raised concerns about the feasibility of media guidelines.[16] They highlighted that newsworthy suicides are reported to inform

the public and to prevent taboo or stigma around suicide.[16] Given these concerns, the mental health and media sector should continue to collaborate to enhance national recommendations for safe reporting of suicide and their dissemination and uptake.[16]

Demographics: at-risk groups

The demographic trends we identified suggest that adult men with serious mental illness, those with prior suicide attempts, and those who are single and live alone comprise the group most likely to die by suicide on Toronto's subway. Men were also more likely to be involved in non-fatal suicide incidents, whereas women more often exhibited help-seeking behaviour by calling Crisis Link. This information paints a clear picture of who may be at risk of transit suicide, which is particularly relevant for major subway systems and mental health professionals in urban areas. Suicide prevention efforts on the subway could, for example, promote help-seeking in a way that is more likely to target and resonate with men.

Demographics: comparison to Toronto data from 1954 to 1980

The demographics of individuals involved in suicide deaths (N = 207) and attempts (N = 223) on the TTC subway system from its inception in 1954 until 1980 has previously been published.[7] The following characteristics remained consistent with our study (1998 to 2021): 1) depression and schizophrenia were the most prevalent psychiatric diagnoses, 2) a subset had prior suicide attempt(s) (14% from 1954 to 1980, 21% from 1998 to 2021).[7] Among all individuals involved in suicide incidents on the TTC system from 1954 to 1980, females (59%) outnumbered males (41%).[7] In contrast, from 1998 to 2021, the deceased were 71% male vs. 29% female

(Table 5). This suggests that over the years, the gender distribution among suicides on the Toronto subway system has shifted to be mostly male—which is consistent with other urban subway systems, violent methods of suicide, and a recent publication reporting the outcomes of trauma patients in Toronto who presented with a subway-related injury from 2010 to 2018.[1,7,8] Characteristics of individuals involved in TTC suicide incidents should continue to be assessed over time, allowing for interventions to be adapted and targeted towards those who use subways as a suicide modality.[46]

Demographics: comparison to other jurisdictions

Our demographic profile of individuals involved in transit suicide incidents in Toronto is comparable to other jurisdictions. A literature review of the epidemiology of suicides on subway systems also found that more males than females were involved with suicide incidents, and most of the deceased were single, living alone, and/or had a known psychiatric history.[1] Lastly, our findings are consistent with the literature, where at least 20% of suicides on subway systems had a history of prior suicide attempt.[1] Other studies reported that suicide notes were left by the individual in 15–21% of cases, which is higher than our study's 11% incidence rate.[1] However, suicide notes often did not specify a plan or intention to use the subway to end their life (Supplementary Text S1).[1]

Strengths

Strengths of our study include the large database we collected on TTC suicide incidents occurring over 23 years in Toronto–Canada's most populous city and North America's third largest transit system. Moreover, to our knowledge, no studies have examined the impact of both intentional interventions (e.g. Crisis Link helpline) and naturalistic phenomena (e.g. media reporting, unemployment rate, CPI, COVID-19 pandemic) on transit suicides of a large metropolitan city like Toronto. Our study addresses this gap.

Limitations

There are some limitations of our study. First, we acknowledge that there was some unknown and/or missing information in the datasets provided by the Coroner, TTC, and Distress Centres of Greater Toronto, which may have influenced results. Linkage of Coroner's and TTC datasets with health records was out of scope for this study, but could yield important insights in a follow-up study. Second, there were some changes in the TTC's definition of "suicide attempt" over the years. The TTC broadened its reporting of suicide attempts in 2014 to also include attempts that did not contact the train, and later in 2017, individuals who reach track level and are apprehended under the MHA. As a result, incidents which were not previously counted as "suicide attempts" prior to the definition changes

Variable	Johnston & Waddell study[7]: 1954 to 1980 (N = 207)	Our study: 1998 to 2021 (N = 302)
Gender[a]		
Male	178 (41.4%)	214 (70.9%)
Female	252 (58.6%)	87 (28.8%)
Not available	0 (0%)	1 (0.3%)
Age group: highest prevalence	20–30 years	25–64 years
Mental health condition[b]		
Depression	27 (13.0%)	106 (35.1%)
Schizophrenia	10 (4.8%)	41 (13.6%)
Substance abuse	–	34 (11.3%)
Bipolar	–	17 (5.6%)
Anxiety	–	14 (4.6%)
Other	36 (17.4%)	107 (35.4%)
Past suicide attempt(s)[b]	29 (14.0%)	64 (21.2%)

TTC—Toronto Transit Commission. [a]Johnston & Waddell study only reports the gender distribution for combined suicide attempts (N = 223) and deaths (N = 207) from 1954 to 1980. [b]Johnston & Waddell study: Coroner's records were only available for 119 cases.

***Table 5:* Suicide deaths on the TTC subway system from 1954 to 1980 vs. 1998 to 2021.**

were subsequently included in the annual count of suicide attempts in the years following 2014 and 2017. Thirdly, statistical results should be interpreted with caution due to the limited sample size and the insignificant results from one of the sensitivity analyses. However, the statistical power of this sensitivity analysis may be lacking due to even smaller sample size by restricting to a shorter time period, and our primary results were supported by another sensitivity analysis with longer time period and larger sample size. Additionally, the primary analysis of this study utilized the most comprehensive suicide sample obtained from the Coroner and TTC; there was no additional data we could draw upon. Next, the interrupted time-series results can only be interpreted at an ecological level. Although there is demographic data of Crisis Link callers, their experiences and perceptions of the helpline's effectiveness are unknown. Furthermore, while we included many relevant potential confounders in our analysis, there may be additional unaccounted for variables which could have influenced the results, for example ethnicity, which we were unable to measure. Our study also did not distinguish between different types and/or quality of media articles about suicide on the TTC. Future work should examine the nuances of which types of reporting may or may not have conferred harm. Finally, since this study analyzed Toronto's subway system from 1998 to 2021, it may be limited in its generalizability to other locations, eras, and transit systems.

Conclusion

The introduction of Crisis Link was associated with a numerically large but nevertheless non-significant decrease in suicide rates on the TTC. The numerical reduction was not sustained in the long-term; this may, in part, be attributable to media reporting which was associated with increased suicides. These results point to the potential utility of suicide helplines, but also, the potential for negative impacts of media reporting on a high-lethality suicide method. This should inform suicide prevention policies in Canada and around the world. Specifically, interventions such as Crisis Link may need to be augmented over time to sustain effectiveness. The results also underscore the importance of responsible media reporting. Finally, the demographic trends suggest that adult men with serious mental illness, individuals with prior suicide attempts, and individuals who are single and live alone—are at higher risk of suicide by subway. To identify unique risk factors for subway-related suicide, future studies can compare these characteristics to those of people who died by other suicide methods.

Contributors

SC, RZ, NJ, and MS submitted the study protocol and subsequently received approval from the Sunnybrook Health Sciences Centre Research Ethics Board.

SC led the project from study conceptualization to development of methodology, project administration, data collection, analysis, and interpretation, and manuscript writing.

VYM contributed to the development of methodology, data collection of media reports, conducted the interrupted time-series analysis, interpreted the results, and helped write the manuscript.

SC, VYM, RZ, AS, CT, ME, DS, MV, NJ, and MS all contributed to data collection for the study's large datasets. Specifically, AS and MS partnered with the Office of the Chief Coroner of Ontario to establish the database of suicide records. This data was subsequently collected by NJ and SC. Data of suicide incidents on the TTC was provided by CT; the data was then cleaned by RZ and SC. Crisis Link data was provided by ME at the Distress Centres of Greater Toronto; the data was then cleaned by RZ and SC. A database search of major Toronto media publications for TTC/subway-related articles was conducted by SC, VYM, DS, and MV.

SC, VYM, MJS, MS, and NJ directly accessed and verified the underlying data reported in the manuscript.

MJS contributed to the design and completion of statistical analysis, interpretation of results, and helped write the Methods and Results section.

MS supervised all stages of the study, providing oversight and leadership for the planning and execution of the project.

All authors helped revise and edit the manuscript.

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