Screening and Treatment of Posttraumatic Stress Disorder in Wildfire Evacuees: A Cost-Utility Analysis

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Abstract

Background. Global climate change is resulting in dramatic increases in wildfires. Individuals exposed to wildfires experience a high burden of posttraumatic stress disorder (PTSD), and the cost-effectiveness of the treatment options to address PTSD from wildfires has not been studied. The objective of this study was to conduct a cost-utility analysis comparing screening followed by treatment with paroxetine or trauma-focused cognitive behavioral therapy (TF-CBT) versus no screening in Canadian adult wildfire evacuees. **Methods.** Using a Markov model, quality-adjusted life-years (QALYs) and costs were evaluated over a 5-y time horizon using health care and societal perspectives. All costs and utilities in the model were discounted at 1.5%. Probabilistic and deterministic sensitivity analyses examined the uncertainty in the incremental net monetary benefit (INMB) under a willingness-to-pay threshold of $50,000. **Results.** From a societal perspective, no screening (NMB = $177,641) was dominated by screening followed by treatment with paroxetine (NMB = $180,733) and TF-CBT (NMB = $181,787), with TF-CBT having the highest likelihood of being cost-effective at a willingness-to-pay threshold of $50,000 per QALY (probability = 0.649). The initial prevalence of PTSD, probability of acceptance of treatment, and costs of productivity had the largest impact on the INMB of both paroxetine or TF-CBT versus no screening. Neither intervention was cost-effective at a willingness-to-pay threshold of $50,000 per QALY from a health care perspective. **Interpretation.** Screening followed by treatment with paroxetine or TF-CBT compared with no screening was found to be cost-saving while providing additional QALYs in wildfire evacuees. Governments should consider funding screening programs for PTSD followed by treatment with TF-CBT for wildfire evacuees.

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Highlights

- Two prior studies examined the cost-effectiveness of screening followed by treatment for PTSD among individuals exposed to other disaster-type events (i.e., terrorist attack and Hurricane Sandy) and found screening followed by treatment (i.e., cognitive behavioral therapy [CBT]) to be highly cost-effective.
- Among wildfire evacuees, screening followed by treatment with paroxetine or trauma-focused (TF)–CBT provides additional quality-adjusted life-years (QALYs) and is cost-saving from a societal perspective. TF-CBT was the treatment option found most likely to be cost-effective.
- Neither treatment option was cost-effective at a willingness-to-pay threshold of $50,000 per QALY from a health care perspective.
- Screening programs for PTSD should be considered for wildfire evacuees, and individuals diagnosed with PTSD could be prescribed either TF-CBT or paroxetine depending on their preference and resources availability.

Global climate change is resulting in devastating wildfires globally and in Canada, which are predicted to get worse as global temperatures continue to rise.[1] In 2016, the city of Fort McMurray, Alberta, was evacuated due to the Horse River Wildfire,[2] while nearly the entire town of Lytton, British Columbia, was destroyed by a devastating wildfire in 2021.[3] The year 2023 was the worst on record with an estimated 196,000 individuals evacuated due to forest fires as of mid-August.[4] Being evacuated from a wildfire results in a high risk of developing posttraumatic stress disorder (PTSD),[5] with a 3-month prevalence of PTSD of 29.1% among Fort McMurray evacuees,[6] a substantially greater prevalence than the general population's lifetime prevalence (9.2%).[7] Although there are limitations to the sampling of this study (i.e., small sample and convenience sampling), the prevalence estimated from this study is very similar to the prevalence of PTSD estimated from a systematic review among individuals experiencing nonintentional trauma.[8] Postwildfire PTSD is a chronic issue with a 10-y prevalence of 7.6%,[5] which is more than 3 times the prevalence of the general population (2.4%).[7] Despite significant distress, reduced health-related quality of life (HRQoL),[9] and increased health care burden,[10] PTSD often goes undetected and untreated in primary care.[11]

Trauma-focused cognitive behavioral therapy (TF-CBT) or treatment by selective serotonin reuptake inhibitors (SSRIs; e.g., paroxetine)[12] are typically recommended as first-line treatments for PTSD.[12,13] Although TF-CBT is more effective (i.e., higher remission rate)[14,15] and has negligible adverse effects, it costs more than 10 times as much as paroxetine. Moreover, it is not as easily implemented or accessible given it is usually administered by psychotherapists, who are a limited in number and whose services are often not covered by government-run health care plans.

Given there are tradeoffs between paroxetine and TF-CBT and that PTSD is highly elevated for a long period post wildfire,[5] modeling studies are needed to consider the dynamics of condition over time to appropriately estimate the impacts of treatment. Although there have been studies on the cost-effectiveness of different treatment options for PTSD[15,16] and for screening for PTSD

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after other types of disasters (i.e., terrorist attacks, hurricanes),[11,17] no studies have been conducted that examine the cost-effectiveness of different screening and treatment options in wildfire evacuees. Therefore, the objective of this study was to examine the incremental cost-utility ratio (ICUR) and incremental net monetary benefit (INMB; i.e., net monetary value of the health benefits) of screening followed by treatment with paroxetine or TF-CBT versus no screening in Canadian adult wildfire evacuees.

Methods

Study Design

An economic evaluation was conducted to evaluate screening followed by treatment with paroxetine or TF-CBT, both of which were compared with no screening for wildfire evacuees. Combining paroxetine and TF-CBT is not recommended as it is not more effective than individual treatments.[12] It was assumed that in the no-screening option, individuals would be treated with paroxetine as they seek care or are diagnosed over time. In the base case, it was assumed that all individuals who are offered treatment accept it. The target population was adults (≥18 y) evacuated from a region experiencing wildfires, regardless of whether their home or family members/friends were directly affected, given that there is a lack of evidence to suggest that the prevalence of PTSD meaningfully differs across other wildfire-specific exposures, such as property damage or injury.[5] Children were not examined since there were several school-based mental health–related programs implemented after the Fort McMurray wildfires.[18] Outcomes included quality-adjusted life-years (QALYs), costs, net monetary benefit (NMB), ICUR, and INMB. A QALY is a function of quality of life and length of life (e.g., 1 QALY is equivalent to a year spent in perfect health).

Screening

Individuals underwent a screening protocol similar to that of Hogan et al.,[11] which mimicked the protocol implemented after the 2005 and 2017 London bombings. Individuals were first screened with the Trauma Screening Questionnaire at 3 mo, and those who screened positive completed a Structured Clinical Interview for DSM-5 (SCID-5).[11] We similarly assumed that the SCID-5 is 100% accurate, and false positives are screened out by this tool, but the tool has a false-negative rate, which we applied.[11] Screening occurred at month 3 and month 9 after the wildfire.[11]
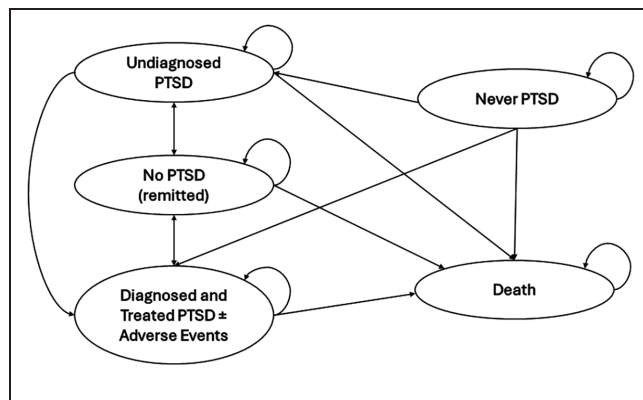

Figure 1 Simplified state transition diagram of a wildfire evacuees.

Model

The base case for the model was chosen to be a 30-y-old Canadian wildfire evacuee. A Markov model approach was used to simulate transitions between different health states of PTSD over time. The base-case time horizon was 5 y, given we modeled only the initial course of treatment, which lasted for 3 to 6 mo and aids comparison with other studies.[11,17] A within-cycle correction was applied, and the Markov model cycle length was 1 quarter (3 mo).

Model States

The Markov model enabled individuals to transition between the following health states as shown in Figure 1: never PTSD, remitted PTSD, undiagnosed active PTSD, diagnosed active PTSD, diagnosed active PTSD with treatment, and a death-absorbing state (i.e., a state from which individuals cannot transition out). The effect of screening was modeled by shifting all individuals with PTSD initially (prevalence = 18.8%[8]) from the undiagnosed active PTSD state to the diagnosed active PTSD with treatment state. Both undiagnosed active PTSD and diagnosed active PTSD with treatment were considered tunnel states, which enabled time-in-state specific remission rates for untreated PTSD.

Based on discussion with a psychiatrist (S.S.), the decision to not include mild-moderate-severe PTSD states was determined to be reasonable given this is not considered in treatment decisions.

Data

The data incorporated in the model were derived from the available literature (Table 1). The probabilities of

Table 1 Parameters Used in the Markov Model to Estimate Costs and Quality-Adjusted Life-Years for Canadian Wildfire Evacuees

Parameter	Parameter Value	Standard Deviation/Distribution Parameters	Source
Costs (inflation adjusted, quarterly): Gamma distribution			
Screening	$1,062.51	$1,062.51 × 0.20	Hogan et al.[11]
Paroxetine (including costs of 2 family physician visits per year)	$93.29	$93.29 × 0.20	Alberta College of Physicians, OHIP Schedule of Benefits[20,21]
TF-CBT	$3,150.00	$3,150 × 0.20	CBT Associates[22]
Health care	$228.03	$2,28.03 × 0.20	Lamoureux-Lamarche et al.[10]
Unemployment	$330.75	$330.75 × 0.20	Van Ameringen et al.[7] (% unemployment), Statistics Canada[23] (wages)
Caregiving	$1,092.47	$1,092.47 × 0.20	Davis et al.,[24] Statistics Canada[23] (wages)
Absenteeism and presenteeism	$2,570.57	$2,570.57 × 0.20	Davis et al.,[24] Statistics Canada[23] (wages)
Utilities: Beta distribution (yearly)			
Never PTSD	0.84	(Never PTSD-no PTSD) × 0.20	Hawthorne et al.[25]
No PTSD (remitted)	0.76	0.24	Hawthorne et al.[25]
PTSD	0.70	(No PTSD- PTSD) × 0.20	Hawthorne et al.[25]
Utility loss due to adverse events	0.06	0.06 × 0.20	Sullivan et al.[26]
Initial probabilities: Beta distribution			
Initial PTSD prevalence	0.19	0.09	Santiago et al.[8]
Acceptance of treatment	1.00	NA	Assumption
False-positive rate	0.00	NA	Assumption
False-negative rate	0.05	NA	Hogan et al.[11]
False-negative rate—9 mo	0.13	NA	Hogan et al.[11]
Transition probabilities (quarterly): Beta distribution			
Remission	Specific to time in state (quarters) 2: 0.23 3–4: 0.03 5–8: 0.03 9–20: 0.01	NA	Santiago et al.,[8] Mavranezouli et al.[15]
Death (non-PTSD)	Age specific	NA	Statistics Canada[27] (2017–2019 life table)
Death (PTSD)	$1 - e^{[HR*LN(1 - \text{age-specific mortality})]}$ HR: 1.54	NA	Statistics Canada[27] (2017–2019 life table), Giesinger et al.[28]
Recurrence	0.03	α = 2.60; β = 97.40 = Sqrt (0.11 × (1 − 0.11)/14,888) × sqrt(3) = 0.010	Mavranezouli et al.[15]
Adverse events	0.29	= Sqrt (0.03 × (1 − 0.03)/287) × sqrt (3) = 0.02	Sullivan et al.[26]
Diagnosis of PTSD without screening	0.10		Binet et al.[19]
Intervention effect estimates versus no treatment (odds ratios): log-normal distribution			
TF-CBT	14.06	95% CI: 6.76–29.81	Mavranezouli et al.[15]
Paroxetine	7.99	95% CI: 1.50–44.61	Mavranezouliet al.[15]

CI, confidence interval; HR, hazard ratio; NA, not applicable; OHIP, Ontario Health Insurance Plan; PTSD, posttraumatic stress disorder; TF-CBT, trauma-focused cognitive behavioral therapy. For studies that did not include standard deviations or confidence intervals, 0.20 × mean was chosen as the standard deviation, consistent with other studies.

diagnosis of PTSD over time without screening were specific to wildfire victims.[19] It was assumed that wildfire-induced PTSD had similar values for other parameters compared with PTSD induced by other forms of trauma given a lack of parameters specific to this population. This was considered reasonable based on conversations with a psychiatrist (S.S.) who mentioned that the effect of type of trauma is not a significant factor in PTSD clinical decision making. Where not quarterly, all original parameter values were converted to the quarterly values as shown in Table 1.

Probabilities

Time-in-state specific probabilities of remission for untreated PTSD were used. From a systematic review of untreated PTSD among patients with nonintentional trauma, the study prevalence at 3 mo is 18.8% and at 6 mo is 14.4%. Therefore, we assumed 23.4% remission ([18.8–14.8]/18.8)) from quarter 1 to 2.[8] After this period, from quarters 3 to 20, we used the time-in-state specific remission probabilities from Mavranezouli et al.[15] (Table 1). We used standard formulas to convert probabilities to rates and then rates to probabilities to estimate quarterly values from annual or monthly values. Given that some time is required to set up a screening program postwildfire and given spontaneous remission of PTSD is common after nonintentional trauma, a prevalence of 18.8% was chosen as the initial prevalence, which is the 3-mo prevalence of PTSD among individuals who have experienced nonintentional trauma and have not yet received intervention.[8]

Death rates were age specific and calculated based on published life tables,[27] and the hazard ratio of death due to PTSD was applied to this population to estimate the death rates for individuals with PTSD.[28] Given the prevalence of treatment was 33% at 1 y without a screening program postwildfire among Fort McMurray, Alberta, evacuees in 2016, the diagnosis of PTSD over time, without screening, was assumed to occur at the level found in Fort McMurray.[19] A 1-quarter incidence was calculated from this yearly value, and this value was assumed to be constant over time within the first year and beyond.

Utilities

Given the unavailability of utilities for the Canadian general population for individuals with active and remitted PTSD, we relied on values from the Australian general population from the Australian Survey of Mental Health and Wellbeing study.[25] The utilities for active (i.e., past-year PTSD; $n = 533$), remitted PTSD (i.e., lifetime PTSD; $n = 1,026$), and never PTSD ($n = 7,280$) were derived using the Assessment of Quality of Life (AqoL-4D) instrument, which consists of 4 domains (i.e., independent living, physical senses, psychological well-being, and social relationships).[25] To estimate the utility value from the AqoL-4D questionnaire, a multiattribute utility function was generated from a representative sample of the general population of Victoria, Australia, using the time-tradeoff method.[25] A reduction in utility from adverse events due to paroxetine was estimated using the EuroQol-5D.[15,26] Since no adverse effects were expected from the use of TF-CBT (discussed with S.S.), a probability and disutility of adverse effects of 0 were used.

Costs

All costs from a societal perspective were inflated to 2020 values using the Consumer Price Index for health and personal care.[29] The cost of screening was £588 in 2018,[11] which, after adjustment, equated to $1,092.47. These costs included the costs of program start-up, management, screening, and referral management.[11] It was assumed that individuals would receive paroxetine[20] for 3 mo at a dose of 20 mg/d, and during this period they would have 1 visit to a family physician to prescribe and oversee medication (cost: $36.85, K081 remote primary mental health care).[21] The cost of paroxetine for 1 quarter would be $56.44 for a total cost of $93.29 per quarter.[20] Each individual with PTSD received 12, 1.5-h-long sessions of TF-CBT over a period of 3 mo. This is in agreement with Hogan et al.[11] and slightly more than Mavranezouli et al.,[15] who included 9 sessions over 12 wk. The unit cost was $175 per hour[22] for a psychologist salary, which results in a total cost of $3,150 per quarter (12 sessions × 1.5 h × $175). Based on discussions with a psychiatrist (S.S.), it was assumed that individuals stopped treatment once they achieved remission, given limited resources to treat PTSD in the community and the high remission rate without treatment. To reduce the impact of this assumption, the base-case assumption was an additional 3 mo of treatment costs accumulated post-remission for individuals receiving paroxetine, which would similarly cost $93.29 (i.e., cost of drug with 1 physician visit). Given TF-CBT is a nonpharmacologic treatment, we assumed no maintenance treatment was required during remission. The total excess health care costs due to PTSD were based on a prior study that included outpatient, emergency department, hospitalization, and medication costs (except antidepressants) among individuals ≥65 y old.[10] The excess health care

costs of PTSD were assumed to be the same for adults <65 and ≥65 y old given a lack of data and given prior studies show a large amount of variation across countries.[30] Indirect costs included the cost of unemployment, caregiving, and productivity losses. The health care and indirect costs are excess costs of PTSD compared with no PTSD. The cost of unemployment was calculated based on a prevalence of excess unemployment of 2.7%[7] and median wage for Canadians of $49,000.[31] We calculated caregiving costs and productivity losses per quarter as follows[24,31,32]:

Caregiving cost : $999.56 per week

(average weekly wage of health care or

social assistance sectors)/40 hours

= $24.99 per hour ∗ 3.4 hours per week =

$84.97 per week/7 days per week ∗ 90 days per quarter

= $1092.47 per quarter

Productivity losses(Absenteeism(A)and Presenteeism(P))

= 9.7(A)and 33.1(P)days per year/4 quarter per year

= 2.43(A) + 8.28(P) days per quarter

= 10.7 days per quarter ∗ $30.03 mean wage per hour∗

8 hours per day = $2,570.57 per quarter

Intervention Effects

The effects of treatment were modeled through changes in remission rates, which means transitioning from the PTSD state to the no PTSD state.[15] In the case of paroxetine and TF-CBT, the effect of intervention versus no treatment was applied as an odds ratio taken from a network meta-analysis, which made direct comparisons between TF-CBT and SSRIs.[14] We have used the estimates for the effects of treatment for TF-CBT (odds ratio: 14.06) and for SSRI (7.99) from this study, which are for remission at "treatment endpoint" and refer to a 1-quarter time period for receiving the intervention.[14,15]

Given a small proportion of patients would have a response but not achieve remission, treatment effects would be underestimated; however, it is not clear from the literature what the change in utility would be for those on treatment who do not achieve remission. It was assumed that there is no effect of intervention on the hazard ratio of death for PTSD (discussed with S.S.).

Analysis

Calibration and validation. The calculated prevalence of PTSD over time without screening was compared with previous estimates,[5,8] and life expectancy from the model was compared with Statistics Canada life tables.[27]

The face validity of the model was discussed with S.S., a psychiatrist who has experience in building cost-effectiveness models.

Base case, sensitivity, and scenario analyses. Model estimates of costs and QALYs were used to calculate the ICUR of both interventions compared with no screening: ICUR = ΔCosts/ΔQALYs. According to Canadian Agency for Drugs and Technologies in Health (i.e., central agency for health technology assessments) guidelines,[33] INMB was calculated using a willingness-to-pay (WTP) threshold (λ) of $50,000, which is frequently used in Canada[34]: INMB = (λ ∗ ΔQALYs)−ΔCosts and costs and utilities were discounted at a 1.5% rate in the base case. NMB was also calculated using a WTP threshold (λ) of $50,000: NMB = (λ ∗ QALY_S) − Costs. We have used the 1.5% discount rate as recommended by Canadian Agency for Drugs and Technologies in Health.[33] However, we have adjusted our sensitivity analysis to vary the discount rate from 0% to 7%. The base-case results are derived from the probabilistic sensitivity analysis.

Deterministic 1-way sensitivity analyses were presented as tornado diagrams highlighting how varying parameter inputs across a range of values influences the results. Most parameters were varied 50% above and below the base-case values.[35] The false-negative rate was varied from 0 to 0.5, while the probability of accepting treatment was varied between 0.5 and 1. The number of months of additional treatment after remission was varied between 0 and 6 mo.

To further examine the impact of uncertainty in model parameters on model conclusions, probabilistic sensitivity analyses were conducted by running the model 10,000 times with model parameters randomly selected from predefined distributions. Beta distributions were used for probabilities and utilities, log-normal distributions for intervention effects, and gamma distributions for costs. Parameters defining these distributions (i.e., alpha, beta, lambda) or the standard deviation were used based on prior studies where available (Table 1), and where not, standard deviations were set to 0.2 times the mean, consistent with other studies.[36] Results from probabilistic sensitivity analyses were presented as incremental cost-effectiveness scatterplots, which present each simulation as 1 point on a Cartesian plane of incremental costs and incremental effects, and as cost-effectiveness acceptability curves, which present the results as the percentage of iterations that are below varying WTP

Table 2 Comparison of the Costs, QALYs, and INMBs across Different Intervention Groups and between Analysis of the Base Case for 5 y (Societal Perspective), 2 y (Societal Perspective), and 5 y (Health Care Perspective), Ranked by Cost

	QALYs	Costs	ΔQALYS	ΔCosts	NMB	INMB	ICUR
5 y (base case): societal perspective							
Screening and TF-CBT	3.759	$6,162.84	0.006	−$753.99	$181,787.16	$1,053.99	Dominant
Screening and paroxetine	3.753	$6,916.83	0.012	−$2,492.07	$180,733.17	$3,092.07	Dominated
No screening	3.741	$9,408.90	—	—	$177,641.10	—	Dominated
2 y: societal perspective							
Screening and TF-CBT	1.418	$3,090.37	0.003	−$180.49	$67,809.63	$330.49	Dominant
Screening and paroxetine	1.415	$3,270.86	0.005	−$679.41	$67,479.14	$929.41	Dominated
No screening	1.410	$3,950.27	—	—	$66,549.73	—	Dominated
5 y: health care perspective							
No screening	3.741	$521.55	−0.012	−$884.65	$186,528.45	$284.65	
Screening and paroxetine	3.753	$1,406.20	−0.006	−$397.25	$186,243.80	$97.25	Extended Dominance
Screening and TF-CBT	3.759	$1,803.45	—	—	$186,146.55	—	$71,216.67

ICUR, incremental cost-utility ratio; INMB, incremental net monetary benefit; QALY, quality-adjusted life-year; TF-CBT, trauma-focused cognitive behavioral therapy. Calculations are relative to the nextrow; NMB = QALYs × $50,000 – costs.

thresholds. Scenario analyses also included calculations of INMB at 2 y from a societal perspective and 5 y without indirect costs (i.e., health care perspective) to compare results to studies that examined screening and treatment among populations exposed to other traumatic events including a hurricane[17] and terrorist attack.[11] All analyses were completed in TreeAge Health Care Pro 2022.

Results

Validation

The calculated prevalence of PTSD over time without screening was in line with previously published estimates.

Base Case (5-y Time Horizon, Societal Perspective)

The results from the base-case (probabilistic) analysis are shown in Table 2, in Figure 2 as incremental cost-effectiveness scatterplots, and in Figure 3 as a cost-effectiveness acceptability curve. Compared with no screening, screening followed by treatment with paroxetine or TF-CBT showed cost-savings and higher benefits (Table 2). Meanwhile, the TF-CBT option provided greater incremental QALYs (0.006) compared with the paroxetine option, and TF-CBT saved more money from a societal perspective; therefore, it was found to be the option most likely to be cost-effective (probability = 0.649) at a WTP threshold of $50,000 per QALY in the cost-

effectiveness acceptability curve (i.e., most simulations with highest NMB; Figure 3).

Sensitivity and Scenario Analyses

Scenario analysis with a 2-y time horizon from a societal perspective indicated cost-savings with both strategies (screening with paroxetine or TF-CBT), with savings and NMB being higher for screening followed by treatment with TF-CBT. Screening followed by TF-CBT yielded 0.003 more incremental QALYs compared with screening followed by paroxetine.

Sensitivity analysis (5-y time horizon) from a health care perspective suggested that neither of the strategies are cost-effective at a WTP threshold of $50,000 and no screening had the highest NMB.

Tornado diagrams examined the INMBs rather than ICURs since the ICURs for paroxetine and TF-CBT were negative (Appendix Figure 1A–C). Comparing both paroxetine and TF-CBT treatment to no screening suggested that the parameters with the greatest effects on the INMB were initial prevalence of PTSD (higher = higher INMB), probability of accepting treatment (lower = lower INMB), cost of absenteeism/presenteeism (higher = higher INMB), and treatment effects of paroxetine and TF-CBT (higher = higher INMB). The INMB for both paroxetine and TF-CBT remained positive across all parameters that were varied. Comparing paroxetine to TF-CBT, the parameters that changed the relative ranking between the 2 treatments was the effectiveness of paroxetine, effectiveness of TF-CBT, cost of TF-CBT,
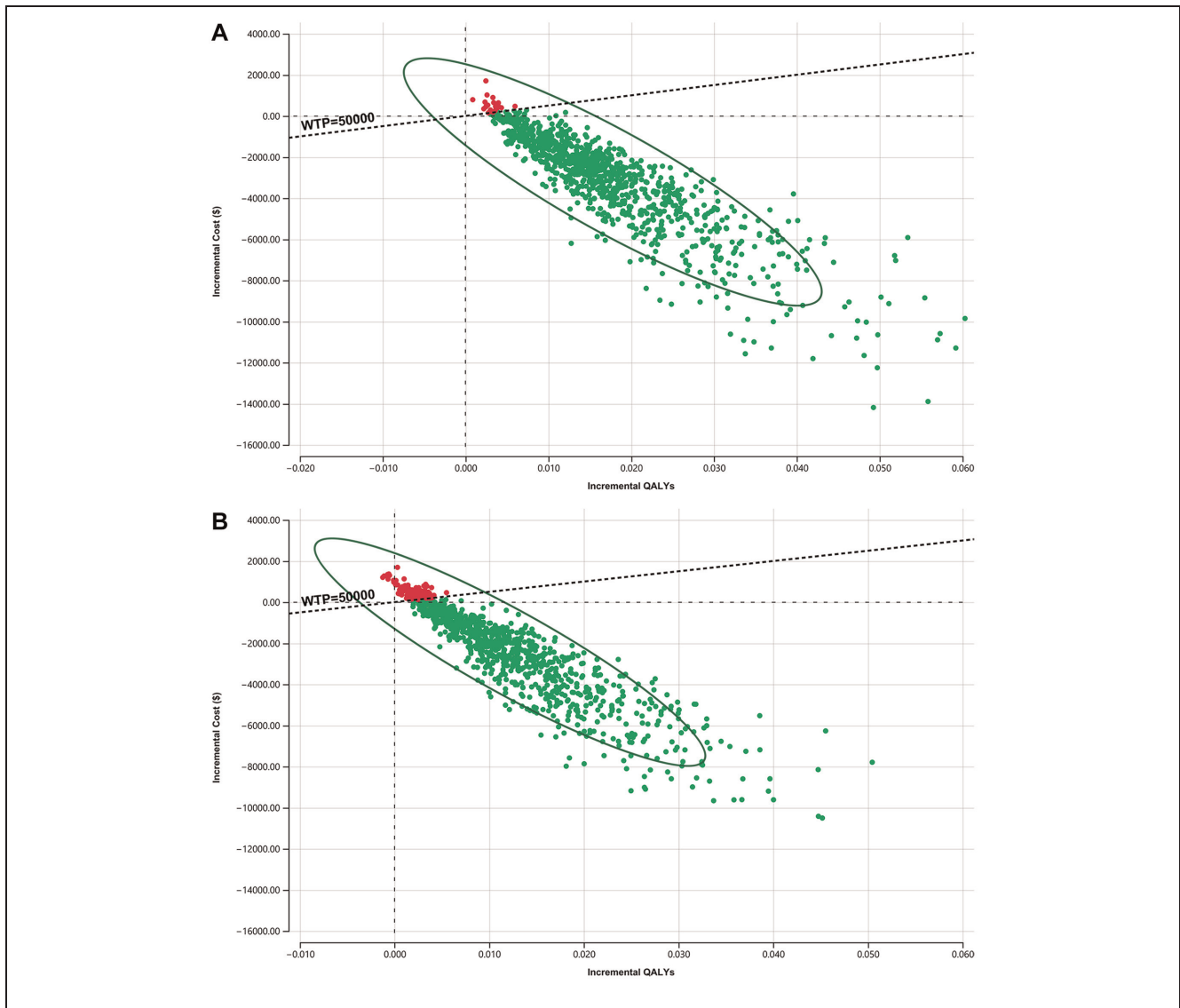
Figure 2 Probabilistic sensitivity analysis from a societal perspective, incremental cost-effectiveness scatterplot, 5-y horizon: (A) screening and trauma-focused cognitive behavioral therapy versus no screening and (B) screening and paroxetine versus no screening.

and probability of remission over time. Tornado diagrams from a health care perspective (Appendix Figure 2A–C) highlighted that the initial prevalence of PTSD and cost of screening were the most important factors.

Discussion

Key Findings

The cost-effectiveness of screening followed by treatment with paroxetine and screening followed by treatment with TF-CBT treatment were evaluated in comparison with

no screening, and to each other, using a Markov model to address the high prevalence of PTSD among wildfire evacuees. Screening followed by treatment with paroxetine and TF-CBT were cost-saving, and both interventions provided additional QALYs, with TF-CBT being the most cost-effective option (Table 2). Deterministic sensitivity analyses highlighted that the initial prevalence of PTSD, initial acceptance of treatment, productivity costs, and treatment effects had the greatest impact on INMB of both treatment arms versus no screening. This suggests that the high indirect costs of PTSD are among
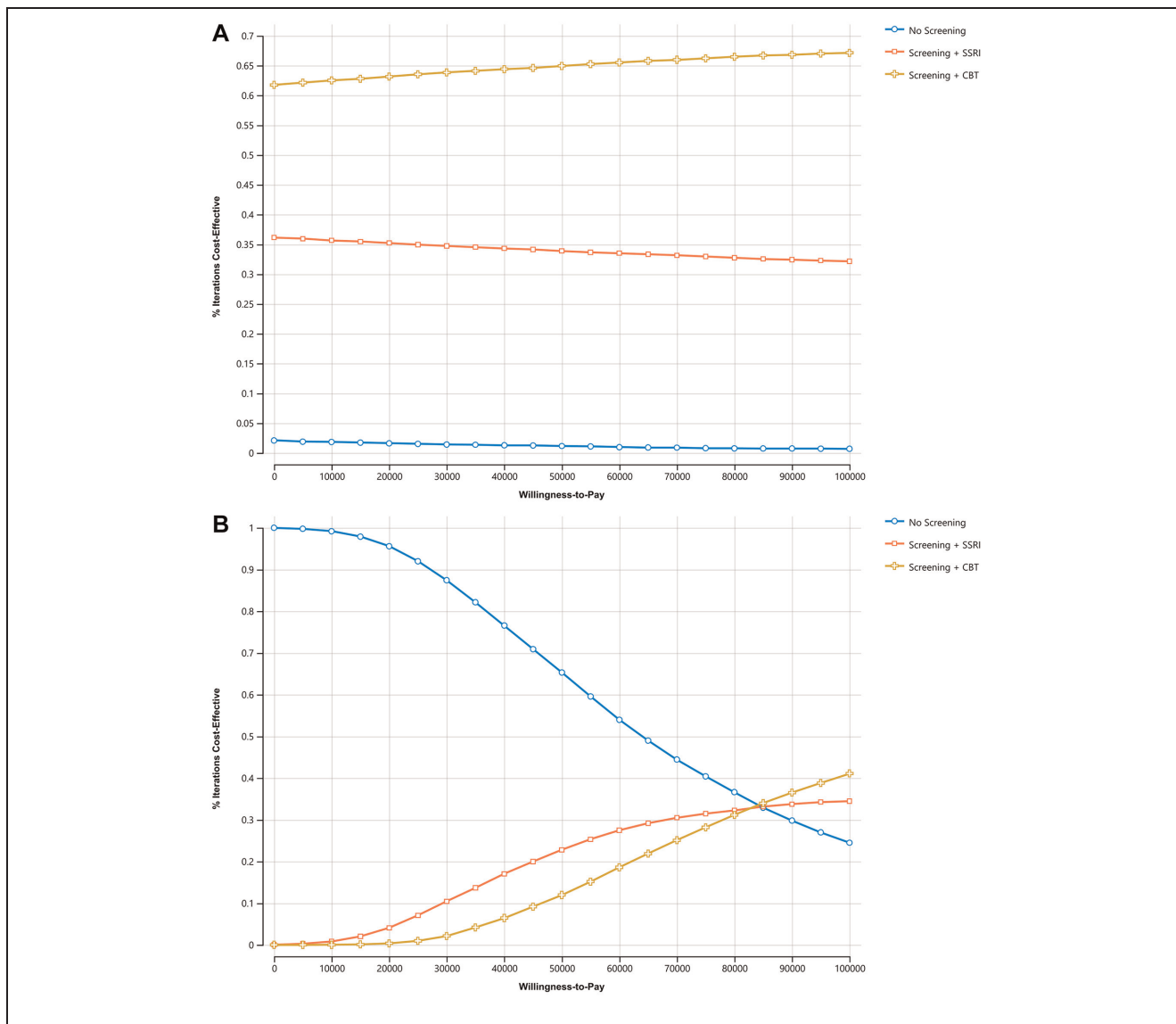
Figure 3 Probabilistic sensitivity analysis, cost-effectiveness acceptability curve, 5-y time horizon. (A) Societal perspective. (B) Health care perspective.

the most important drivers of the results. From a health care perspective, neither intervention was cost-effective at a threshold of $50,000 per QALY. Meanwhile, the initial prevalence of PTSD and the cost of screening were the most important factors affecting the INMB from a health care perspective.

Comparison to Prior Studies

Mavranezouli et al.[15] found the same pattern of results as the current study, in which individuals with PTSD treated with TF-CBT versus SSRIs had slightly higher levels of QALYs, higher costs, and consequently lower NMB from the perspectives of the National Health Service and personal social services in England. Similarly, using a health care perspective, Mihalopoulos et al.[16] showed the same pattern of results (slightly higher QALYs gained and higher incremental costs) for TF-CBT than treatment with SSRI. In contrast to both of these studies where all individuals were treated,[15,16] we did not find these interventions to be cost-effective relative to no treatment from a health care perspective.

This difference is likely due to the fact that all individuals needed to be screened and only a fraction of those individuals are treated. Screening of those who do not subsequently need treatment increases total costs without offering any benefits. This is highlighted by the results showing that the cost of screening and initial prevalence of PTSD were the 2 most important factors in 1-way sensitivity analyses. Thus, if the fraction of screened individuals who required treatment (i.e., were positive for PTSD) was higher or if the cost of screening was lower, then screening followed by treatment (paroxetine) wouldalso be cost-effective under a health care perspective.

Treatment options in prior disaster-related cost-effectiveness studies included screening followed by TF-CBT versus treatment as usual (assessment and identification of PTSD by a general practitioner) after a terrorist attack[11] and stepped care (i.e., TF-CBT) intervention versus usual care (i.e., skills for psychological recovery, a skill-building intervention) in the treatment of PTSD after Hurricane Sandy.[17] Both studies found screening and treatment to be highly cost-effective (terrorist attack: £7,931 per QALY[11]; hurricane [range]: $3,428.71–$6,857.68 per disability-adjusted life-year avoided[17]). Paroxetine and TF-CBT were cost-effective and cost-saving estimated over a 2-y and 5-y time horizon from a societal perspective but not cost-effective from a health care perspective. Although the model time horizon was different across studies along with other modeling differences (e.g., allowable state transitions[11]), it appears the most important factor was the type of treatment (i.e., pharmaceutical or psychological therapy) examined and the associated costs (i.e., 14-fold difference in the cost of treatment). Altogether, the results from our and these other 2 studies[11,17] generally suggest that screening programs for PTSD after population-wide traumatic events are cost-effective.

Implications

Given that the main parameters (i.e., prevalence of PTSD, treatment effects) were derived from sytematic reviews and meta-analyses,[8,14] utilities were derived from the general population of individuals with PTSD,[25] and the screening and treatment program was the same as that implemented in another developed country (i.e., the United Kingdom),[11] we believe that the main finding that both interventions are cost-saving from a societal perspective is important, and the study findings may be transferable to other contexts with similar health care costs and ability to implement these type of screening programs. This is also supported by 2 other studies examining the cost-effectiveness of screening after other disasters that found similar results.[11,17] However, the results from the health care perspective were above the threshold of $50,000 per QALY, which needs to be considered given that the health care sector would bear the costs for this policy's implementation. It suggests that much of the value of the program lies in reducing indirect costs such as costs of productivity losses and caregiving time. It is important to note that this threshold is not official or consistently applied in Canada, has been in use for many years without adjustment for inflation, and treatments greater than $50,000 are frequently funded[34] (i.e., Canadian Agency for Drugs and Technologies in Health uses 50,000 and 100,000 per QALY thresholds). More research from other countries is needed to evaluate the cost-effectiveness with local costs and WTP thresholds and to determine the feasibility of its implementation.

In addition, costs and other parameters were varied considerably in the sensitivity analysis, which we expect to account for some of these cross-country differences, thereby increasing the generalizability of the results.

Given the growing scale of wildfires, with close to 200,000 Canadian evacuees in 2023 across many towns, cities, and provinces, many of which were rural locations,[4] the requirements on the health care labor force to implement this intervention would be demanding. Given that 18 h of therapy is recommended, with tens of thousands of individuals with PTSD (at a prevalence of 18.8%), the number of hours of required therapy could easily expand beyond the available supply, especially in rural jurisdictions. This would likely require TF-CBT to be provided by a psychotherapist working remotely. In addition, this intervention would likely require tens of thousands of visits to family practitioners to prescribe paroxetine, putting a significant strain on these resources, which may be alleviated if nurse practitioners could be involved in prescribing paroxetine in addition to screening. Therefore, despite the interventions being cost-saving, the initial resource implications need to be considered when designing the final screening program. The eventual screening program may need to include a mix of these 2 interventions to accommodate system resources and patient preferences.

Strengths and Limitations

This is the first study to examine the cost-effectiveness of screening and treating PTSD among wildfire evacuees and one of the few cost-effectiveness analyses focused on PTSD in Canada. The analysis was modeled over a 5-y time horizon using a Markov modeling approach, similar

to other studies, such as those on terrorist events (5 y)[11] and hurricanes (2 y)[17] This enabled measurement of the changes in costs and outcomes over the course of this chronic, relapsing condition.

This study is not without limitations. First, the model did not address the existence of comorbidities such as depression, which are common in patients with PTSD and elevated among wildfire evacuees and have the potential to influence costs and HRQoL. Future research is recommended that incorporates depression in the model and screening interventions could consider screening and treatment for both PTSD and depression. Second, due to a lack of wildfire-specific PTSD data, most parameters are from studies with a mix of patients with different types of traumatic exposures. In addition, there were several assumptions made for model parameters due to a lack of data. However, we attempted to address potential biases from assumptions using probabilistic sensitivity analyses and incorporating large variations (±50%) into deterministic sensitivity analyses. Moreover, several assumptions were confirmed with a psychiatrist (S.S.) and were generally made to result in more conservative results. Future research should collect data specific to wildfire evacuees with PTSD. Third, due to data availability, we did not consider discontinuation in the model; however, this is indirectly included given that the effect estimates from the meta-analysis used to inform treatment effects were from studies conducted in an intention-to-treat fashion. Lastly, we did not include opportunity costs of seeking therapy, as it is not commonly reported in the literature.

Conclusions

Screening followed by treatment with paroxetine or TF-CBT for wildfire evacuees results in additional QALYs gained and cost-savings relative to no screening from a societal perspective, but neither intervention was cost-effective from a health care perspective. Both interventions were found to have favorable INMB in most sensitivity analyses conducted. Therefore, screening programs for PTSD should be considered for wildfire evacuees, and individuals diagnosed with PTSD could be prescribed either paroxetine or TF-CBT depending on patient preference, availability of physicians and psychotherapists, and resource constraints.

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Author Contributions

ML/AH, conception, data curation, methodology, formal analysis, writing–original draft; writing–review and editing.

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Data Access

The data used in this article are based on a literature review, and data values have been presented in Table 1.

Supplemental Material

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References

1. Sun Q, Miao C, Hanel M, et al. Global heat stress on health, wildfires, and agricultural crops under different levels of climate warming. *Environ Int*. 2019;128:125–36.
2. Thurton D. Fort McMurray population down nearly 11 per cent since wildfire, census shows. *CBC*. 2019. Available from: https://www.cbc.ca/news/canada/edmonton/fort-mcmurray-census-population-1.4978907#:~:text=Social%20Sharing-,Fort%20McMurray%27s%20first%20census%20since%20the%20devastating%202016%20wildfire%20suggests,Tuesday%20in%20a%20news%20release
3. CBC Radio. 2 months after Lytton, B.C., was destroyed by fire, its future is still unclear. 2021. Available from: https://www.cbc.ca/radio/thecurrent/the-current-for-sept-7-2021-1.6166608/2-months-after-lytton-b-c-was-destroyed-by-fire-its-future-is-still-unclear-1.6171191
4. Austen I, Isai V. As wildfire nears, entire Canadian city evacuates. *New York Times*. 2023. Available from: https://www.nytimes.com/2023/08/17/world/canada/canada-wildfire-evacuation-yellowknife.html
5. To P, Eboreime E, Agyapong VIO. The impact of wildfires on mental health: a scoping review. *Behav Sci*. 2021;11:126.
6. Belleville G, Ouellet M-C, Morin CM. Post-traumatic stress among evacuees from the 2016 Fort McMurray wildfires: exploration of psychological and sleep symptoms three months after the evacuation. *Int J Environ Res Public Health*. 2019;16:1604.

7. Van Ameringen M, Mancini C, Patterson B, Boyle MH. Post-traumatic stress disorder in Canada. *CNS Neurosci Ther*. 2008;14:171–81.

8. Santiago PN, Ursano RJ, Gray CL, et al. A systematic review of PTSD prevalence and trajectories in DSM-5 defined trauma exposed populations: intentional and non-intentional traumatic events. *PLoS One*. 2013;8:e59236.

9. Gospodarevskaya E. Post-traumatic stress disorder and quality of life in sexually abused Australian children. *J Child Sex Abus*. 2013;22:277–96.

10. Lamoureux-Lamarche C, Vasiliadis H-M, Préville M, Berbiche D. Healthcare use and costs associated with post-traumatic stress syndrome in a community sample of older adults: results from the ESA-Services study. *Int Psychogeriatr*. 2016;28:903–11.

11. Hogan N, Knapp M, McDaid D, Davies M, Brewin CR. Cost-effectiveness of 'screen-and-treat' interventions for post-traumatic stress disorder following major incidents. *BMJ Open*. 2021;11:e049472.

12. Katzman MA, Bleau P, Blier P, et al. Canadian clinical practice guidelines for the management of anxiety, post-traumatic stress and obsessive-compulsive disorders. *BMC Psychiatry*. 2014;14:1–83.

13. Martin A, Naunton M, Kosari S, Peterson G, Thomas J, Christenson JK. Treatment guidelines for PTSD: a systematic review. *J Clin Med*. 2021;10:4175.

14. Mavranezouli I, Megnin-Viggars O, Daly C, et al. Psychological treatments for post-traumatic stress disorder in adults: a network meta-analysis. *Psychol Med*. 2020;50:542–55.

15. Mavranezouli I, Megnin-Viggars O, Grey N, et al. Cost-effectiveness of psychological treatments for post-traumatic stress disorder in adults. *PLoS One*. 2020;15:e0232245.

16. Mihalopoulos C., Magnus A, Lal A, Dell L, Forbes D, Phelps A. Is implementation of the 2013 Australian treatment guidelines for posttraumatic stress disorder cost-effective compared to current practice? A cost-utility analysis using QALYs and DALYs. *Aust N Z J Psychiatry*. 2015;49:360–76.

17. Cohen GH, Tamrakar S, Lowe S, et al. Comparison of simulated treatment and cost-effectiveness of a stepped care case-finding intervention vs usual care for posttraumatic stress disorder after a natural disaster. *JAMA Psychiatry*. 2017;74:1251–8.

18. Brown MRG, Agyapong V, Greenshaw AJ, et al. Significant PTSD and other mental health effects present 18 months after the Fort McMurray wildfire: findings from 3,070 grades 7–12 students. *Front Psychiatry*. 2019;10:623.

19. Binet É, Ouellet MC, Lebel J, et al. A portrait of mental health services utilization and perceived barriers to care in men and women evacuated during the 2016 Fort McMurray Wildfires. *Adm Policy Ment Health*. 2021;48(6):1006–18.

20. Alberta College of Family Physicians. Price comparison of commonly prescribed pharmaceuticals in Alberta 2018. 2018. Available from: https://acfp.ca/wp-content/uploads/2018/03/ACFPPricingDoc2018.pdf

21. Ontario Health Insurance Plan (OHIP). OHIP schedule of benefits. 2021. Available from: https://www.health.gov.on.ca/en/pro/programs/ohip/sob/

22. CBT Associates. Rates and fees. 2021. Available from: https://www.cbtassociates.com/about-us/rates-fees/

23. Statistics Canada. Income of individuals by age group, sex and income source, Canada, provinces and selected census metropolitan areas. 2020. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid = 1110023901

24. Davis LL, Schein J, Cloutier M, et al. The economic burden of posttraumatic stress disorder in the United States from a societal perspective. *J Clin Psychiatry*. 2022;83:40672.

25. Hawthorne G, Korn S, Richardson J. Population norms for the AQoL derived from the 2007 Australian National Survey of Mental Health and Wellbeing. *Aust N Z J Public Health*. 2013;37:7–16.

26. Sullivan PW, Valuck R, Saseen J, MacFall HM. A comparison of the direct costs and cost effectiveness of serotonin reuptake inhibitors and associated adverse drug reactions. *CNS Drugs*. 2004;18:911–32.

27. Statistics Canada. Life tables, Canada, provinces and territories 1980/1982 to 2017/2019 Note. 2020. Available from: https://www150.statcan.gc.ca/n1/pub/84-537-x/84-537-x2020001-eng.htm

28. Giesinger I, Li J, Takemoto E, Cone JE, Farfel MR, Brackbill RM. Association between posttraumatic stress disorder and mortality among responders and civilians following the September 11, 2001, disaster. *JAMA Netw Open*. 2020;3:e1920476.

29. Statistics Canada. Consumer price index, annual average, not seasonally adjusted. 2021. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid = 1810000501

30. von der Warth R, Dams J, Grochtdreis T, König H-H. Economic evaluations and cost analyses in posttraumatic stress disorder: a systematic review. *Eur J Psychotraumatol*. 2020;11:1753940.

31. Statistics Canada. Average weekly earnings by industry, annual. 2022. Available from: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid = 1410020401

32. Penner M, Rayar M, Bashir N, Roberts SW, Hancock-Howard RL, Coyte PC. Cost-effectiveness analysis comparing pre-diagnosis autism spectrum disorder (ASD)-targeted intervention with Ontario's autism intervention program. *J Autism Dev Disord*. 2015;45:2833–47.

33. Canadian Agency for Drugs and Technologies in Health. *Guidelines for the Economic Evaluation of Health Technologies: Canada*. 4th ed. Ottawa: Canadian Agency for Drugs and Technologies in Health; 2017.

34. Balijepalli C, Gullapalli L, Druyts E, et al. Can standard health technology assessment approaches help guide the price of orphan drugs in Canada? A review of submissions to the Canadian agency for drugs and technologies in health common drug review. *Clinicoecon Outcomes Res.* 2020;12:445–57.

35. Briggs AH, Weinstein MC, Fenwick EA, et al. Model parameter estimation and uncertainty: a report of the ISPOR-SMDM Modeling Good Research Practices Task Force-6. *Value Health*. 2012;15:835–42.

36. Lanitis T, Muszbek N, Tichy E. The probability of a successful probabilistic sensitivity analysis. *The Evidence Forum*. 2014. Available from: https://www.evidera.com/wp-content/uploads/2015/04/The-Probability-of-a-Successful-Probabilistic-Sensitivity-Analysis.pdf