

Cost-Effectiveness of Digital Preventive Parent Training for Early Childhood Disruptive Behaviour

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Abstract

Background: Childhood disruptive behaviour disorder associates with various, also costly problems. Parent training is effective in reducing childhood disruptive behaviour. Only a few studies have evaluated the cost-effectiveness of digital parent training in reducing children's disruptive behaviour.

Aims of the Study: We evaluated the two-year cost-effectiveness of an Internet and telephone assisted parent training intervention called the Strongest Families Smart Website (SFSW) for prevention of children's disruptive behaviour compared to education control (EC) from the combined perspective of the health care funder and parents.

Methods: This study used data from a randomized controlled trial (RCT). The trial screened a population-based sample of 4,656 four-year-olds at annual child health clinic check-ups in Finnish primary care. A total of 464 disruptively behaving children participated in the RCT; half received the SFSW and half EC. We evaluated intention-to-treat based incremental net monetary benefit with a range of willingness to pay values. Costs contained the interventions' and parents' time-use costs. The effectiveness measure was the Child Behavior Checklist (CBCL/1.5-5) externalizing score. The trial is registered at Clinicaltrials.gov (NCT01750996).

Results: From the health care funder's perspective, SFSW costs per family were €1,982 and EC €661, and from the parents' perspective SFSW costs per family were €462 and EC €77. From the combined health care funder and parents' perspective, costs were €1,707 higher in the SFSW intervention than in EC. The SFSW decreased the CBCL externalizing score (1.94, SE=0.78, p=0.01) more in comparison to the EC group. In cost-effectiveness analysis using the combined perspective, the incremental net monetary benefit was zero [95% CI €-1,524 to €1,524] if the willingness to pay for one extra point of CBCL externalizing score reduced was €879. If the willingness to pay was more than €879, the average incremental net monetary benefit was positive.

Discussion: The cost-effectiveness of the SFSW depends on the decision makers' willingness to pay, which is not stated for CBCL out-

comes. Also, the decision maker should consider the uncertainty of cost-effectiveness estimates. The lack of other service use information and micro-costing of SFSW and EC intervention costs weakens our conclusions. However, our study had multiple strengths, such as population-based screening, high sample size, 2-year follow-up, and use of proper methods to conduct a full economic evaluation.

Implications for Health Care Provision and Use: The SFSW is effective in reducing children's disruptive behaviour. Although digitally provided, the SFSW intervention included professional time and, thus, costs. The costs of intervention to the healthcare provider and time cost to families should be taken into account when interventions are implemented. The cost-effectiveness of SFSW interventions depends on the willingness to pay of health care decision makers.

Implications for Health Policies: Investment decisions should require high-quality economic evaluation of interventions and independent evaluation research of interventions should be financed.

Implications for Further Research: Decision makers need more economic evaluations of digital interventions. Research should use similar high-quality methods to allow comparison between studies. In an early planning phase of research, health economists should be consulted to enable usability of data and high-quality research.

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Introduction

Childhood disruptive behaviour problems are prevalent mental health problems and diminish the well-being of families. A meta-analysis¹ has shown worldwide prevalence of children's and adolescents' disruptive disorders to be 5.7% (conduct disorder 2.1%, oppositional defiant disorder 3.6%). Childhood disruptive behaviour often associates with a wide range of problems^{2,3} and high use of public services in the long term.⁴ The high use of public services causes considerable costs to society.⁵⁻⁷

Preventive services present an opportunity to tackle these long-term adverse outcomes and costs. Previous research⁸ has shown that multiple parent training interventions have been effective for reducing childhood externalizing behaviour

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problems. In recent decades the delivery of some of the mental health services has transitioned to Internet and telephone assisted interventions⁹ that could also be used for prevention. Systematic reviews^{10,11} have found technology-assisted parent training interventions for disruptive behaviours to be effective. One of these is the Strongest Families Smart Website (SFSW), an Internet and telephone assisted parent training intervention. SFSW has been shown to be effective^{12,13} in decreasing child disruptive behaviour symptoms and other psychiatric symptom domains and improving parenting skills compared to education control (EC) in 6-, 12- and 24-month follow-ups. In addition, use of child mental health services was less likely in the SFSW group than in the EC group during 2-year follow-up.

However, with limited budgets and unlimited needs, information on effectiveness alone is insufficient for decision making regarding implementation. Economic evaluation supports decision makers by comparing both the effectiveness and costs of options. The aim is to bring ‘the best’ out of the available resources.¹⁴

A recent systematic review¹⁵ characterized parenting interventions for preventing child externalizing behaviour as good value for money. Nevertheless, to the best of our knowledge, only one study¹⁶ has conducted an economic evaluation of distance parent training for the prevention of disruptive behaviour. The Canadian cost-effectiveness study of the telephone-assisted Strongest Families parent training for families of disruptive behaving children concluded that the intervention potentially provided cost savings to society compared to the usual care during a 22-month follow-up.

This study evaluates the two-year cost-effectiveness of the SFSW intervention compared to EC from a combined health care funder and parents’ perspective. The SFSW focuses on strengthening parent-child relationships, reinforcing positive behaviour, reducing conflict, managing daily transitions, planning for difficult situations, and encouraging prosocial behaviour. The EC was a website focusing briefly on positive parenting.^{12,13} This study uses data from a randomized controlled trial (RCT)^{12,13} targeting 4-year-olds with a high level of childhood disruptive behaviour. The prevalence of childhood disruptive behaviour, the long-term adverse outcomes and costs associated with it, and the lack of economic evaluations of preventive digital parent training call for the information that this study provides for health care decision makers and parents.

Methods

Evaluation Framework

This is a post hoc cost-effectiveness analysis of a randomized controlled trial (RCT). The effectiveness results of the RCT have been published already^{12,13} and the present cost-effectiveness analysis is the economic component of the trial. The time horizon of the analysis is 2-years (24 months). We used intention-to-treat based analyses and evaluated the incremental net monetary benefit of the SFSW compared to

EC. The analysis used a combined health care funder and parents’ perspective with regard to costs. During the trial, Finnish municipalities (n > 300) organized health and social services and special support in schools. As the payer, municipalities had wide interest in children’s well-being. Since 2023, Wellbeing Service Counties (n=21) have organized and funded health and social services and, thus, the SFSW intervention. The effectiveness outcome was the Child Behavior Checklist (CBCL) externalizing score. We discounted both costs and outcomes at 3%.

We also conducted an additional cost-effectiveness analysis using CBCL total score as the effectiveness outcome instead of the CBCL externalizing score. The CBCL total score measures both behavioural and emotional problems and thus evaluates the effectiveness of the intervention more widely. Lastly, we conducted sensitivity analyses to evaluate the robustness of the results.

Study Design and Population

The protocol of the effectiveness study¹⁷ and 1-year effectiveness study¹³ describe the study design, population, and sample size calculation in detail. Population-based screening of 4-year-olds living in Southwest Finland and attending annual health check-ups in child health clinics (N=4,656) started in 2011 (**Figure 1**). The Strengths and Difficulties Questionnaire (SDQ) is routinely used in health check-ups for 4-year-olds in Finland. In the trial, the SDQ was used for assessing the eligibility of the children. Parents completed the SDQ conduct problems subscale.¹⁸ The subscale score for eligible participants was 5 points or over corresponding to the 80th percentile cut-off. Parents also needed to respond to a single question that their child was having difficulties with emotions, concentration, behaviour or being able to get on with other people. The trial excluded children using behaviour treatments or with a diagnosed disability. The research ethics committees of the Hospital District of Southwest Finland and IWK Health Centre approved the 2-parallel RCT. Parents gave informed consent as part of the application process. The trial is registered at Clinicaltrials.gov with identifier: NCT01750996.

The screening yielded 730 (15.7%) families fulfilling the eligibility criteria. The trial randomization stratified by sex included 464 (63.6%) families: 232 in the SFSW and 232 in the EC group. Families completed effectiveness measures at four measurement points: at baseline and 6-, 12-, and 24-months after randomization.¹³ Families completed the baseline questionnaires from December 16, 2011 to February 5, 2014. The 2-year follow-up was from January 14, 2014 to April 15, 2016.

The 1-year effectiveness study¹³ describes in detail the characteristics of children and families. Briefly, at the baseline, groups were similar in gender (61.85% boys), language, place of residence, family structure, number of siblings, mother’s age, parents’ education level and share of children in daycare. The only significant (p=0.002) difference was that the fathers in the EC group were younger on average (31.4, [95% CI 30.69-32.18]) than fathers in the SFSW group (33.2, [95% CI 32.38-33.96]).

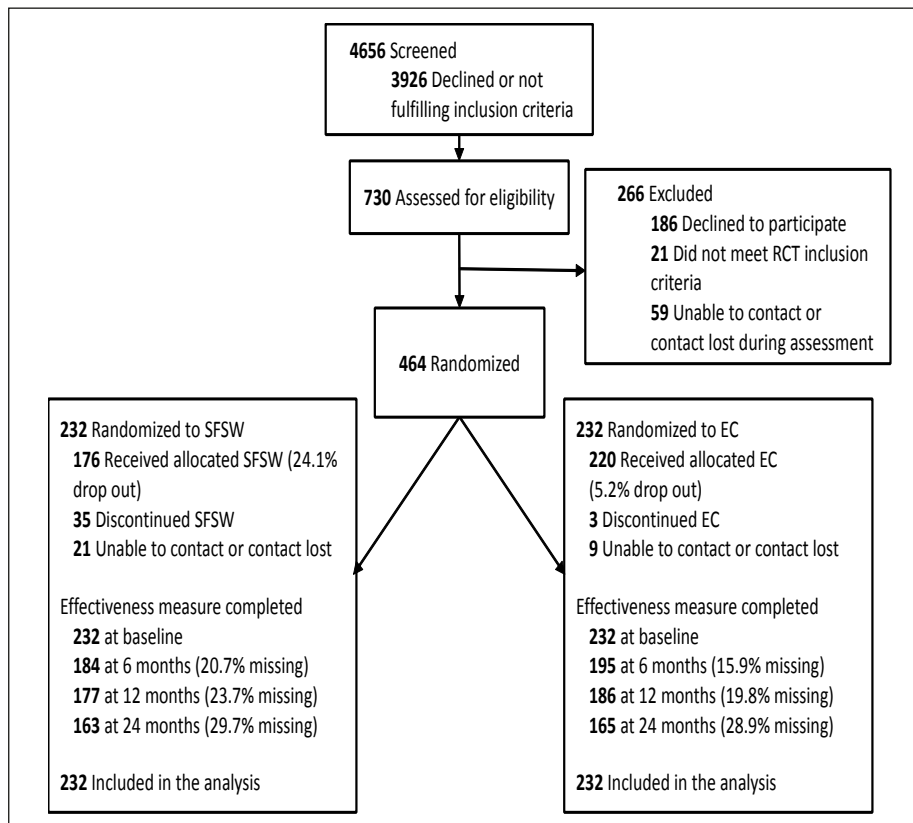


Figure 1. Consort Flow Diagram.

Resource Use and Valuation

We applied both the health care funder’s and parents’ perspective to identify and measure resource use and costs. The cost analysis included the SFSW and EC intervention costs to health care payer and parents’ time costs of participating in the intervention. Parents’ time use costs are an important part of the true costs of the interventions. A high time cost for families might negatively influence their participation in the intervention.¹⁹ All costs are in 2022 euros.²⁰

The study protocol¹⁷ and a 1-year effectiveness study¹³ describe the content of the interventions in detail. The 11-week SFSW intervention contained a weekly online session and a weekly 45-minute phone call with a licensed health care professional coach. Online session materials consisted of videos, audio clips and exercises. After 7-, 10- and 18-months of randomization, the parents received booster calls including a review of the weekly themes. In addition, families received a monthly booster email with a brief summary of each theme, starting from 12-months after randomization. EC participants accessed a brief positive parenting website and had a 45-minute call with a coach.

The costing of interventions included the resources used for screening, materials, and personnel costs for coaches, their supervisor and an engineer in charge of software and equipment. The SFSW intervention is currently in the implementation phase^{21,22} and, in 2018, was offered to municipalities at a fixed price based on a contract. The analysis used this price to measure the value of resources used per family in SFSW. For

the costs of EC, we used a third of the SFSW costs.*

To evaluate parents’ time use, we used data stored by the Internet platforms and call logs. The Internet platform stored data on the time parents spent online for all randomized families. For 226 families in the SFSW and 167 in the EC group, the call logs automatically saved the time of coaching calls. We used group averages for the recruitment (SFSW n=167; EC n=156) and booster calls (first n=125; second n=112; third n=78) due to the high missingness of call logs. For acceptance calls, the time used is an assumption as the data was not available. Parents’ time costs did not include the time parents used in applying the skills. We regarded the training as part of their normal daily life. The valuation of parents’ time used the Finnish average hourly wage in 2016²³ including overheads²⁴ converted to 2022 euros²⁰ (€29.62/hour).

Outcome Measures

The outcome measure was the Child Behavior Checklist (CBCL/1.5-5)²⁵ externalizing score, which has 24 items and a range of 0–48. A higher score associates with more disruptive behaviour. An additional cost-effectiveness analysis used the CBCL total score (CBCL/1.5-5) as the effectiveness outcome instead of the CBCL externalizing score. The CBCL total score has 100 items and a range of 0-200. The CBCL total score sums up all behavioural and emotional problems measured. Families completed the CBCL questionnaire on the Internet platforms.

* Personal communication, Research Centre for Child Psychiatry, University of Turku, June 2018.

Data Analytic Procedures

To apply the intention-to-treat (ITT) principle, two types of imputation methods were used to handle missing data. First, we used single imputation to impute zeros to the missing coaching call logs in the EC group as we assumed the coaches failed to reach the parents. After that, we used multiple imputation by chained equations (MICE)²⁶ for the missingness in the CBCL externalizing score, CBCL total score and SFSW group's coaching call logs. We used predictive mean matching with the five closest cases, separately by group in the imputation model. In the model, we assumed the missing data to be missing at random (MAR). The predictors in the model were sex, all CBCL externalizing and total scores, and the variables statistically significantly predicting the missingness of CBCL externalizing and total scores (**Appendix, Table A1**). We imputed 40 datasets because 60% of participants reported all four CBCL externalizing and total score measurements, costs, and the values of included predictors. We used Rubin's rules to produce ITT-based results.²⁷

We estimated the effectiveness of the SFSW compared to EC using the linear mixed effect model for repeated measurements with the restricted maximum likelihood (REML) method. The model followed the study protocol¹⁷ and effectiveness studies.^{12,13} The child indicator was a within-subjects factor. Variables controlling for between-subject variation were the binary intervention variable, the four points of measurement, sex, and the interaction term for the intervention and the point of measurement. We used Cohen's *d* to measure standard effect sizes.²⁸

Cost-effectiveness analysis used the net monetary benefit (NMB) approach.²⁹ Individual-level NMB combines a change in costs and effectiveness outcomes with decision makers' willingness to pay (WTP, λ) for one extra unit of effectiveness. The WTP for one point reduction of CBCL externalizing score or total score have not been stated. To overcome the lack of threshold, we used a range for WTP for one extra point reduction of CBCL externalizing and total scores.

$$\text{NMB} = \lambda * \text{change in outcome measure} - \text{change in cost}$$

We modelled the incremental net monetary benefit (INMB) between the SFSW and EC groups with ordinary least square regressions (OLS) using group (SFSW or EC) and sex as independent variables. The model produced INMB and its 95% confidence interval. In addition, we calculated the cost-effectiveness acceptability curve.³⁰

The decision rules of INMB²⁹ are: (i) if the chosen WTP produces an INMB above zero, SFSW is cost-effective compared to EC, (ii) if the chosen WTP produces an INMB below zero, EC is cost-effective compared to SFSW. We discounted both costs and outcomes at the Finnish national recommendation³¹ of 3% and performed the analyses with Stata statistical software (SE14.2).

Sensitivity Analyses

One-way sensitivity analyses tested the robustness of the cost-effectiveness results to changes in costs, effectiveness (CBCL externalizing), or the imputation method. The first

analysis used 20% higher SFSW intervention costs. The second and third analyses tested if the result is sensitive to changes in valuation of parents' time use by using 50% and 30% of the unit cost. The fourth analysis used 10% lower effectiveness for the SFSW group. The fifth analysis assumed the missingness of CBCL externalizing scores to be missing not at random (MNAR), instead of the MAR assumption. In the MNAR, we imputed the 24-month CBCL externalizing scores of participants with missing measures to be systematically (20%) worse than those of participants with complete 24-month data. The last sensitivity analysis used only data from participants who reported CBCL externalizing scores both at the baseline and 24-month measurement points (SFSW $n=161$; EC $n=165$).

Results

Demographic Information of the Sample

The groups were similar at baseline for almost all characteristics¹³. The only significant ($p=0.002$) difference was that the fathers in the EC group were younger on average (31.4, [95% CI 30.69-32.18]) than fathers in the SFSW group (33.2, [95% CI 32.38-33.96]). **Table 1** describes the sample characteristics.

Costs

The intervention costs of the SFSW was €1,982 and of EC €661 per family. The majority of the costs of the interventions accumulated from personnel expenses.

Table 2 presents parents' time use and the total time costs. Parents' in the SFSW intervention spend an average of 15.6 hours [95% CI 14.8-16.4] on phone calls and online sessions and parents in the EC group used an average of 2.6 hours [2.4-2.7]. Parents' time use was valued based on the Finnish average hourly wage including overheads: the SFSW intervention costs were €462 [95% CI €439-485] per family and EC group costs were €77 [€73-81] per family. From the combined funder and parents' perspective, the average SFSW costs with parents' time-use were €2,444 per family and EC costs were €738 per family. The incremental cost of SFSW was €1,707 compared to EC.

Effectiveness

In this cost-effectiveness study, the effectiveness results were based on imputed and discounted data. At baseline, CBCL externalizing scores ($p=0.46$) were similar across groups. (**Table 3**) During the 24-month follow-up, the SFSW intervention decreased the CBCL externalizing score (1.94, $p=0.01$) more in comparison to the EC group. Cohen's *d* for the CBCL externalizing score was 0.21, indicating a small effect size.

In the additional analysis, CBCL total scores at baseline ($p=0.77$) were similar across groups. During the 24-month follow-up, the SFSW intervention decreased the CBCL total score (5.64, $p=0.00$) more in comparison to the EC group. Cohen's *d* for the CBCL total score was 0.25, also indicating a small effect size.

Table 1. Socio-demographic Characteristics of SFSW and EC Groups

	SFSW (n=232)	EC (n=232)
<i>Children's age</i>	4.17 (SD 0.11)	4.17 (SD 0.12)
<i>Children's sex</i>		
Male	61.2%	62.5%
Female	38.8%	37.5%
<i>Children's mother tongue (SFSW n=230, EC n=230)</i>		
Finnish	95.7%	95.7%
Swedish	4.3%	3.0%
Other	0%	1.3%
<i>Region</i>		
Turku	55.2%	53.0%
Kaarina	14.2%	15.5%
Raisio	9.1%	10.3%
Naantali	7.3%	7.8%
Härkätie	3.4%	4.3%
Rauma	6.5%	3.9%
Paimio-Sauvo	4.3%	5.2%
<i>Parents living in same household with child (SFSW n=230, EC n=231)</i>		
Biological parents	83.5%	82.3%
Biological mother & foster father	3.9%	4.8%
Biological mother alone	10.4%	10.0%
Other	2.2%	3.0%
<i>Siblings</i>	1.38 (SD 1.01)	1.38 (SD 0.82)
<i>Mothers' age</i>	30.51 (SD 5.45)	29.78 (SD 4.95)
<i>Fathers' age</i>	33.17 (SD 5.90)**	31.44 (SD 5.64)**
<i>Mothers' education level (SFSW n=230, EC n=231)</i>		
Elementary school or less	5.7%	6.9%
Secondary education	37.0%	35.1%
College or university degree	57.4%	58.0%
<i>Fathers' education level (SFSW n=216, EC n=214)</i>		
Elementary school or less	7.4%	7.5%
Secondary education	45.8%	47.7%
College or university degree	46.8%	44.9%

Note: P<0.05=*, p<0.01=**, p<0.001=***

Table 2. Parents' Time Use (minutes) and Time Cost (in 2022 euros) by Group.

	SFSW (n=232)		EC (n=232)	
	Minutes [95% CI]	Costs [95% CI]	Minutes [95% CI]	Costs [95% CI]
Parents' time use				
Recruitment call	18		17	
Acceptance call	3		3	
Phone calls	381 [355-407] (n=226) ^a		31 [28-34]	
Webpage visits	426 [399-453]		105 [97-112]	
Booster calls	103			
Total time use	936 [889-982] (n=226) ^a		156 [148-164]	
Total time use costs		€462 [€439-485] ^b		€77 [€73-81]

Note:

^a Parenthesis show the sample size if it was different from the original.

^b For 6 participants with incomplete phone call logs, the MICE imputation model imputed the total time costs. Therefore, the costs data is for all 232 participants in SFSW.

Table 3. Effectiveness Measures at Baseline, 6 Months, 12 Months and 24 Months After Randomization (imputed and discounted data).

	SFSW (n=232)	EC (n=232)	Incremental analysis
<i>CBCL externalizing score (SE)</i>			
Baseline	19.92 (0.51)	19.40 (0.52)	
6 months	14.06 (0.53)	15.90 (0.52)	
12 months	13.37 (0.47)	15.65 (0.62)	
24 months	12.60 (0.57)	14.02 (0.61)	
Difference (baseline and 24 months)	-7.32 (0.60)	-5.38 (0.60)	1.94 (0.78)*
<i>Additional analysis: CBCL total score (SE)</i>			
Baseline	44.83 (1.30)	44.32 (1.43)	
6 months	30.27 (1.22)	35.37 (1.23)	
12 months	29.36 (1.19)	36.46 (1.52)	
24 months	27.62 (1.33)	32.76 (1.57)	
Difference (baseline and 24 months)	-17.20 (1.43)	-11.56 (1.57)	5.64 (1.85)**

Note: p<0.05=*, p<0.01=**, p<0.001=***

Table 4. Results of Sensitivity Analyses.

Analysis:	WTP for CBCL externalizing score point reduced that produced zero INMB	INMB and its 95% confidence interval
Primary analysis	€879	€0 [€-1,524 to €1,524]
SFSW intervention cost increases by 20%	€1,083	€0 [€-1,878 to €1,878]
Parents' time valuation 50% of Finnish average hourly wage including overheads	€780	0€ [€-1,351 to €1,354]
Parents' time valuation 30% of Finnish average hourly wage including overheads	€741	0€ [€-1,282 to €1,285]
SFSW intervention effectiveness decreases by 10%	€2,506	€0 [€-4,483 to €4,483]
Imputed effectiveness measures are 20% lower at 24 months (MNAR assumption)	€855	€0 [€-1,587 to €1,587]
Data only from participants with baseline and 24-month effectiveness measurements completed (SFSW n=161; EC n=165)	€839	€0 [€-1,423 to €1,423]

Cost-Effectiveness

The SFSW intervention was effective and more costly than EC. Therefore, the cost-effectiveness of the SFSW depends on the decision makers willingness to pay. The SFSW was cost-effective compared to the EC if the decision makers' WTP for one extra point reduction of CBCL externalizing score produced a positive INMB. A WTP value of €879 produced 0 [95% CI €-1,524 to 1,524] INMB. A WTP value higher than €879 per one extra point reduction of CBCL externalizing a produced positive average INMB. **Figure 2** illustrates the importance of WTP on INMB and its 95% confidence interval. Numerical results for different WTP values are given in **Appendix, Table A2**.

In the additional analysis, the INMB was zero [95% CI €-1,289 to 1,290] if the WTP for one extra CBCL total score

reduced was €302. **Appendix, Figure A1** presents the INMB with various WTP values for CBCL total. **Figure 3** presents the cost-effectiveness acceptability curves.

Sensitivity of Cost-effectiveness Results

The cost-effectiveness result was less sensitive to changes in SFSW intervention costs than to changes in the effectiveness of the SFSW intervention. Diminishing effectiveness (CBCL externalizing) by 10% more than doubled the WTP needed to produce a zero INMB. The decrease in unit cost of parents' time use had a moderate effect on the results. Assumptions about missing mechanism (MNAR) in the imputation method or inclusion of only participants with both effectiveness measures completed had only a minor effect on the cost-effectiveness results. (**Table 4**)

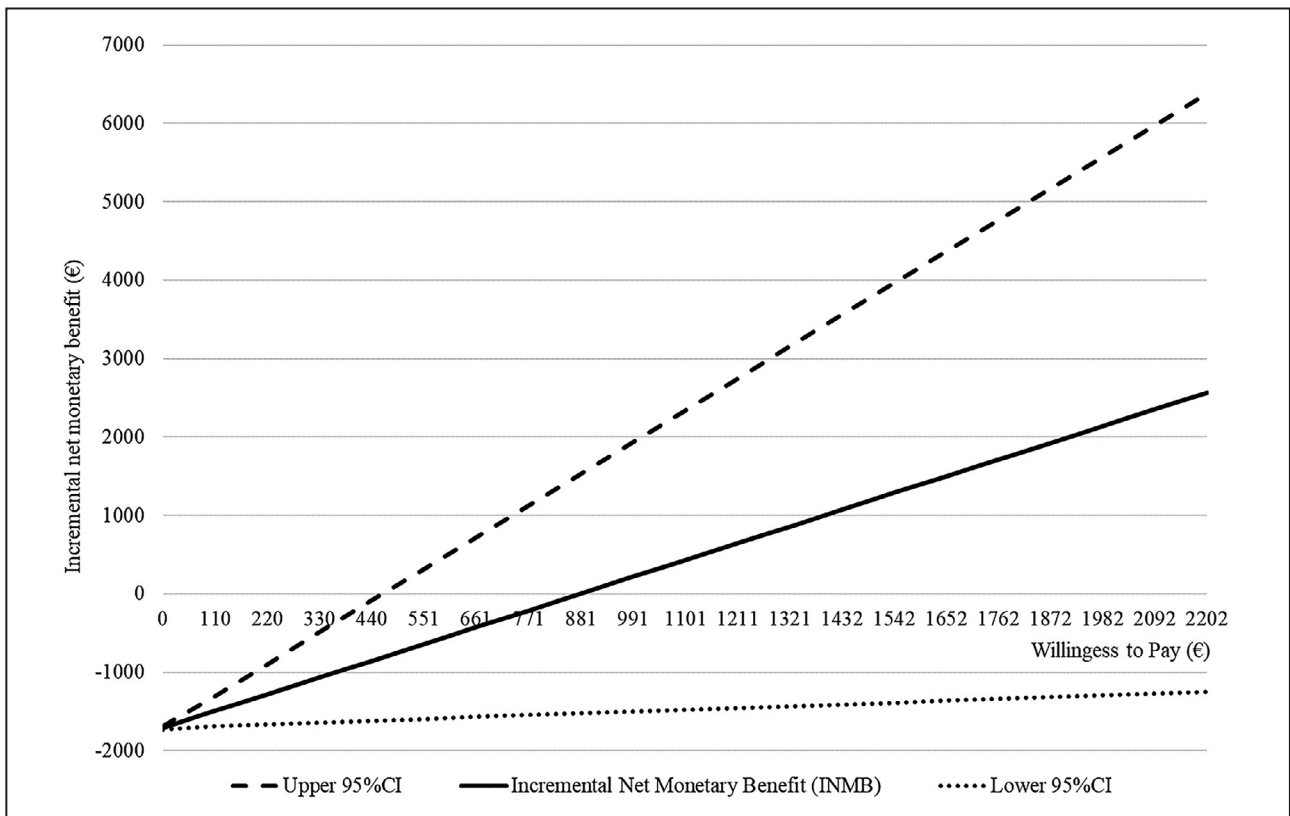


Figure 2. Incremental Net Monetary Benefit and 95% CI with Different Willingness to Pay Values for CBCL Externalizing Score.

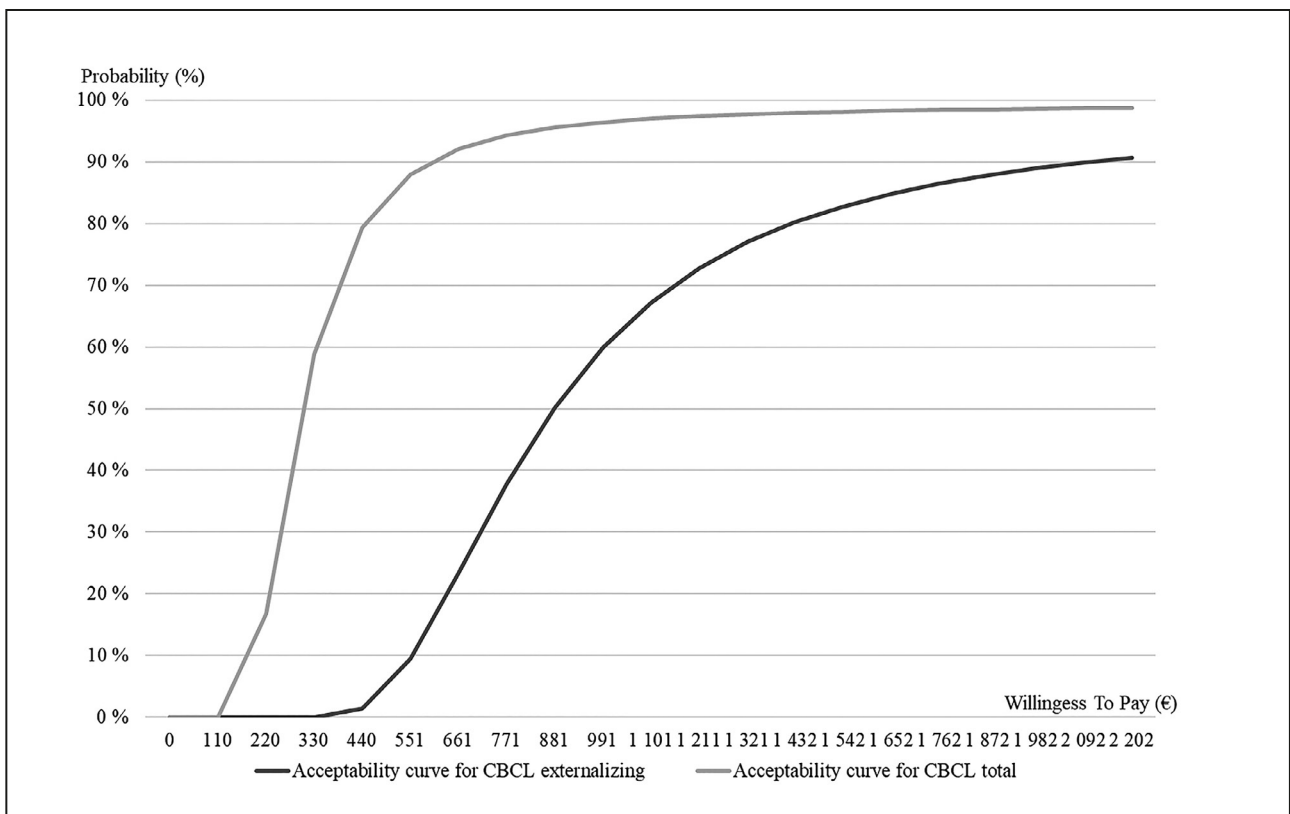


Figure 3. Cost-effectiveness Acceptability Curves Shows the Probability that SFSW was Cost-effective Compared to EC at Different Willingness to Pay Values for One Extra CBCL Externalizing or Total Point Reduction.

Note: Different scales for CBCL externalizing [0, 48] and CBCL total [0, 200] scores.

Discussion

This study evaluated the cost-effectiveness of the SFSW intervention compared to EC from a combined health care funder and parents' perspective. The SFSW intervention was effective in reducing childhood disruptive behaviour compared to EC and had higher costs than EC. Therefore, the cost-effectiveness of the SFSW compared to EC depends on the decision makers' WTP. The SFSW intervention produced a positive INMB and therefore was cost-effective only if the WTP was over €879 [0 INMB with 95% CI €-1,524 to €1,524] per one extra point reduction in the CBCL externalizing score. Still, with €879 WTP the SFSW intervention had 50% probability to be cost-effective compared to EC. The probability increases together with WTP. An additional analysis of CBCL total score showed that the WTP for one extra point reduction in the score needs to be above €302 [0 INMB with 95% CI €-1,289 to €1,290] to obtain a positive INMB for the SFSW intervention compared to EC. Depending on the decision maker's WTP, there is also need for consideration of the average INMB together with its uncertainty estimates.

At 2-year follow-up, the standardized effect size for effectiveness was small (0.21-0.25). At the baseline, some children already scored rather low in the CBCL externalizing score even though parents reported problems in the screening. The low-score families have smaller potential for improvement. Compared to a study of Strongest Families in Canada parent training¹⁶ with similar follow-up (22-month), our study had a higher standard effect size for CBCL externalizing score (0.21 vs. 0.05). Studies with shorter follow-up have reported higher effect sizes.^{12,13,32,33} Overall, the effect sizes of parent-based interventions have substantial heterogeneity.⁸ Implementation studies of the SFSW show that children with more difficult behavioural problems²¹ or with longer behavioural problems²² participated in the intervention compared to the original RCT study. Based on 6-month follow-up results of implementation study,²² the effectiveness of the SFSW was similar to the RCT study.¹³

The 11-session SFSW intervention costs (€1,982) were higher than in other distance interventions such as 12-session telephone-assisted Strongest Families¹⁶ (€1,216) and 7-session Internet-based Parent Management Training³³ (€178). The cost difference between SFSW and telephone-assisted Strongest Families cannot be evaluated as in both studies the cost of interventions is based on personal communication. The planned time-use of the coaching is similar. The realization of the planned coaching sessions in telephone-assisted Strongest Families¹⁶ is not reported. Internet-based Parent Management Training³³ had fewer sessions than the other two interventions and included only the time use of the research assistant who worked with the families. In SFSW and Strongest Families, the intervention costs represented all costs related to the intervention delivery.

Group interventions³⁴ such as the 11-session Comet (€976), 10-session Cope (€450) and 10-session Connect (€376) had lower costs per family/child. The cost of the 12-session Incredible Years intervention has varied between

cost-effectiveness studies. In a Swedish study,³⁴ the cost of the Incredible Years intervention was €1,508, and in a British study³⁵ of previous economic evaluations conducted in the UK and Ireland, the cost of an average of 12.7-session Incredible Years was €3,594 (SD €1,858) per family. All above costs were converted to 2022 euros.³⁶ The variation might be due to differences in service systems (resource use and their costs). In general, whether digital services reduce costs from the health care funder's perspective depends on the need for human resources. The Internet-based SFSW is based on individual coaching, and family-specific time use is higher than in group-based interventions.

Parents' time use estimate in the SFSW intervention (15.6 hours with 95% CI 14.8 to 16.4) was lower than in other parent training interventions, namely Comet (33 hours), Connect (20 hours), Incredible Years (42 hours) and Cope (30 hours), reported in cost-effectiveness study.³⁴ Some differences arise from wider inclusion of parents' costs. The previous study³⁴ also included parents' time use for homework. The advantage of digital delivery of the intervention is the decrease in parents' time use and cost of travelling to meetings.

Overall, the differences in study populations, comparators, outcomes, time horizons and cost perspectives complicate the comparison of our cost-effectiveness results with previous studies. Only few other economic evaluations of parent training interventions^{16,37,38} have used CBCL scores as an effectiveness estimate. The Canadian cost-effectiveness study¹⁶ of Distance-Delivered Strongest Families was the most similar to our study. The study included older children (6–12-year-olds) with more severe disruptive behaviour whose families were already seeking help from community children's mental health clinics compared to our study. In addition, that study included the costs of the families' other service use. At 22-month follow-up, their study showed that Strongest Families did not differ statistically in CBCL scores or costs from usual care. Based on their probabilistic sensitivity analysis, Strongest Families had a 44.5% probability of having better effects and being less costly than usual care.

A UK pilot study³⁷ of 42 families evaluated the cost-effectiveness of an intensive practise-based parent training intervention for 2–10-year-olds' severe behavioural problems compared to standard treatment. The multi-sectoral services perspective analysis included intervention costs and participant's other service use (health, special education, and social services). At 4-year follow-up, their study showed the intensive intervention to be effective and less costly than standard treatment.

Another Canadian cost-effectiveness study³⁸ compared group-based parent training and individual parent training to a waitlist control in a 6-month follow-up. The study included 150 children with behaviour problems above the 90th percentile. The group-based parent training was effective compared to individual parent training and less costly than individual parent training. The cost analysis contained intervention costs and parents' travel costs.

In preventive services, decision makers are interested in long-term cost-effectiveness. Only a few studies have eval-

uated the long-term cost-effectiveness of parent training in preventing childhood disruptive behaviour.³⁹⁻⁴¹ Overall, their results showed the Comet, Incredible Years, Cope, Connect, and Triple P parent training interventions to be cost-effective compared to no intervention in preventing conduct problems in the long-term. For treatments, long-term cost-effectiveness evaluations of parent training for childhood conduct disorder show similar results.^{42,43}

In interpreting our results, the following limitations should be taken into account. Our cost perspective was limited to only the health care funder and parents' perspectives. However, the costs of other services may alter the results of cost-effectiveness analyses. Previously, effectiveness studies^{12,13} have shown that participants in the SFSW group use behaviour treatments less often than participants in the EC group. Unfortunately, the service use data was too imprecise to monetize the service use reliably. Previously, short-term (6-month) economic evaluations of the Incredible Years intervention^{35,40,44,45} have shown no difference between Incredible Years and control groups in the per-child costs of other services except for a small (27 €) difference in mental health services³⁵. The evaluation by Gardner *et al.*³⁵ (including data from O'Neill *et al.*⁴⁰ and Edwards *et al.*⁴⁴) included the costs of hospital, community health care, mental health, social worker and other social care, child placement, voluntary sector, and self-help services. Also, the evaluation by Edwards *et al.*⁴⁵ found that the costs of children's special educational services or parents' social and health care services did not differ. It is possible that cost-savings would be visible only in longer-term evaluations.

As recommended,⁴⁶ researchers should decide the unit costs prior to unblinding the trial data. We received the production costs of SFSW and EC afterwards. For the cost information for SFSW we used a fixed price based on a contract with the municipalities purchasing the service. We used an assumption for the cost of EC, which is probably an overestimation.

The value of the reduction in CBCL outcome is complicated to interpret. We lack a stated WTP for that outcome measure. For the WTP decision, researchers should evaluate the meaningful change in the CBCL effectiveness measure, either clinically or for families. Also, we lack population references that could help to evaluate what would have happened without any intervention. As the SFSW effectiveness studies^{12,13} showed, the SFSW intervention reduced the disruptive behaviour of children more, and faster, than EC. The faster reduction is likely important for children and their families.

The CBCL effectiveness outcome does not include a time component, which would have benefitted the analyses. Often, economic evaluations use Quality-adjusted life years (QALYs) or Disability-adjusted life years (DALYs) as effectiveness measures. Both include health-related quality-of-life and time components. Many countries have a stated threshold for QALYs gained. Nowadays, the use of QALYs or DALYs is uncommon in short-term economic evaluations of parent training interventions. The reason might be that many of the health-related quality-of-life instruments used to calculate QALY lack externalizing and

social competence dimensions and child-based weights.⁴⁷ Nonetheless, future studies should include health-related quality-of-life instruments as an outcome measure as they allow QALY evaluation and the results can be evaluated together with willingness-to-pay threshold. As for the other effectiveness outcomes, the QALY data need to be collected right from the start of the trial to enable QALY calculation. For example, a parent rated proxy version of EQ-5D-Y can be used for 4-7 year-olds to calculate QALYs.⁴⁸ In addition, an algorithm⁴⁹ has been generated to translate SDQ measure outcomes to health utility values, which have been recently used in economic evaluation⁵⁰ to calculate QALYs.

Despite these limitations, our study has multiple strengths to note. The population-based screening covered almost all children. The trial had large number of participants and long follow-up. The cost-effectiveness analysis used all randomized children as recommended.⁵¹ The families with more severely behaving children more often had missing data and including them in the analysis improved the reliability of the results. The full economic evaluation used proper methods for imputation of missing values, to combine costs and effectiveness with WTP and to evaluate the uncertainty around cost-effectiveness results.

In general, cost-effectiveness studies should compare several interventions and 'usual care' together with similar high-quality methods to allow comparison between interventions. In the early phase of planning a new study, health economists should be consulted to enable high-quality data and research. Cost-effective services ensure the sustainable use of society's resources. Economic evaluations should therefore be required for investment decisions.

Conclusion

Whether the Strongest Families Smart Website intervention is cost-effective compared to education control depends on decision makers' willingness to pay for a point reduction in the Child Behavior Checklist externalizing or total scale. At present, decision makers need more economic evaluation research on digital parent training interventions. Additionally, researchers should assist decision makers with willingness-to-pay decisions by evaluating meaningful change in effectiveness measures, either clinically or for families.

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Appendix

Table A1. Logistic Regression of Missingness of Effectiveness Measures.

Variable (% of missing)	Missing CBCL externalizing score at 6-months (18.32%) Coefficient (SE)	Missing CBCL externalizing score at 12-months (21.77%) Coefficient (SE)	Missing CBCL externalizing score at 24-months (29.31%) Coefficient (SE)	Missing CBCL total score at 6-months (18.32%) Coefficient (SE)	Missing CBCL total score at 12-months (21.77%) Coefficient (SE)	Missing CBCL total score at 24-months (29.31%) Coefficient (SE)
<i>Intervention (0%) (EC)</i>						
SFSW	0.32 (0.24)	0.23 (0.23)	0.04 (0.20)	0.32 (0.24)	0.23 (0.23)	0.04 (0.20)
<i>Sex (0%) (Boy)</i>						
Girl	-0.09 (0.25)	0.03 (0.23)	-0.04 (0.21)	-0.09 (0.25)	0.03 (0.23)	-0.04 (0.21)
<i>Language (0.86%) (Finnish)</i>						
Swedish	-0.51 (0.76)	-0.24 (0.65)	-0.30 (0.58)	-0.51 (0.76)	-0.24 (0.65)	-0.30 (0.58)
Other	2.20 (1.23)	2.00 (1.23)	0.19 (1.23)	2.20 (1.23)	2.00 (1.23)	0.19 (1.23)
<i>Region (0%) (1)</i>						
(2)	-0.29 (0.35)	-0.00 (0.32)	-0.07 (0.29)	-0.29 (0.35)	-0.00 (0.32)	-0.07 (0.29)
(3)	-1.06 (0.55)	-0.76 (0.46)	-0.49 (0.38)	-1.06 (0.55)	-0.76 (0.46)	-0.49 (0.38)
(4)	-0.52 (0.51)	-0.68 (0.50)	0.23 (0.38)	-0.52 (0.51)	-0.68 (0.50)	0.23 (0.38)
(5)	-1.56 (1.04)	-0.96 (0.76)	-2.07 (1.04)*	-1.56 (1.04)	-0.96 (0.76)	-2.07 (1.04)*
(6)	-0.06 (0.53)	-0.22 (0.52)	-0.58 (0.52)	-0.06 (0.53)	-0.22 (0.52)	-0.58 (0.52)
(7)	-0.58 (0.64)	-0.39 (0.57)	-0.22 (0.50)	-0.58 (0.64)	-0.39 (0.57)	-0.22 (0.50)
<i>Parents living with child (0.65%) (Biological parents)</i>						
Biological mother & foster father	0.49 (0.53)	1.00 (0.47)*	1.43 (0.47)**	0.49 (0.53)	1.00 (0.47)*	1.43 (0.47)**
Biological mother alone	0.51 (0.36)	0.65 (0.34)	0.55 (0.32)	0.51 (0.36)	0.65 (0.34)	0.55 (0.32)
Adoptive parents	-	-	-	-	-	-
Foster parents	-	-	-	-	-	-
Other	0.89 (0.72)	0.16 (0.81)	0.33 (0.72)	0.89 (0.72)	0.16 (0.81)	0.33 (0.72)
<i>Mother's language (1.51%) (Finnish)</i>						
Swedish	-0.81 (1.06)	-0.22 (0.79)	-0.10 (0.69)	-0.81 (1.06)	-0.22 (0.79)	-0.10 (0.69)
Other	1.90 (0.92)*	1.68 (0.92)	1.29 (0.92)	1.90 (0.92)*	1.68 (0.92)	1.29 (0.92)
<i>Father's language (6.03%) (Finnish)</i>						
Swedish	0.11 (0.65)	1.07 (0.51)*	0.37 (0.52)	0.11 (0.65)	1.07 (0.51)*	0.37 (0.52)
Other	0.81 (0.51)	0.58 (0.50)	0.57 (0.47)	0.81 (0.51)	0.58 (0.50)	0.57 (0.47)
Number of siblings (11.21%)	0.20 (0.13)	0.16 (0.12)	-0.01 (0.12)	0.20 (0.13)	0.16 (0.12)	-0.01 (0.12)
Mother's age (1.08%)	-0.09	-0.09	-0.11	-0.09	-0.09	-0.11 (0.02)***
Father's age (5.17%)	(0.02)***	(0.02)***	(0.02)***	(0.02)***	(0.02)***	-0.05 (0.02)**
	-0.03 (0.02)	-0.02 (0.02)	-0.05 (0.02)**	-0.03 (0.02)	-0.02 (0.02)	
<i>Mother's education (0.65%) (Lower level)</i>						
Middle	-1.60	-1.12	-2.02	-1.60	-1.12	-2.02 (0.49)***
High	(0.42)***	(0.41)**	(0.49)***	(0.42)***	(0.41)**	-2.69 (0.48)***
	-2.09	-1.74	-2.69	-2.09	-1.74	
	(0.42)***	(0.41)***	(0.48)***	(0.42)***	(0.41)***	
<i>Father's education (7.33%) (Lower level)</i>						
Middle	-0.67 (0.42)	-0.49 (0.41)	-0.38 (0.39)	-0.67 (0.42)	-0.49 (0.41)	-0.38 (0.39)
High	-0.97 (0.43)*	-0.99 (0.42)*	-0.90 (0.40)*	-0.97 (0.43)*	-0.99 (0.42)*	-0.90 (0.40)*
Child age at baseline (0%)	0.22 (1.03)	2.18 (0.92)*	2.52 (0.86)**	0.22 (1.03)	2.18 (0.92)*	2.52 (0.86)**
CBCL externalizing score at baseline (0%)	0.02 (0.02)	0.03 (0.01)	0.04 (0.01)**	0.02 (0.02)	0.03 (0.01)	0.04 (0.01)**
CBCL externalizing score at 6-months (18.32%)	-	0.01 (0.02)	0.01 (0.02)	-	0.01 (0.02)	0.01 (0.02)
CBCL externalizing score at 12-months (21.77%)	-0.05 (0.04)	-	0.02 (0.02)	-0.05 (0.04)	-	0.02 (0.02)
CBCL externalizing score at 24-months (29.31%)	-0.17 (0.06)**	0.00 (0.04)	-	-0.17 (0.06)**	0.00 (0.04)	-



(continued)

Variable (% of missing)	Missing CBCL externalizing score at 6-months (18.32%) Coefficient (SE)	Missing CBCL externalizing score at 12-months (21.77%) Coefficient (SE)	Missing CBCL externalizing score at 24-months (29.31%) Coefficient (SE)	Missing CBCL total score at 6-months (18.32%) Coefficient (SE)	Missing CBCL total score at 12-months (21.77%) Coefficient (SE)	Missing CBCL total score at 24-months (29.31%) Coefficient (SE)
CBCL total score at baseline (0%)	0.01 (0.01)	0.01 (0.01)*	0.02 (0.00)**	0.01 (0.01)	0.01 (0.01)*	0.02 (0.00)**
CBCL total score at 6-months (18.32%)	-	0.01 (0.01)	0.00 (0.01)	-	0.01 (0.01)	0.00 (0.01)
CBCL total score at 12-months (21.77%)	-0.01 (0.02)	-	0.01 (0.01)	-0.01 (0.02)	-	0.01 (0.01)
CBCL total score at 24-months (29.31%)	-0.08 (0.03)*	-0.00 (0.02)	-	-0.08 (0.03)*	-0.00 (0.02)	-
Parenting score at the baseline (0%)	0.55 (0.23)*	0.71 (0.22)***	0.61 (0.19)**	0.55 (0.23)*	0.71 (0.22)***	0.61 (0.19)**
Parenting score at the 6-months (18.97%)	-	0.23 (0.35)	0.22 (0.25)	-	0.23 (0.35)	0.22 (0.25)
Parenting score at the 12-months (22.20%)	0.42 (0.50)	-	0.61 (0.29)*	0.42 (0.50)	-	0.61 (0.29)*
Parenting score at the 24-months (30.17%)	0.03 (0.61)	0.48 (0.62)	-	0.03 (0.61)	0.48 (0.62)	-
Parents' time-use cost (1.29%)	-0.00 (0.00)***	-0.00 (0.00)***	-0.00 (0.00)***	-0.00 (0.00)***	-0.00 (0.00)***	-0.00 (0.00)***

Note: P<0.05=*, p<0.01=**, p<0.001=***

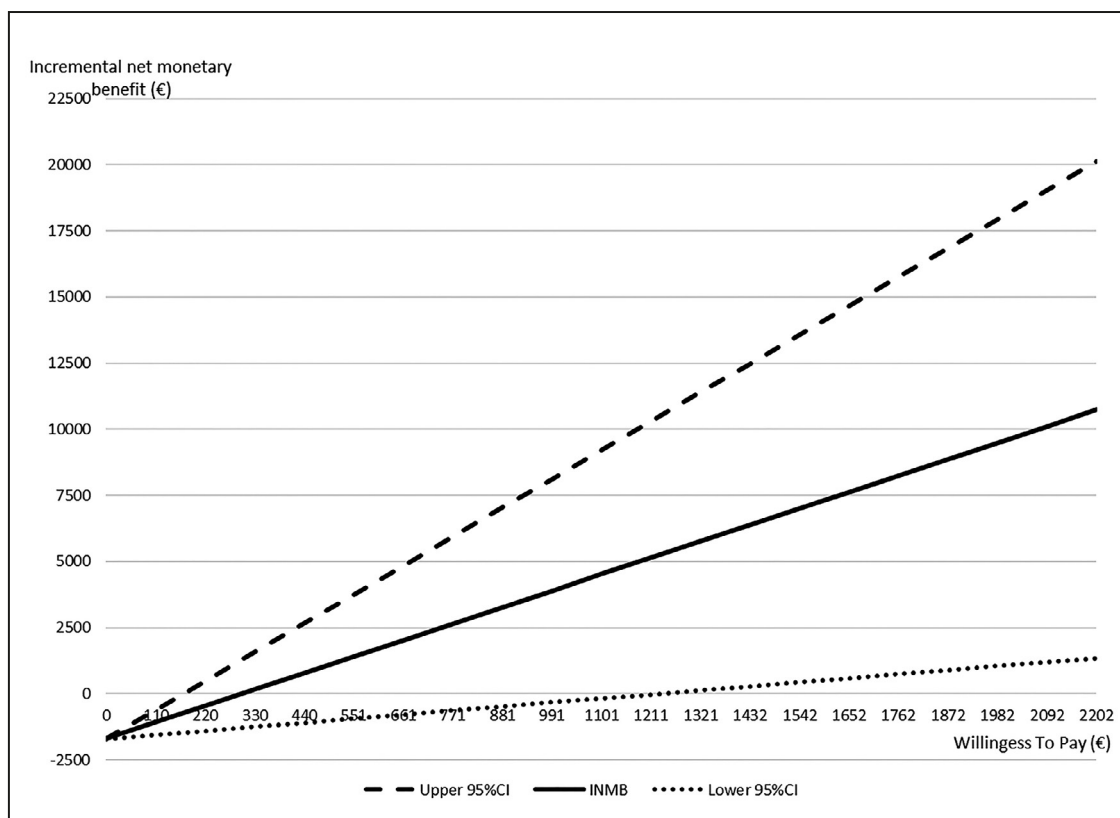


Figure A1. Incremental Net Monetary Benefit and 95% CI with Different Willingness to Pay Values for CBCL Total Score

Table A2. Model-Based Incremental Net Monetary Benefits and Probabilities for Acceptability Curve.

WTP to pay for one extra point reduced in CBCL externalizing score ^a	Incremental net monetary benefit ^b	95% confidence interval		P-value ^c	One-sided p-value ^d	Acceptability curve probability ^e
€0	-€1,707	-€1,730	-€1,683	0	0	0 %
€110	-€1,493	-€1,687	-€1,299	0	0	0 %
€220	-€1,279	-€1,663	-€895	0	0	0 %
€330	-€1,065	-€1,639	-€491	0.003	0.002	0 %
€440	-€851	-€1,616	-€87	0.086	0.043	4 %
€551	-€638	-€1,593	€318	0.347	0.174	17 %
€661	-€424	-€1,570	€722	0.677	0.339	34 %
€771	-€210	-€1,547	€1,127	0.966	0.483	48 %
€881	€4	-€1,524	€1,532	0.811	0.406	60 %
€991	€218	-€1,501	€1,936	0.648	0.324	68 %
€1,101	€432	-€1,478	€2,341	0.528	0.264	74 %
€1,211	€645	-€1,455	€2,745	0.439	0.220	78 %
€1,321	€859	-€1,431	€3,150	0.372	0.186	81 %
€1,432	€1,073	-€1,408	€3,554	0.320	0.160	84 %
€1,542	€1,287	-€1,385	€3,959	0.280	0.140	86 %
€1,652	€1,501	-€1,362	€4,364	0.248	0.124	88 %
€1,762	€1,715	-€1,339	€4,768	0.222	0.111	89 %
€1,872	€1,928	-€1,316	€5,173	0.201	0.101	90 %
€1,982	€2,142	-€1,293	€5,577	0.184	0.092	91 %
€2,092	€2,356	-€1,270	€5,982	0.169	0.085	92 %
€2,202	€2,570	-€1,247	€6,387	0.157	0.079	92 %
€2,753	€3,639	-€1,132	€8,409	0.116	0.058	94 %
CBCL Total						
WTP to pay for one extra point reduced in CBCL externalizing score ^a	Incremental net monetary benefit ^b	95% confidence interval		P-value ^c	One-sided p-value ^d	Acceptability curve probability ^e
€0	-€1,707	-€1,730	-€1,683	0	0	0 %
€110	-€1,085	-€1,556	-€613	0	0	0 %
€220	-€462	-€1,403	€478	0.556	0.278	28 %
€330	€160	-€1,250	€1,569	0.634	0.317	68 %
€440	€782	-€1,097	€2,661	0.313	0.157	84 %
€551	€1,404	-€944	€3,752	0.185	0.093	91 %
€661	€2,026	-€791	€4,843	0.124	0.062	94 %
€771	€2,648	-€638	€5,934	0.091	0.046	95 %
€881	€3,270	-€485	€7,026	0.071	0.036	96 %
€991	€3,893	-€332	€8,117	0.059	0.030	97 %
€1,101	€4,515	-€179	€9,208	0.050	0.025	98 %
€1,211	€5,137	-€26	€10,299	0.044	0.022	98 %
€1,321	€5,759	€127	€11,391	0.039	0.020	98 %
€1,432	€6,381	€280	€12,482	0.035	0.018	98 %
€1,542	€7,003	€433	€13,573	0.032	0.016	98 %
€1,652	€7,625	€586	€14,665	0.030	0.015	99 %
€1,762	€8,248	€739	€15,756	0.028	0.014	99 %
€1,872	€8,870	€892	€16,847	0.026	0.013	99 %
€1,982	€9,492	€1,045	€17,938	0.025	0.013	99 %
€2,092	€10,114	€1,198	€19,030	0.024	0.012	99 %
€2,202	€10,736	€1,351	€20,121	0.023	0.012	99 %
€2,753	€13,847	€2,117	€25,577	0.019	0.010	99 %

Note: ^aDecision-makers willingness to pay (WTP) values for one extra point reduction of CBCL externalizing score or CBCL total score.

^bPotential incremental Net Monetary Benefits received from SFSW intervention compared to EC with different willingness to pay values.

^cOLS regression p-values.

^dP-values divided by 2.

^eThe calculation of probabilities for acceptability curve: 1) if the INMB is below zero, the probability is the same as one-sided p-value 2) if the INMB is above zero, the probability is 1 minus one-side p-value. (Hoch *et al.*³⁰)