

The cost-effectiveness of a virtual intervention to prevent eating disorders in young women in Sweden

Patricio Martínez de Alva MD, MSc¹  | Ata Ghaderi PhD²  |
Gerhard Andersson PhD³ | Inna Feldman PhD¹ | Filipa Sampaio PhD¹

¹Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden

²Division of Psychology, Department of Clinical Neuroscience, Karolinska Institute, Stockholm, Sweden

³Department of Clinical Neuroscience, Karolinska Institute, Stockholm, Sweden

Correspondence

Patricio Martínez de Alva, Department of Public Health and Caring Sciences (IFV), Uppsala University, BMC, Husargatan 3, 751 22 Uppsala, Sweden.
Email: patricio.martinez@pubcare.uu.se

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Abstract

Objective: To determine the cost-effectiveness of a virtual version of the Body Project (vBP), a cognitive dissonance-based program, to prevent eating disorders (ED) among young women with a subjective sense of body dissatisfaction in the Swedish context.

Method: A decision tree combined with a Markov model was developed to estimate the cost-effectiveness of the vBP in a clinical trial population of 149 young women (mean age 17 years) with body image concerns. Treatment effect was modeled using data from a trial investigating the effects of vBP compared to expressive writing (EW) and a do-nothing alternative. Population characteristics and intervention costs were sourced from the trial. Other parameters, including utilities, treatment costs for ED, and mortality were sourced from the literature. The model predicted the costs and quality-adjusted life years (QALYs) related to the prevention of incidence of ED in the modeled population until they reached 25 years of age. The study used both a cost-utility and return on investment (ROI) framework.

Results: In total, vBP yielded lower costs and larger QALYs than the alternatives. The ROI analysis denoted a return of US \$152 for every USD invested in vBP over 8 years against the do-nothing alternative and US \$105 against EW.

Discussion: vBP is likely to be cost-effective compared to both EW and a do-nothing alternative. The ROI from vBP is substantial and could be attractive information for decision makers for implementation of this intervention for young females at risk of developing ED.

Public Significance: This study estimates that the vBP is cost-effective for the prevention of eating disorders among young women in the Swedish setting, and thus is a good investment of public resources.

KEYWORDS

cognitive dissonance, cost-effectiveness analysis, decision modeling, feeding and eating disorders, Markov chains, mental health, online intervention, primary prevention

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1 | INTRODUCTION

The worldwide prevalence of eating disorders (ED) has increased from 3.5% to 7.8% between 2000 and 2018, although these numbers are believed to be an underestimation (Galmiche et al., 2019). EDs are afflictions that carry substantial disease and economic burden (Klump et al., 2009). They disrupt psychosocial functioning and affect several systems in the body that may lead to somatic disturbances (American Psychiatric Association, 2013; Treasure et al., 2020), and have a negative impact on work participation and performance (Safi et al., 2022). Individuals with ED have a high risk of mortality due to cardiovascular, respiratory, and gastroenterological complications (Jáuregui-Garrido & Jáuregui-Lobera, 2012; Rosling et al., 2011) and have higher suicide mortality rates compared with the general population, over 10 times higher specifically for anorexia nervosa (AN) (Chesney et al., 2014; Crow et al., 2009).

Characteristically, EDs are difficult to diagnose and treat effectively (Hay, 2020). Long-term follow-up studies of inpatients with an ED showed that 64% of persons previously diagnosed with AN still met diagnostic criteria after treatment, specifically, 54% for bulimia nervosa (BN) and 30% for binge-eating disorder (BED) (Fichter et al., 2017). Approximately, only 25% of those with ED receive treatment specifically for eating or weight problems (Swanson et al., 2011), and current treatments such as cognitive behavioral therapy (CBT) and family-based treatment (FBT) are effective for less than 50% of patients (Hay, 2013).

EDs carry a large economic burden for individuals and society. A report from Australia estimated the total socioeconomic cost of ED in 2012 at US \$47.2 billion (69.7 billion 2012 AUD) (Paxton et al., 2012), with healthcare costs representing about 75.5% of the total cost, and the remaining 21.7% corresponding to productivity losses. In the United States, this cost was estimated at US \$64.7 billion in 2019, with healthcare costs and productivity losses representing 7% and 75% of the total cost, respectively (Streatfeild et al., 2021). In the United Kingdom, treatment for ED alone was estimated to cost US \$12.7 million (8.8 million GBP) per 1000 patients in 2015 (PwC, 2015).

The importance of prevention is highlighted by the difficulties in diagnosing and treating patients with ED, the limited access to treatment, as well as the substantial economic burden. There are some encouraging interventions for prevention of ED risk factors. For universal prevention, media literacy interventions significantly reduce shape and weight concerns (González et al., 2011; Wade et al., 2003; Wilksch et al., 2015). For selective prevention, cognitive dissonance interventions have better results for reducing ED symptoms (Serdar et al., 2014). Prevention trials based on CBT has had the largest effect size on dieting outcome at 9-month follow-up (Le, Barendregt, Hay, & Mihalopoulos, 2017). However, it is uncertain whether indicated prevention actually reduces ED incidence mainly because most of these studies focus on continuous measures of ED risk factors without reporting outcomes for actual cases who met ED diagnostic criteria (Le, Barendregt, Hay, & Mihalopoulos, 2017).

The Body Project (Stice & Presnell, 2007), a dissonance-based prevention program, is one of only two interventions that showed a significant reduction of incidence of ED over multiyear follow-ups in

clinical trials in the United Kingdom and United States (Halliwell & Diedrichs, 2014; Stice et al., 2008, 2017).

In Sweden, a virtual version of the Body Project (vBP) intervention has been carried out in a randomized clinical trial to assess its effectiveness. The vBP showed significantly greater reduction in ED symptoms, clinical impairment, body dissatisfaction, and internalization of thin ideal compared with a control group after intervention and at 6-month follow-up. When compared to an alternative preventive intervention, expressive writing (EW) (Kupeli et al., 2018), vBP had 77% lower incidence of ED across 24 months of follow-up (vBP 2%, EW 8.8%) (Ghaderi et al., 2020). The virtually delivered format of this intervention has the potential to allow broader implementation of this effective prevention program. However, the cost-effectiveness of this virtual intervention has not been investigated in the Swedish context and this might be a barrier for decision on broad implementation of the intervention.

Health economic analyses are systematic tools used to support decision makers in complex medical decision (Ryder et al., 2009). Economic evaluations provide the framework to measure, value, and compare the costs and benefits of different healthcare interventions (Jain, 2016), such as preventive interventions.

Few studies have examined the cost-effectiveness of interventions to prevent ED. In the latest systematic review of cost-effectiveness studies of prevention and treatment for ED, findings were inconsistent (Le et al., 2018). A previous study on the cost-effectiveness of the Body Project delivered by clinicians on site reported a cost of \$838 per person with reduced ED symptoms (Akers et al., 2017). However, that version of the Body Project did not reduce ED onset to a significant degree relative to educational controls. Another study reported the cost-effectiveness of different delivery modalities for the Body Project (Akers et al., 2021), including clinician-led, peer-led, and internet-delivered, with peer-led being the most cost-effective with a cost of \$740 per case of ED averted compared to an educational video control. The internet-delivered version (eBody Project) produced greater reduction of ED risk factors and symptoms relative to the video control, but yielded lower benefits at higher costs than the control by the peer-led modality (Akers et al., 2021).

This version of the vBP is peer-led, which could yield better results in this study given the peer-led format was previously regarded as the best modality in terms of cost-effectiveness (Akers et al., 2021).

The goal of the current study was to evaluate the cost-effectiveness of the vBP to prevent ED among young women with a subjective sense of body dissatisfaction in Sweden.

2 | METHODS

2.1 | Evaluation framework

This study used data on sample characteristics and effectiveness from a randomized clinical trial (RCT) performed in Sweden between 2016 and 2019 (Ghaderi et al., 2020). The inclusion criteria were to be female 15–20 years old with a subjective sense of body dissatisfaction, and able to

read and write in Swedish. Exclusion criteria were a current diagnosis of ED, concurrent psychological treatment, severe depression, suicidality, or any serious condition that required psychiatric care (e.g., bipolar disorders or schizophrenia). Ads on social media were posted referencing the website of the study where participants could declare interest. One thousand six hundred and seventy-eight people were inclined to participate, but 436 of those never started screening or screening was incomplete. The remaining 1242 persons were screened for the items in the inclusion/exclusion criteria and 433 of those were eligible (799 were excluded) and invited to participate in the study. All 433 persons were accepted and were randomized for the study. The RCT investigated the effectiveness of the vBP compared to EW and a waitlist control group (henceforth called a do-nothing alternative). For this study, a decision tree combined with a Markov model was developed in Microsoft Excel 2019 to estimate the cost-effectiveness of delivering the vBP to prevent ED among young Swedish females compared to both EW and a do-nothing alternative. The overall model predicts the costs and quality-adjusted life years (QALYs) related to the incidence of ED among the target population, over an 8-year time horizon (2 years in decision tree to reflect the same period as the RCT and 6 years in Markov model to cover for peak incidence of ED; Micali et al., 2013). The model used both a cost-utility (expressed as cost per QALY gained) and a return on investment (ROI) framework (estimated as the difference in total costs divided by the difference in intervention cost between comparators). Healthcare and societal perspectives were adopted. All costs were presented in 2021 USD. Future costs and QALYs were discounted at 3% yearly (Lundgren, 2017). A consolidated health economic evaluation reporting standards (CHEERS) checklist (Husereau et al., 2013) is included in the [Supporting Information](#).

2.2 | Modeled population

This study modeled a trial population of 433 females aged 15–20 years old (mean age 17 years old) at risk of developing ED who participated in the RCT. In the trial, the participants were randomized to one of three groups: vBP ($n = 149$), EW ($n = 148$), and Waitlist control ($n = 146$).

2.3 | Interventions description

The vBP consisted of four sessions, delivered one per week with a duration of 1 h per session. In Session 1, patients were asked to define the thin body ideal and discuss the costs of pursuing it. They were also assigned home exercises such as writing a letter to a younger girl telling the costs of pursuing the thin body ideal and recording positive self-qualities. In Session 2, the home exercises were reviewed, and role-playing took place to dissuade the pursuit of the thin ideal between the participants. Sessions 3 and 4 reinforced this approach with similar activities of dissuasion, diverting thin-ideal comments, and resisting future pressure to be thin, along with more home exercises.

EW consisted of written instructions sent to participants, where they were asked to write about their thoughts, images, emotions, and

whatever comes to their mind in relation to their body for 40 min. A do-nothing alternative was also modeled, representing the waitlist control included in the trial.

2.4 | Modeling health outcomes

A decision tree combined with a Markov model was developed for this study. The decision tree captures the incidence and remission of ED in each arm of the trial (vBP, EW, and do-nothing) at each follow-up, across two health states: “at risk of ED” and “ED.” To reflect both the follow-up timepoints and the time horizon of the RCT, the decision tree had 6-month cycles and a 2-year time horizon (the RCT had 6-month follow-up periods until 2 years). At every cycle, each health state was paired with corresponding costs and utilities.

Incidence of ED was chosen as outcome since this economic evaluation sought to model the costs and health benefits of the prevention of ED. Incidence was operationalized as the number of cases diagnosed with ED at follow-up period in the RCT, and was estimated at 6, 12, and 24 months (Ghaderi et al., 2020). Remission rates of ED were sourced from the published literature (Fairburn et al., 2000), and used throughout the model in every arm.

Since an 18-month period needed to be accounted for in the model, and the RCT did not register data at that point, the incidence at the 18-month period was assumed to be the same as at the 12-month follow-up (based on expert opinion). Another assumption was made where the incidence for the do-nothing alternative reached a peak at the patient's 19 years of age and then diminished until the end of the modeling period (Stice et al., 2013).

The Markov model simulated how the cohort transitioned between the states: “At risk,” “ED,” and “Dead,” in each arm of the trial over 1-year cycles. It was used to estimate the long-term health and economic outcomes over a 6-year time horizon, matching when patients became 25 years old on average (assuming if peak incidence of ED is between 15 and 19 years old [Micali et al., 2013], there would be lessening merit to model after 25 years old). Further, extending the time horizon well into the future would require additional assumptions and would bring more uncertainty into the results.

In a similar fashion, each health state was paired with corresponding costs and utilities. Total costs and utilities were estimated across the full modeling period of 8 years for the cost-utility analysis. Since there is no data on effects of the vBP beyond the RCT duration we assumed a decay of effect (reduction of ED incidence) of 10% per year. The decision tree and Markov model are represented below in Figure 1.

2.5 | Model parameters

2.5.1 | Epidemiological parameters

The population characteristics and effect estimates (incidence) were sourced from the RCT. Swedish female population mortality rates were sourced from Statistics Sweden (SCB) (Statistics Sweden, 2022).

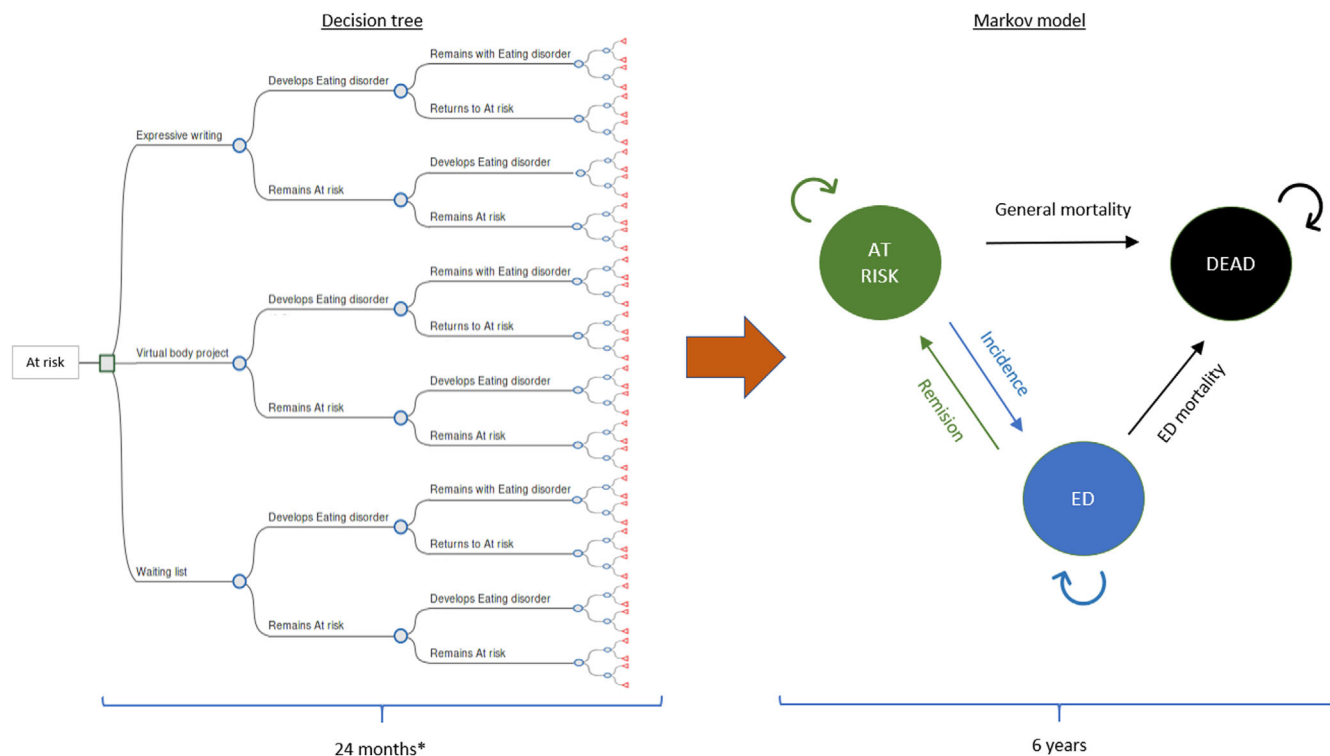


FIGURE 1 Decision tree and Markov model. *24 months divided into 6-month periods for each cycle in the decision tree (6, 12, 18, and 24 months). The first two cycles (6 and 12 months) are represented in the figure with labels, the remaining cycles (18 and 24 months) follow the same structure and are represented in smaller scale without labels for size purposes. ED, eating disorder.

ED mortality rates for Swedish females were sourced from the latest Global Burden of Disease study (GBD 2019) (Vos et al., 2020). Table 1 outlines the input parameters used in the model.

2.5.2 | Utilities

Health state utility values (HSUVs) for the health states ED and at risk were sourced from a population-based study in Australia (Le et al., 2021). HSUVs in the mentioned study were derived from the SF-6D. It included separate HSUVs for specific ED categories listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) (American Psychiatric Association, 2013), and these were: AN, BN, BED, other specified feeding or eating disorder (OSFED), and unspecified feeding or eating disorder (UFED). Multiple linear regression models, adjusted for age, sex, working status, marital status, country of birth, and education, were used to test the differences of HSUVs across ED categories. Each category had its own utility. To get a single utility estimate for ED, each category was weighted by its sample size and averaged for this study.

2.5.3 | Costs

Intervention and screening costs

The cost to implement the Body Project virtually included the peer-leader's time to deliver the intervention plus training and supervision

costs. Peer-leader's time was valued at US \$14 per hour as given in the RCT. Training and supervision costs were US \$2575 for a 2-day session and US \$125 per hour respectively, sourced from The Body Project Collaborative (n.d.). Costs were added and divided by sample size in the intervention group ($n = 149$), yielding US \$21 per person. Intervention was delivered via a no-cost video conference platform (Google Hangouts). Cost of EW was calculated as the cost of one working day for the peer leader to create the written instructions (US \$75.3) divided by the number of participants receiving the EW intervention ($n = 148$), yielding US \$.51 per person. Screening costs were calculated at US \$14 per person (1 h of Peer-leader's time to screen one person). One thousand two hundred and forty-two people were screened, yielding a total cost of US \$17,532. In our model the screening costs would attribute only to the vBP group. To obtain the cost per person for the model the total screening cost was divided by the sample size ($n = 433$), yielding US \$41 per person.

Costs related to ED

Due to lack of healthcare cost data of ED in Sweden, information was derived from a population-based register study from Denmark (Christensen et al., 2022). Healthcare cost was calculated as the annual sum of hospital costs from psychiatric and somatic services (comorbid somatic services related to ED), subsidized prescription cost, and primary healthcare service cost for every individual diagnosed with ED (absolute costs limited to AN and/or BN) (Christensen et al., 2022) based on the DRG National Patient Register (The Danish

TABLE 1 Model parameters.

Parameter	Value	Range	Distribution	Source
Population	15–20-year-old females (mean age 17 years old)	-	Not varied	Ghaderi et al. (2020)
Cost of virtual Body Project ^a	21	17–25	PERT	RCT administration logs (The Body Project Collaborative, n.d.)
Cost of expressive writing ^a	.51	.41–.61	PERT	RCT administration logs
Cost of do-nothing ^a	0	-	Not varied	RCT administration logs
Cost of screening ^b	41	35–46	PERT	RCT administration logs
Healthcare cost ^c	6322	5058–7587	PERT	Christensen et al. (2022)
Productivity loss ^c	906	725–1087	PERT	Christensen et al. (2022)
Discount rate	3%	-	Not varied	Lundgren (2017)
Utility for health state at risk ^d	.82	.824–.816	Beta	Le et al. (2021)
Utility for health state ED ^d	.79	.78–.80	Beta	Le et al. (2021)
Incidence of ED in expressive writing group ^e	6 months: .056; 12 months: .021; 18 months: .021; 24 months: .026	-	Not varied	Ghaderi et al. (2020)
Incidence of ED in virtual Body Project group ^e	6 months: .000; 12 months: .014; 18 months: .014; 24 months: .004	-	Not varied	Ghaderi et al. (2020)
Incidence of ED in do-nothing alternative ^e	6 months: .071; 12 months: .053; 18 months: .040; 24 months: .030	-	Not varied	Ghaderi et al. (2020)
Remission in decision tree (all groups)	6 months: .000; 12 months: .416; 18 months: .460; 24 months: .520	-	Not varied	Fairburn et al. (2000)
Remission in Markov model (all groups)	Year 3: .500; year 4: .650; years 5–8: .845	-	Not varied	Fairburn et al. (2000)
Average mortality rate for health state at risk	.0002	-	Not varied	Statistics Sweden (2022)
Average mortality rate for health state ED	.0356	.02–.06	Log normal	Vos et al. (2020)

Abbreviations: ED, eating disorder; RCT, randomized clinical trial.

^aCost expressed as 2021 USD per person.

^bCost of screening 1242 participants.

^cCost expressed as 2021 USD per person year.

^dUtility values describe the value of a health state on a scale where 1 represents full health, 0 represents states deemed to be as bad as being dead.

^eValues for each follow-up period (6, 12, 18, and 24 months).

Health Data Authority, 2017). Costs of lost productivity related to income loss were also obtained from this study and were measured as the difference in personal income between people diagnosed with ED and controls, excluding public transfer payments (Christensen et al., 2022). All costs were converted to 2021 USD using a currency converter and purchasing power parities tool (Shemilt et al., 2010). All costs are displayed in Table 1.

2.6 | Cost-effectiveness analyses

The primary analysis employed a cost-utility framework and the results were reported as incremental cost-effectiveness ratios (ICERs) which expressed the incremental difference in costs and QALY between vBP, EW, and the do-nothing scenario. Interventions were compared pairwise and an ICER was estimated for each comparison. A willingness to pay threshold of US \$79,000 (SEK

700,000) was used to determine whether the interventions should be considered cost-effective in the Swedish setting based on the lowest cost per QALY of declined reimbursements by the Swedish Dental and Pharmaceutical Benefits Agency (TLV), sourced from a review of reimbursement decisions between 2005 and 2011 (Svensson et al., 2015).

2.7 | ROI analysis

The secondary analysis included ROI analyses of vBP compared against EW and the do-nothing alternative. EW was also compared against the do-nothing alternative. The difference in total costs between comparators was divided by the difference in intervention costs. This revealed the returns from investing in vBP or EW in 8 years. The ROI was estimated as a benefit–cost ratio, which is an approach previously used by Public Health England to estimate ROI of

services for promotion of mental health and wellbeing and prevention of mental ill-health (McDaid et al., 2017).

2.8 | Uncertainty analysis

A probabilistic sensitivity analysis (PSA) was conducted, using Monte Carlo simulation with 3000 iterations, by simultaneously sampling parameter values such as costs, health utilities, and mortality rates from probability distributions. Results from the PSA were graphed in a cost-effectiveness plane.

2.9 | Sensitivity and threshold analyses

Univariate sensitivity analyses for certain parameters were run to estimate the impact of the following scenarios: (1) applying a 0%, and a 5% discount rate to both costs and effects as recommended by Swedish guidelines (Lundgren, 2017); (2) no effect of vBP on the incidence of ED after the trial period (24 months); (3) removing costs and QALYs of AN from the ED category. Based upon the assumption that the vBP intervention might not target risk factors that predict future onset of threshold or subthreshold AN, according to a meta-analytic review (Stice et al., 2021). This was done by removing the category AN from the single utility estimate for ED and also discarding the healthcare and productivity costs related to AN.

Additionally, a threshold analysis was also conducted to: (1) identify how much the vBP intervention would have to cost for it to no longer dominate when compared to EW in the societal perspective; (2) identify how much the cost of ED would have to be for the vBP to stop being dominant when compared to EW in the societal perspective. A goal of US \$1 per QALY gained was set for both analyses. For threshold analysis 1, only the intervention cost of vBP was varied. For threshold analysis 2, only the aggregated costs of healthcare and productivity loss were varied. The remaining parameters in the model were unchanged.

2.10 | Institutional review board statement

Most data used in this study were collected from published literature; therefore, no ethical approval was needed. The RCT that this project gathers data from was approved by the Regional Ethics Board in Stockholm (Dnr. 2015/841-31/2 and 2015/2051-32). Participants were asked to sign an informed consent and the digital questionnaire data were encrypted. The current study did not handle personal information.

3 | RESULTS

3.1 | Cost-effectiveness analysis results and ROI

vBP had the lowest cost and the highest QALY gains per person of all alternatives with US \$790 and 9.11 QALYs from the societal

perspective. EW had substantially higher costs at US \$2914 per person and lower QALYs at 9.09. The do-nothing alternative had the highest cost and the lowest health gains with US \$3948 per person and 9.08 QALY, respectively. Results are presented below in Table 2.

An ICER was calculated for each pairwise combination of alternatives. The vBP and EW dominated the do-nothing alternative, yielding higher QALYs and lower costs. Moreover, vBP also dominated EW in both perspectives. The uncertainty around the benefit and cost estimates for each pairwise comparison is presented on a cost-effectiveness plane in Figure 2.

The cost-effectiveness plane represents the uncertainty around the cost and QALY estimates. The x axis represents incremental QALYs and the y axis represents incremental costs. Each quadrant has cost-effectiveness decision implications. The upper left quadrant represents higher costs and lower QALYs (the intervention is dominated by the comparator); the lower right quadrant represents lower costs and higher QALYs (the intervention dominates the comparator); the upper right quadrant represents higher costs and higher QALYs; and the lower left quadrant represents lower costs and lower QALYs. These two last quadrants imply a trade-off and incremental costs and benefits should be in relation to a willingness to pay threshold for a QALY gained.

In our analysis, the ICER iterations for each pairwise comparison spread in the lower quadrants of the cost-effectiveness plane. vBP dominates against EW in 68.7% of the iterations and 67.9% against the do-nothing alternative.

The ROI for vBP compared to the do-nothing alternative in the healthcare perspective was US \$133 and US \$152 in the societal perspective. Comparing vBP against EW, the ROI was US \$92 and US \$105 for healthcare and societal perspective respectively. For every US \$1 invested in vBP there would be a return ranging between US \$92 to US \$152 depending on comparator and perspective. Cost savings produced by vBP exceeded total intervention costs in both perspectives.

3.2 | Sensitivity and threshold analysis results

Results remained robust to scenarios 1, 2, and 3 (see Section 2.9) where vBP remained cost-effective and dominated the alternatives. Results of the univariate sensitivity analyses are shown below in Figure 3. A table with the sensitivity results is included in the [Supporting Information](#).

Figure 3a,c displays the ICER of every scenario for vBP versus EW and vBP versus do-nothing respectively. In both graphs, the ICERs of every scenario are situated in the lower-right quadrant of the CE plane. And thus, vBP remains cost-effective when compared to EW and the do-nothing alternative in every scenario. Figure 3b illustrates the expected ROI of vBP compared to EW for each scenario. For every US \$1 invested in vBP, we could expect a return between US \$36 and US \$114 depending on the scenario. Similarly, in Figure 3d, a ROI between US \$53 and US \$154 is expected for the vBP compared to the do-nothing alternative depending on the scenario.

TABLE 2 Results of the cost-effectiveness analysis and ROI (total costs presented in 2021 USD per person).

Parameters	vBP Mean (95% UI)	EW Mean (95% UI)	Do-nothing Mean (95% UI)
Costs			
Screening cost	41 (35 to 46)	0	0
Intervention cost	21 (18 to 24)	.51 (.44 to .58)	0
Healthcare cost	638 (545 to 732)	2550 (2180 to 2925)	3455 (2954 to 3963)
Productivity loss	91 (78 to 104)	364 (311 to 416)	493 (421 to 563)
Healthcare cost + productivity loss	729 (623 to 835)	2914 (2491 to 3341)	3948 (3375 to 4526)
Total costs for healthcare perspective ^a	699 (598 to 802)	2551 (2181 to 2926)	3455 (2954 to 3963)
Total cost for societal perspective ^b	790 (676 to 906)	2914 (2492 to 3342)	3948 (3375 to 4526)
QALYs	9.11 (5.47 to 10.99)	9.09 (5.52 to 10.92)	9.08 (5.55 to 10.89)
Incremental			
	vBP versus EW (95% UI)	vBP versus do-nothing (95% UI)	EW versus do-nothing (95% UI)
Screening cost	41 (35 to 46)	41 (35 to 46)	0
Intervention cost	20.57 (17.76 to 23.58)	21.08 (18.20 to 24.16)	.51 (.44 to .58)
Healthcare cost	-1912 (-1635 to -2194)	-2817 (-2409 to -3231)	-905 (-774 to -1038)
Productivity loss	-273 (-233 to -312)	-402 (-343 to -459)	-129 (-110 to -148)
Healthcare + productivity loss	-2185 (-1868 to -2505)	-3219 (-2752 to -3691)	-1034 (-884 to -1185)
Total costs healthcare perspective	-1851 (-1583 to -2124)	-2755 (-2356 to -3161)	-904 (-773 to -1037)
Total costs societal perspective	-2124 (-1816 to -2436)	-3157 (-2699 to -3620)	-1033 (-883 to -1185)
QALYs	.02 (-.04 to .07)	.03 (-.07 to .10)	.01 (.03 to .03)
ICER			
ICER for healthcare perspective	Dominant (37,460 to dominant)	Dominant (31,643 to dominant)	Dominant (24,011 to dominant)
ICER for societal perspective	Dominant (42,979 to dominant)	Dominant (36,257 to dominant)	Dominant (27,437 to dominant)
ROI			
Healthcare perspective	92 (72 to 114)	133 (105 to 164)	1780 (1435 to 2171)
Societal perspective	105 (84 to 129)	152 (122 to 186)	2034 (1672 to 2467)

Abbreviations: Dominant, a dominant ICER means that the intervention is cost saving and yields higher QALYs relative to the comparator; EW, expressive writing; ICER, incremental cost-effectiveness ratio; QALYs, quality-adjusted life years; ROI, return on investment; UI, uncertainty interval; vBP, virtual Body Project.

^aTotal costs corresponded to total healthcare cost plus intervention cost plus screening cost per person.

^bTotal costs corresponded to total healthcare cost plus productivity loss plus intervention cost plus screening cost per person.

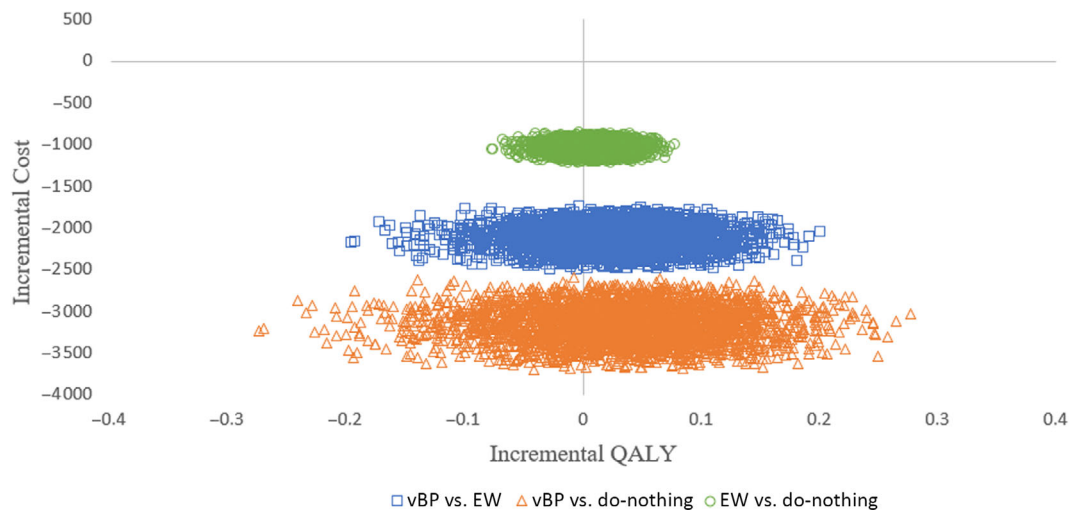


FIGURE 2 Cost-effectiveness plane. Monte Carlo simulation with 3000 iterations per analysis. Virtual Body Project (vBP) versus expressive writing (EW): 68.7% dominates; vBP versus do-nothing: 67.9% dominates; EW versus do-nothing: 65.7% dominates.

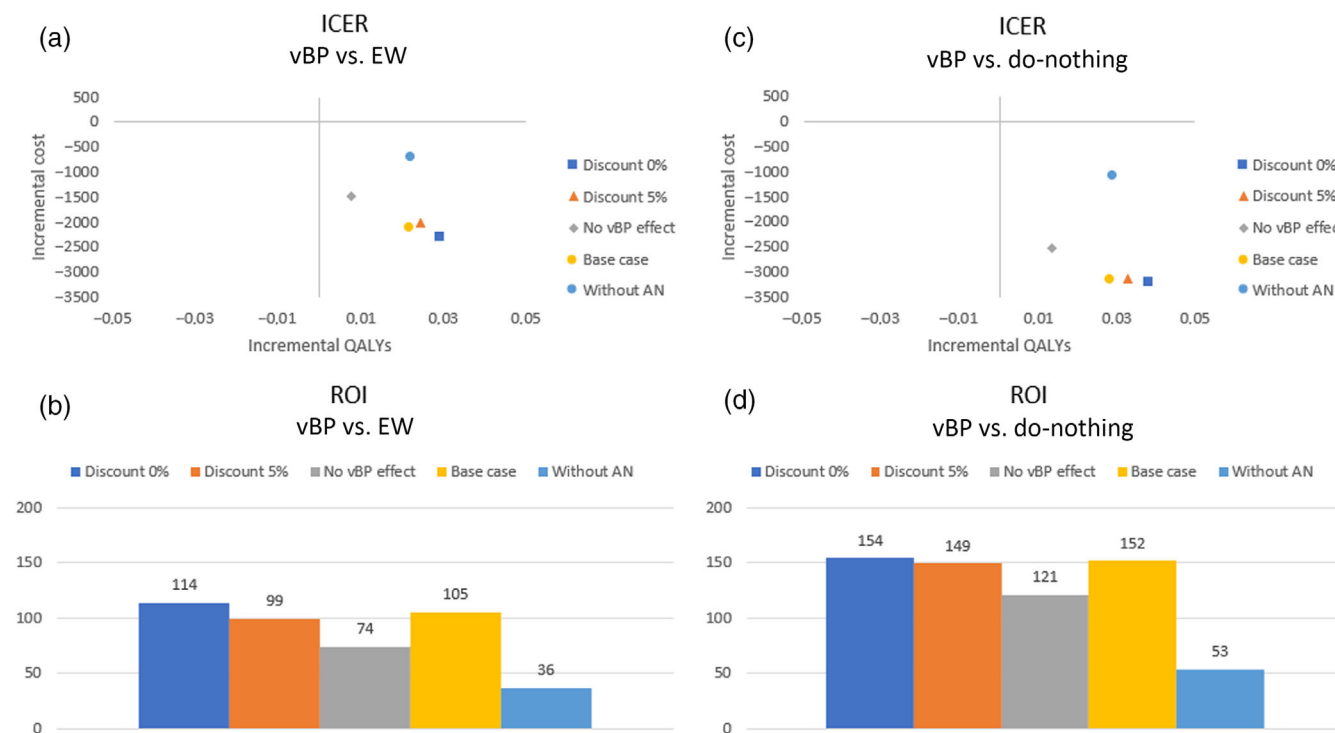


FIGURE 3 Results of sensitivity analyses. The ICER of each scenario is displayed in graphs (a) and (c) for (vBP vs. EW) and (vBP vs. do-nothing alternative) respectively. The ROI of each scenario are displayed in graphs (b) and (d) for (vBP vs. EW) and (vBP vs. do-nothing alternative) respectively. AN, anorexia nervosa; EW, expressive writing; ICER, incremental cost-effectiveness ratio; QALYs, quality-adjusted life years; ROI, return on investment; vBP, virtual Body Project.

Regarding threshold analysis 1, the intervention cost of vBP would have to be at US \$2145 per person to stop being dominant against EW, with an ICER of US \$1 per QALY gained in the societal perspective. In threshold analysis 2, the cost of ED (healthcare costs + productivity loss) in the vBP group would have to be at US \$2853 per person to yield an ICER of US \$1 per QALY gained. A table with the threshold analysis results is included in the [Supporting Information](#).

4 | DISCUSSION

This study estimated the cost-effectiveness of the vBP compared to EW and a do-nothing scenario to prevent ED among young women with body dissatisfaction in the Swedish context, using health economic decision modeling.

The results demonstrated that vBP is likely to be cost-effective while providing positive health gains and have a large return on investment compared to both EW and a do-nothing scenario, with vBP yielding more benefits and lower costs than the alternatives in 68% of the iterations when compared to EW. These results could be explained by the 77% reduction in future ED onset from the RCT data that this economic analysis took as reference. In a sensitivity analysis, the effect of the vBP intervention on the future onset of ED was neglected after the duration of the trial period and the result remained cost-effective compared to both alternatives (EW and do-nothing). In

addition, the base model considers a 10% decay of effect of the vBP per year after trial period. Even so, vBP remained robust.

Another possible explanation for the results is the relative low cost of delivering vBP. If administered by peer leaders with a no-cost platform and assuming computer equipment is already on site, the vBP intervention had a cost of just over US \$3000 to deliver to 149 individuals. By considering the economic impact of ED in the healthcare system and society over the modeling period, and the savings of preventing the disease, the intervention cost is overshadowed.

The virtual format of this intervention is a key factor in terms of increased access, lower costs, and a major potential for large scale implementation of prevention of ED among young women at increased risk of incidence of ED.

There are not many economic evaluations of cognitive dissonance interventions for preventing ED. A recent systematic review found 13 cost-effectiveness studies on prevention and treatment of ED. It reported inconsistent findings, lack of evidence for long-term cost-effectiveness (over 2 years), and no conclusions regarding value-for-money could be drawn (Le et al., 2018). Moreover, only two studies in the systematic review evaluated cognitive dissonance interventions.

The first study by Le, Barendregt, Hay, & Mihalopoulos (2017) used a population-based Markov model of girls aged 15–18 years in Australia. It estimated the cost per disability-adjusted life-year (DALY) averted by cognitive dissonance relative to no intervention over a 10-year time horizon. The perspective focused on costs and benefits

accruing to students, healthcare providers, school staff, and third-party payers. It reported an ICER of AU \$103,980 (US \$81,500 in 2021 prices) per DALY averted, and was not considered cost-effective (Le, Barendregt, Hay, Sawyer, et al., 2017).

The second study, by Akers et al., 2017, estimated the within-trial cost-effectiveness of delivering the Body Project against an educational brochure, from the perspective of the university as the payer, to young women aged 21 years, in the USA, for reducing ED symptoms. Effectiveness was defined as achieving a clinically meaningful reduction in ED symptoms, and only intervention costs were considered. It reported an ICER of US \$838 per individual with clinical meaningful change (Akers et al., 2017), over a time horizon of 3 years, and was unable to conclude if this clinical gain represented good value for money.

In contrast, our study reports cost-effectiveness from a cognitive dissonance intervention to prevent ED. We presume the difference in results between the before mentioned economic evaluations and this one, relies not only on the low cost and the higher effect size from the vBP, but also on the sample and estimates from a randomized controlled trial. Comparatively, the study by Le, Barendregt, Hay, & Mihalopoulos (2017) relies on pooled effect estimates from a meta-analysis of studies applied to the whole Australian population. Moreover, perspectives and outcomes utilized between this economic evaluation and the rest were different.

One of the strengths of the present study relies on the broad economic perspective used, which accounted for cost for treatment, use of healthcare services, and productivity losses related to income loss and thus, helping unveil the economic burden of ED over a time horizon of 8 years from societal perspective. Furthermore, QALYs were used as health outcome, which allows for comparison with other cost-effectiveness analyses (Weinstein et al., 2009).

The decision model of this study, similarly to other decision models, employed several assumptions that may pose limitations to this study and impact the results. For example, effect data to populate the do-nothing scenario in the model, sourced from the RCT, was limited to 6 months. This was because the control group was offered the vBP thereafter and withdrawn from further analysis. Given the constraints, an assumption was made where the incidence for the do-nothing alternative reached a peak at the patient's 19 years of age and then diminished until the end of the modeling period, which might not reflect how a control group transitions through health states in the long term.

Furthermore, to fit data in all cycles in the decision tree, incidence at 18 months was assumed the same as at 12 months (18-month follow-up data were not gathered in the RCT). Based on expert opinion, incidence was assumed not to vary substantially between these periods, but we recognize this is a limitation.

Additionally, this study sources healthcare costs and productivity loss from a population-based study in Denmark (Christensen et al., 2022). We assume such costs related to developing an ED to be similar to those of Sweden, given the similarity in the population and healthcare systems, but until local data are available, this remains a limitation. Moreover, since QALYs were not measured within the trial,

HSUVs for the health states in the model had to be sourced from a study in Australia (Le et al., 2021). Although the utilities were an acceptable fit given the similarities of age, sex, and condition, the difference in populations is another limitation.

Further studies are needed to support cost-effectiveness estimations of such preventive interventions, namely studies with larger population-based samples with direct record of costs, utilities, and longer follow-up periods.

5 | CONCLUSION

Health economic modeling estimated that the vBP was cost-effective compared to EW, and a do-nothing scenario to prevent ED among young women with a subjective sense of body dissatisfaction in Sweden. The results add evidence to support the investment in this intervention and may contribute to devising appropriate preventive interventions for young females at risk of developing ED.

AUTHOR CONTRIBUTIONS

Patricio Martínez de Alva: Formal analysis; methodology; writing – original draft; writing – review and editing. **Ata Ghaderi:** Conceptualization; data curation; writing – review and editing. **Gerhard Andersson:** Writing – review and editing. **Inna Feldman:** Conceptualization; methodology; supervision; writing – review and editing. **Filipa Sampaio:** Conceptualization; methodology; supervision; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data are available on request.

ORCID

Patricio Martínez de Alva  <https://orcid.org/0000-0002-4875-2020>
Ata Ghaderi  <https://orcid.org/0000-0001-8483-7964>

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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