Evaluating the cost-effectiveness of the Prostate Cancer Patient Empowerment Program: A comprehensive health economic analysis from a randomized controlled trial

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ABSTRACT

Introduction: The aim of this study was to evaluate the cost-effectiveness of the Prostate Cancer Patient Empowerment Program (PC-PEP), a six-month comprehensive intervention designed to enhance psychological well-being and reduce healthcare expenditures among prostate cancer patients.

Methods: In a crossover randomized clinical trial of 128 men aged 50–82 years scheduled for curative prostate cancer surgery or radiotherapy (± hormone treatment), 66 men received the PC-PEP intervention immediately, while 62 were randomized to a waitlist-control arm and received standard care for six months before receiving PC-PEP. The intervention included daily activities targeting physical fitness, pelvic floor training, stress management, intimacy, social support, and dietary guidance. Cost-effectiveness was assessed from a healthcare payer perspective using billing data from Nova Scotia's Medical Services Insurance (MSI) and self-reported outcomes. Incremental cost-effectiveness ratios (ICERs) and cost-effectiveness acceptability curves (CEACs) were calculated using bootstrapped samples. Psychological distress was assessed with the Kessler Psychological Distress Scale (K10), while quality-adjusted life years (QALYs) were estimated from SF-6D utility scores.

Results: PC-PEP resulted in cost savings of $411.53 CAD per patient at six months, with a 30% reduction in clinically significant psychological distress and a QALY gain of 0.013. At 12 months, savings increased to $660.89 CAD per patient, preventing 31% of distress cases and yielding a QALY gain of 0.034. These outcomes demonstrate that PC-PEP is a dominant intervention, achieving both improved clinical outcomes and reduced healthcare expenditures.

Conclusions: PC-PEP is a dominant, cost-effective strategy that significantly improves psychological well-being while lowering healthcare costs. Early implementation following prostate cancer diagnosis is strongly recommended to maximize both clinical and economic benefits.

KEY MESSAGES

- The PC-PEP is a six-month, home-based intervention designed to improve mental health and quality of life for men undergoing PCa treatment while reducing healthcare costs.
- PC-PEP significantly reduced psychological distress and improved patient-reported outcomes, leading to fewer treatment-related side effects.
- The program lowered healthcare costs by approximately $412 CAD per patient at six months and up to $661 CAD at 12 months.
- PC-PEP was found to be a dominant strategy in cost-effectiveness analysis — simultaneously improving health outcomes and reducing overall healthcare spending.

INTRODUCTION

Prostate cancer is the most frequently diagnosed cancer among men in Canada, with one in nine men expected to receive a diagnosis during their lifetime.[1] Despite a five-year survival rate of 91%,[2] many survivors experience declines in quality of life (QoL) due to treatment-related side effects, including erectile dysfunction, urinary incontinence, and psychological distress.[3-7] Men with prostate cancer are nearly five times more likely to experience psychological distress at one month post-diagnosis, over three times more likely at three months, and almost seven times more likely at six months compared to those without a diagnosis.[8] Long-term impairments in health-related quality of life (HRQoL) are particularly pronounced ten years after treatment.[9]

The economic burden of prostate cancer care in Canada's publicly funded healthcare system is substantial, affecting both the healthcare system and patients. In 2021, the total societal cost of prostate cancer treatment was estimated at 1,514 million CAD in direct healthcare expenses, 356 million CAD in out-of-pocket costs, and 325 million CAD in time and indirect costs.10 A population-based cohort study in British Columbia tracking patients from 2010 to 2019 reported the highest mean attributable costs during the first year post-diagnosis (14,307.9 CAD) and the final year of life for those dying from prostate cancer (9,959.7 CAD).[11] These costs highlight the urgent need for cost-effective survivorship interventions that reduce healthcare resource use while improving long-term patient outcomes.
Despite advancements in prostate cancer management, survivors frequently report unmet informational needs, particularly regarding treatment side effects (89%), lifestyle changes (81%), and drug-related effects (82%).[3-4,12-13] While psychosocial and educational interventions show promise, only multifaceted interventions—likely due to their ability to address diverse patient needs—are consistently effective in improving physical and mental health outcomes.[14-15] However, such interventions remain scarce and underutilized in clinical practice.

To address these gaps, the Prostate Cancer Patient Empowerment Program (PC-PEP) was developed as a six-month, home-based health promotion intervention.[16] PC-PEP provides structured daily activities supported by video demonstrations, focusing on stress reduction, physical fitness, pelvic floor exercises, stress management, intimacy and connection training, social support, and dietary guidance. Previous analyses show that PC-PEP significantly reduces psychological distress, decreases the need for psychological treatment, and improves urinary and sexual function, as well as physical fitness.[16-19] These findings highlight the program's potential as a scalable, patient-centered survivorship intervention. However, cost-effectiveness analyses of prostate cancer survivorship interventions remain limited, particularly in Canada.[20-21]

We hypothesize that PC-PEP is a cost-effective intervention at six- and 12-months post-enrollment, reducing healthcare costs while improving psychological outcomes and HRQoL. This study evaluates PC-PEP's cost-effectiveness by assessing its impact on (1) healthcare costs, (2) incidence of psychological distress and need for clinical treatment, and (3) quality-adjusted life years (QALYs) at six and 12 months. Additionally, we examine whether PC-PEP demonstrates cost-effectiveness using both psychological distress reduction and QALY improvements as effectiveness measures.

METHODS

Study context and design

This cost-effectiveness analysis of PC-PEP was a pre-specified secondary evaluation within a single-site, university-based, tertiary care crossover randomized controlled trial (RCT). The primary aim was to assess PC-PEP's impact on psychological distress, while this analysis examined healthcare costs and cost-effectiveness. The study adhered to CHEERS 2022[22] and CONSORT guidelines [Supplementary Material]. The complete protocol and primary outcome evaluation were published in *European Urology*.[16]

Participants were recruited between December 2019 and January 2021 via oncology clinics in Nova Scotia, Canada.[16] Eligibility criteria included biopsy-confirmed prostate adenocarcinoma, planned curative treatment (radical prostatectomy or radiation ± hormone therapy), daily internet access, physical fitness for moderate exercise, and English proficiency. Ethical approval was granted by the Nova Scotia Health Research Ethics Board (#1024822, ClinicalTrials.gov NCT03660085).

Randomization and study flow

Of 171 eligible participants, 140 were randomized (Figure 1). Eleven were excluded due to incomplete curative treatment within six months, yielding a final sample of 128. A fixed-block, computer-generated allocation system was used, with stratification by hormone therapy status, baseline psychological distress (K10 ≥20), and treatment modality (surgery vs. radiation ± hormone therapy) to ensure balance across clinically relevant factors. The PC-PEP group received the intervention immediately, while the control group received standard care for six months before accessing PC-PEP, in accordance with the crossover design. Due to incomplete billing data, nine participants were excluded from the economic analysis, resulting in a final analytic sample of 119 (61 intervention, 58 control). No additional post-randomization matching was performed, as the stratified allocation approach was designed to minimize confounding and preserve internal validity.

Intervention (PC-PEP)

PC-PEP is a six-month, home-based program promoting quality of life through fitness, stress reduction (HeartMath® biofeedback),[24-25] and lifestyle guidance. Participants received daily video-guided exercises, nutritional and sleep recommendations, and social support via peer check-ins and Zoom meetings.

Data collection and measures

Participants completed online assessments via REDCap at baseline, six months, and 12 months.[26] The primary outcome was clinically significant psychological distress (K10 ≥20), measured using the Kessler Psychological Distress Scale (K10) [27]. The K10 summary score was used as a continuous measure, with a binary classification for clinical distress (≥20).[27-29] Reliability was high (Cronbach's α: 0.85 at baseline, 0.94 at six months, 0.97 at 12 months).

The secondary outcome, quality-adjusted life years (QALYs), was calculated using the area under the curve (AUC) method from SF-6D utility scores.[30-32] QALYs range from 0 (death) to 1 (perfect health), with linear interpolation applied between timepoints.

Economic evaluation framework

The cost-effectiveness analysis followed a healthcare payer perspective, focusing on direct healthcare costs as per Canadian health economic guidelines.[33] We selected the healthcare payer perspective to align with the priorities of provincial public insurers and healthcare administrators, who are primarily concerned with reimbursable services within Canada's publicly funded healthcare system. Although the societal perspective is considered the gold standard in economic evaluations, broader cost domains such as lost productivity, out-of-pocket payments, and caregiver burden were not systematically collected in this trial.

Comparator

The control group received standard prostate cancer care as provided by Nova Scotia's publicly funded healthcare system, including routine medical visits, treatment follow-ups, and specialist referrals. This comparator reflected real-world care practices and served as the reference for cost-effectiveness evaluation against the PC-PEP intervention. Participants in the control group were offered PC-PEP after a six-month delay, consistent with the crossover design of the trial.

Time horizon

The cost-effectiveness analysis employed a 12-month time horizon for each participant, covering healthcare costs and clinical outcomes from the date of randomization to their 12-month follow-up. This time frame aligns with the full duration of the crossover randomized controlled trial, which spanned from December 20, 2019, to January 16, 2022, and enabled complete observation of both the intervention and waitlist-control phases.

Cost data collection

Healthcare resource use was extracted from Nova Scotia Medical Services Insurance (MSI) billing records (July 2023) and included physician visits, hospitalizations, emergency department use, prescriptions, and intervention-related expenses. All costs were valued in 2023 CAD and adjusted using the Canadian Consumer Price Index (CPI).[33]

Intervention costs included program development, staff time, administration, and material distribution (e.g., heart rate variability devices, exercise equipment). Physician services were valued using fee-for-service claims or shadow billing rates for salaried providers.
Non-episodic or fixed system costs (such as infrastructure, capital equipment, and administrative overhead) were excluded from the analysis. These costs do not typically vary between groups and are not reflected in MSI billing records. Moreover, as PC-PEP was delivered virtually and outside of institutional infrastructure, we did not expect differential overhead costs between arms.

Verification of prostate cancer-related costs

Healthcare visits in the MSI database were validated against Nova Scotia's Share Clinical Portal. Visits were reviewed manually to determine relevance to prostate cancer care. Relevant visits included oncology, urology, and general practitioner encounters related to treatment, follow-up, and side effect management. Non-relevant visits (e.g., dermatology, ophthalmology, unrelated cardiology) were excluded based on diagnostic codes, physician specialty, and clinical documentation where available. In cases where coding was incomplete, visits were assessed by three independent reviewers (AN, CM and GI) using timing and contextual notes to ensure consistency and minimize misclassification.

Cost-effectiveness analysis

The Incremental Cost-Effectiveness Ratio (ICER) was calculated by dividing the cost difference between groups by the difference in effectiveness—either in reducing psychological distress cases or improving QALYs. Sensitivity analyses were conducted to assess the robustness of the results. Deterministic analyses varied intervention costs by ±25% and ±50%, including exclusion of the HRV biofeedback device (a reduction of CAD 105.33 per participant), and adjusted effectiveness estimates by ±10% for psychological distress reduction and ±25% for QALY gains. Probabilistic sensitivity analysis was conducted using Monte Carlo simulation (10,000 iterations), applying gamma distributions for cost inputs and beta distributions for utility values. These analyses informed the generation of cost-effectiveness acceptability curves (CEACs).

Handling uncertainty

Non-parametric bootstrapping (10,000 iterations) assessed ICER uncertainty. Resampling individual patient data with replacement preserved correlation between costs and outcomes.
The 10,000 ICERs generated cost-effectiveness acceptability curves (CEACs) and 95% confidence intervals. CEACs assessed cost-effectiveness probabilities across willingness-to-pay

(WTP) thresholds (CAD 0–100,000 per QALY and CAD 0–5,000 per psychological distress case averted).[35]

Pre-specified covariates included Charlson Comorbidity Index, age (continuous), treatment type (1: surgery, 2: radiation ± hormone therapy), time from randomization to treatment, relationship status (0: single, 1: partnered), and prescription of anxiety/depression medications (0: no, 1: yes).

Heterogeneity between sub-groups

The Kruskal-Wallis rank-sum test assessed cost-effectiveness differences by age group (50–64, 65–74, 75+) and treatment modality (surgery vs. radiation ± hormone therapy).

Statistical analysis

A generalized linear model (GLM) with a gamma distribution and log link compared mean costs, adjusting for prognostic covariates. Logistic regression analyzed distress (K10 ≥20) at six and 12 months. Two-level linear modeling assessed changes in continuous outcomes (K10 and QALYs). Non-parametric Mann-Whitney U tests were applied for non-normally distributed QALY data. All tests were two-sided ($p<0.05$). Analyses were conducted using R Studio (v4.4) for cost-effectiveness, ICER calculations, bootstrapping, and CEACs [36]; Stata (v17.0) for QALY analysis, GLM models, and non-parametric tests;[37] and SPSS (v27.0) for logistic regression, two-level modeling, and descriptive statistics.[38]

RESULTS

Baseline characteristics of the study population

The baseline characteristics of the study population were generally comparable between the intervention and waitlist control groups, with no statistically significant differences in most variables (Table 1). The notable exception was relationship status, where a significantly higher proportion of men in the waitlist control group were in a relationship compared to the intervention group ($p = 0.03$). Most participants were Caucasian (94%), married or in a relationship (93%), and retired (66%). The mean participant age was 66 years (range: 51–81 years). No adverse events or attrition occurred during the trial.

Cost of administering PC-PEP

The average cost of delivering PC-PEP per participant was CAD 200.07 (Table 2). This cost included materials, heart rate variability (HRV) devices, resistance equipment (provided without return), text messaging, and personnel time. HRV devices were loaned to participants, with overall costs reduced by bulk purchasing and device reuse. This approach ensured cost efficiency without compromising program quality.

Cost to the healthcare system

Table 3 presents healthcare expenditures and per-patient costs in Canadian dollars (CAD) over two time periods: baseline to six months and baseline to 12 months. Generalized linear model (GLM) analysis showed that from baseline to six months, healthcare costs were significantly lower in the intervention group compared to the control group ($\beta = -0.24$, 95% CI: -0.48 to -0.0058, $p = 0.045$). However, the difference in healthcare costs from baseline to 12 months was not statistically significant ($\beta = -0.22$, 95% CI: -0.55 to 0.102, $p = 0.18$).

Calculation of effectiveness

Non-specific psychological distress (K10)

Table 4 summarizes the number of participants with clinically significant psychological distress (K10 $\geq$ 20) at baseline, six months, and 12 months in both groups. In the intervention group, the number of participants with distress remained constant from baseline to six months, while the control group experienced three new cases. Logistic regression controlling for baseline K10 scores and other covariates revealed a significant difference at six months (OR = 3.5, 95% CI: 1.04–12, $X^2(1) = 4.1$, $p = 0.043$). By 12 months, after the waitlist control group received the intervention, distress increased by two cases in the intervention group and five in the control group, though the difference was not statistically significant (OR = 2.0, 95% CI: 0.74–5.3, $X^2(1) = 1.9$, $p = 0.17$).

QALYs as the effectiveness outcome

Mean SF-6D health utility scores were assessed at baseline, six months, and 12 months (Figure 2). The late intervention group showed a decline in health utility scores from baseline to six months, followed by stabilization. In contrast, the early intervention group exhibited relatively stable scores throughout the study, indicating a potential protective effect of PC-PEP on health-related quality of life.

Table 5 shows that QALYs declined in both groups from baseline to six months, with a greater decrease in the control group, suggesting a positive incremental effect in the intervention group. Between baseline and 12 months, QALYs increased in the intervention group but continued to decrease in the control group. The Mann-Whitney U test indicated no statistically significant differences in QALYs at six months ($U = 2007$, $p = 0.201$) or 12 months ($U = 2052$, $p = 0.13$).

Cost-effectiveness analyses

Using non-specific psychological distress as the effectiveness measure, PC-PEP demonstrated cost savings of CAD 411.53 per patient at six months, preventing three additional distress cases compared to standard care. By 12 months, savings increased to CAD 660.89 per patient, with three fewer distress cases (Table 6).

When quality-adjusted life years (QALYs) were used as the effectiveness metric, the intervention yielded comparable economic value. PC-PEP saved CAD 411.53 per patient at six months with an incremental QALY gain of 0.013, and CAD 660.89 at 12 months with a QALY gain of 0.034 (Table 7). These findings show that PC-PEP is a dominant strategy, delivering both improved psychological outcomes and reduced healthcare costs across two independent effectiveness measures. The approximately 30% reduction in clinically significant distress, combined with meaningful QALY gains, renders the calculation of an incremental cost-effectiveness ratio (ICER) unnecessary and provides strong evidence that PC-PEP is a clinically and economically superior intervention for prostate cancer survivorship care.

The cost-effectiveness plane

Cost-effectiveness planes were constructed to visualize the economic and health impacts of PC-PEP using bootstrapped results. The first plane, based on non-specific psychological distress as the outcome, shows the intervention's cost-effectiveness from baseline to six months and baseline to 12 months (Figure 3).

A second cost-effectiveness plane was generated using QALYs as the outcome for the same time periods, applying the same bootstrapping procedure (Figure 4).

The cost-effectiveness acceptability curve (CEAC)

To account for uncertainty in cost-effectiveness, cost-effectiveness acceptability curves (CEACs) were generated for both outcome measures. For psychological distress (K10), the willingness-to-pay (WTP) threshold represents the maximum amount decision-makers would be willing to pay for a one-unit reduction in K10 scores, with thresholds ranging from 0 to 5,000 CAD in 100-CAD increments (Figure 5). For QALYs, thresholds ranged from 0 to 100,000 CAD in 1,000-CAD increments, reflecting standard benchmarks used in Canadian health economic evaluations (Figure 6). Results from probabilistic sensitivity analyses confirmed that PC-PEP remained highly cost-effective across a wide range of WTP values. Specifically, the probability of cost-effectiveness exceeded 95% at WTP thresholds of 5,000 CAD per distress case averted and 65% at 100,000 CAD per QALY gained. These findings were robust to variation in intervention cost and effectiveness parameters, as shown in the deterministic sensitivity analyses.

Heterogeneity between subgroups analysis

Subgroup analyses were conducted using the Kruskal-Wallis rank-sum test to assess cost-effectiveness across age groups and treatment modalities. When using non-specific psychological distress (K10) as the outcome, no significant differences in cost-effectiveness were observed by age at six months ($X^2(2) = 2.7$, $p = 0.3$) or 12 months ($X^2(2) = 3.05$, $p = 0.2$). However, significant differences were found by treatment modality, with radical prostatectomy showing superior cost-effectiveness compared to radiation therapy at six months ($X^2(1) = 5.8$, p = 0.016) and 12 months ($X^2(1) = 5.5$, $p = 0.019$; Table 8). When QALYs were used as the outcome, no statistically significant age-related differences were observed at six months ($X^2(2) = 2.3$, $p = 0.3$) or 12 months ($X^2(2) = 0.39$, $p = 0.8$). Similarly, treatment modality did not yield statistically significant differences at six months ($X^2(1) = 3.5$, $p = 0.061$) or 12 months ($X^2(1) = 0.53$, $p = 0.5$).

DISCUSSION

This study evaluated the cost-effectiveness of PC-PEP compared to standard-care and delayed intervention. PC-PEP reduced healthcare costs while improving health-related quality of life (HRQoL) for men with prostate cancer. It significantly lowered cases of clinically relevant psychological distress and showed a trend toward improved quality-adjusted life years (QALYs), though the latter was not statistically significant. These results demonstrated that PC-PEP is a dominant strategy, a gold standard in health economic evaluations, achieving both improved patient outcomes and lower healthcare costs compared to standard care. Over 12 months, PC-PEP prevented approximately 30% of new cases of clinically relevant psychological distress while yielding per-patient healthcare savings of up to CAD 660.89. These dual benefits were observed across two validated outcome measures (psychological distress and QALYs) reinforcing the program's value as a clinically and economically superior intervention for prostate cancer survivorship.

Cost-effectiveness and health outcomes

At both six and 12 months, PC-PEP reduced healthcare costs and psychological distress, confirming its economic value.[22] At six months, healthcare costs decreased by 411.53 CAD per patient (516.86 CAD excluding the HRV device), preventing 30% of psychological distress cases. By 12 months, savings increased to 660.89 CAD per patient, preventing 31% of distress cases.[39-40] Excluding the HRV device could improve cost-effectiveness without affecting clinical benefits, as mediation analyses found no significant impact on distress reduction.[41-42] Removing it could lower per-participant costs by 105.33 CAD, facilitating broader adoption and reducing logistical burdens.

QALY improvements, though modest (0.0134 at six months, 0.0344 at 12 months), suggest potential long-term benefits. The higher probability of cost-effectiveness using psychological distress rather than QALYs highlights the need to consider multiple health outcomes in economic evaluations.[39-40]

Economic viability and willingness-to-pay thresholds

Cost-effectiveness acceptability curves (CEACs) confirmed PC-PEP's economic value. When psychological distress was used as the effectiveness measure, PC-PEP was highly cost-effective at willingness-to-pay (WTP) thresholds up to 5,000 CAD. For QALYs, the probability of cost-effectiveness rose from 37% at six months to 65% at 12 months at a 100,000 CAD threshold, emphasizing the importance of long-term evaluations.[39,43-44] In Canada, thresholds between 20,000 and 100,000 CAD per QALY support PC-PEP's long-term value.[40,44] Based on our findings, PC-PEP generates an estimated $660.89 CAD in direct healthcare savings per patient per year. Scaled to 1,000 patients, this translates to over $660,000 in annual savings for the public healthcare system. A national implementation for 10,000 patients annually would result in estimated direct healthcare savings exceeding $6.6 million CAD. These figures do not capture potential indirect benefits such as reduced caregiver burden, improved workplace productivity, and fewer emergency healthcare visits, suggesting that the true economic value of PC-PEP may be even greater.

Time frame and long-term benefits

The 12-month trial duration provided a meaningful assessment of PC-PEP's short- to medium-term clinical and economic impacts, capturing the full crossover design and both phases of the intervention. However, this time frame may not fully reflect longer-term cost savings or sustained improvements in quality-adjusted life years (QALYs), consistent with research showing that longer horizons tend to yield more favorable cost-effectiveness ratios.[45] While short-term evaluations remain critical for budget planning, even modest QALY gains in chronic conditions like cancer can have meaningful clinical and economic implications. A Phase 4 trial is currently underway with a 24-month follow-up period to evaluate the durability of PC-PEP's clinical benefits and its potential to deliver extended economic value over time.

Subgroup analysis and treatment-specific effects

PC-PEP appeared more cost-effective for patients undergoing radical prostatectomy than those receiving radiation ± hormone therapy, potentially due to better addressing prostatectomy-related concerns such as urinary incontinence and erectile dysfunction.[46]

Study limitations and future directions

Despite a robust RCT design and comprehensive cost analysis, several limitations should be acknowledged. The 12-month follow-up may not capture longer-term clinical and economic benefits. Similarly, reliance on self-reported HRQoL data introduces potential response bias. Shadow billing may underestimate true healthcare costs, and the exclusion of non-episodic system expenses (such as infrastructure, fixed overhead, and facility maintenance) further narrows the estimates. These costs, while relevant from a broader system perspective, were assumed to be comparable across groups due to the shared care context and the virtual, home-based delivery of PC-PEP. The analysis was conducted from a healthcare payer perspective, which does not capture indirect costs such as productivity loss, unpaid time, or caregiver burden. These domains could not be reliably measured within the current trial framework. However, qualitative findings from our previous work suggest that PC-PEP had broader household benefits: participants' partners and family members reported improved well-being and adoption of healthier behaviors in response to the patient's engagement with the program.15 Future evaluations, including the ongoing Phase 4 Global Implementation trial, will incorporate expanded data collection to allow for a more comprehensive societal perspective.

Additionally, the crossover design (used to ensure ethical access to PC-PEP) may have reduced between-group differences at 12 months. Future studies may benefit from parallel-group designs with extended follow-up to better assess long-term effects. While our trial sample reflects the demographics of prostate cancer patients in Nova Scotia, generalizability may be limited. The ongoing Phase 4 trial includes explicit efforts to recruit more diverse populations and evaluate the program's impact among visible minority, Indigenous, immigrant, and LGBTQ+ participants. These efforts are guided by health equity principles and include culturally responsive adaptations to enhance access and relevance.

Implications for clinicians

PC-PEP is a dominant intervention—achieving both improved health outcomes and reduced healthcare costs—which positions it as a highly valuable tool in clinical survivorship care. It's cost-effectiveness supports its role as a structured, home-based intervention that enhances mental health, HRQoL, and reduces healthcare costs. Clinicians can easily refer newly diagnosed prostate cancer patients to PC-PEP as part of comprehensive care plans. Beyond cost savings, PC-PEP enhances self-efficacy, emotional control, and reduces urinary and sexual dysfunction, improving quality of life.[15-19,41] These benefits position PC-PEP as a transformative intervention in prostate cancer survivorship care.[30-40,48] Integrating PC-PEP into routine care could optimize patient outcomes and reduce long-term healthcare demands. Despite strong scientific and economic evidence, psychological interventions like PC-PEP often face marginalization in cancer care due to entrenched preferences for biomedical treatments. Overcoming these barriers requires healthcare systems to recognize psychosocial health as integral to optimizing clinical outcomes.[50] Given its impact, professional organizations should update clinical guidelines to include evidence-based programs like PC-PEP. Our team has established clinical site leads in 10 of Canada's 13 provinces and territories and internationally in New Zealand, Belgium, South Africa, the Netherlands, and Romania. Integrating PC-PEP into standard-care presents an opportunity to enhance patient outcomes while optimizing healthcare resource utilization.

REFERENCES

1. Bray F, Laversanne M, Sung H, et al. Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2024;74:229-63. https://doi.org/10.3322/caac.21834
2. Brenner DR, Gillis J, Demers AA, et al. Projected estimates of cancer in Canada in 2024. *CMAJ* 2024;196:E615-23. https://doi.org/10.1503/cmaj.240095
3. Anguas-Gracia A, Antón-Solanas I, Echániz-Serrano E, et al. Quality of life after radical prostatectomy: A longitudinal study. *Nurs Rep* 2023;13:1051-63. https://doi.org/10.3390/nursrep13030092
4. Donovan JL, Hamdy FC, Lane A, et al. Patient-reported outcomes 12 years after localized prostate cancer treatment. *N Engl J Med* 2023;2. https://doi.org/10.1056/EVIDoa2300018
5. Fervaha G, Izard JP, Tripp DA, et al. Psychological morbidity associated with prostate cancer: Rates and predictors of depression in the RADICAL PC study. *Can Urol Assoc J* 2021;15:181-6. https://doi.org/10.5489/cuaj.6912
6. Moodie L, Ilie G, Rutledge R, et al. Assessment of current mental health status in a population-based sample of Canadian men with and without a history of prostate cancer diagnosis: An analysis of the Canadian Longitudinal Study on Aging (CLSA). *Front Psychiatry* 2020;11:586260. https://doi.org/10.3389/fpsyt.2020.586260
7. Friberg AS, Brasso K, Larsen SB, et al. Risk of depression after diagnostic prostate cancer workup: A nationwide, registry-based study. *Psychooncology* 2021;30:1939-47. https://doi.org/10.1002/pon.5766
8. Brunckhorst O, Hashemi S, Martin A, et al. Depression, anxiety, and suicidality in patients with prostate cancer: A systematic review and meta-analysis of observational studies. *Prostate Cancer Prostatic Dis* 2021;24:281-9. https://doi.org/10.1038/s41391-020-00286-0
9. Oba A, Nakaya N, Saito-Nakaya K, et al. Psychological distress in men with prostate cancer and their partners before and after cancer diagnosis: A longitudinal study. *Jpn J Clin Oncol* 2017;47:735-42. https://doi.org/10.1093/jjco/hyx066
10. Garaszczuk R, Yong JHE, Sun Z, et al. The economic burden of cancer in Canada from a societal perspective. *Curr Oncol* 2022;29:2735-48. https://doi.org/10.3390/curroncol29040223
11. Zhang W, Guh DP, Mohammadi T, et al. Health care costs attributable to prostate cancer in British Columbia, Canada: A population-based cohort study. *Curr Oncol* 2023;30:3176-88. https://doi.org/10.3390/curroncol30030240
12. Calvo-Schimmel A, Newman SD, Sterba KR, et al. Unmet supportive care needs in prostate cancer survivors with advanced disease: A mixed-methods exploration. *Can Oncol Nurs J* 2022;32:512-25. https://doi.org/10.5737/23688076324512
13. Wollersheim BM, van Stam MA, Bosch RJ, et al. Unmet expectations in prostate cancer patients and their association with decision regret. *J Cancer Surviv* 2020;14:731-8. https://doi.org/10.1007/s11764-020-00888-6

14. Mundle R, Afenya E, Agarwal N. The effectiveness of psychological intervention for depression, anxiety, and distress in prostate cancer: A systematic review of literature. *Prostate Cancer Prostatic Dis* 2021;24:674-87. https://doi.org/10.1038/s41391-021-00342-3
15. Ilie G, MacDonald C, Richman H, et al. Assessing the efficacy of a 28-day comprehensive online prostate cancer patient empowerment program (PC-PEP) in facilitating engagement of prostate cancer patients in their survivorship care: A qualitative study. *Curr Oncol* 2023;30:8633-52. https://doi.org/10.3390/curroncol30090626
16. Ilie G, Rendon R, Mason R, et al. A comprehensive 6-month prostate cancer patient empowerment program decreases psychological distress among men undergoing curative prostate cancer treatment: A randomized clinical trial. *Eur Urol* 2023. https://doi.org/10.1016/j.eururo.2023.02.009
17. Lawen T, Ilie G, Mason R, et al. Six-month prostate cancer empowerment program (PC-PEP) improves urinary function: A randomized trial. *Cancers* 2024;16:958. https://doi.org/10.3390/cancers16050958
18. MacNevin W, Ilie G, Rendon R, et al. PC-PEP, a comprehensive daily six-month home-based patient empowerment program leads to weight loss in men with prostate cancer: A secondary analysis of a clinical trial. *Curr Oncol* 2024;31:1667-88. https://doi.org/10.3390/curroncol31030127
19. Burgher C, Ilie G, Mason R, et al. Assessing the impact of the Prostate Cancer Patient Empowerment Program (PC-PEP) on relationship satisfaction, quality of life, and support group participation: A randomized clinical trial. *Curr Oncol* 2024;31:6445-74. https://doi.org/10.3390/curroncol31100479
20. McNaught E, Reale S, Bourke L, et al. Supported exercise training for men with prostate cancer on androgen deprivation therapy (STAMINA): Study protocol for a randomized controlled trial of the clinical and cost-effectiveness of the STAMINA lifestyle intervention compared with optimized usual care. *Trials* 2024;25:257. https://doi.org/10.1186/s13063-024-07989-y
21. Gallagher A, Shersher V, Mortimer D, et al. The cost-effectiveness of adjunctive lifestyle interventions for the management of cancer: A systematic review. *Appl Health Econ Health Policy* 2023;21:225-42. https://doi.org/10.1007/s40258-022-00759-4
22. Husereau D, Drummond M, Petrou S, et al. Consolidated Health Economic Evaluation Reporting Standards (CHEERS) 2022 explanation and elaboration: A report of the ISPOR Task Force on Good Research Practices. *Value Health* 2022;25:3-31. https://doi.org/10.1016/j.jval.2021.11.003
23. Zelen M. The randomization and stratification of patients to clinical trials. *J Chronic Dis* 1974;27:365-75. https://doi.org/10.1016/0021-9681(74)90015-0
24. Cohen JT, Neumann PJ, Weinstein MC. Does preventive care save money? Health economics and the presidential candidates. *N Engl J Med* 2008;358:661-3. https://doi.org/10.1056/NEJMp0708558

25. The Science of HeartMath. *HeartMath Inc.* https://www.heartmath.com/science/ (accessed 29 December 2021).
26. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: Building an international community of software platform partners. *J Biomed Inform* 2019;95:103208. https://doi.org/10.1016/j.jbi.2019.103208
27. Kessler RC, Barker PR, Colpe LJ, et al. Screening for serious mental illness in the general population. *Arch Gen Psychiatry* 2003;60:184-9. https://doi.org/10.1001/archpsyc.60.2.184
28. Kessler RC, Demler O, Frank RG, et al. Prevalence and treatment of mental disorders, 1990 to 2003. *N Engl J Med* 2005;352:2515-23. https://doi.org/10.1056/NEJMsa043266
29. Vasiliadis HM, Chudzinski V, Gontijo-Guerra S, et al. Screening instruments for a population of older adults: The 10-item Kessler Psychological Distress Scale (K10) and the 7-item Generalized Anxiety Disorder Scale (GAD-7). *Psychiatry Res* 2015;228:89-94. https://doi.org/10.1016/j.psychres.2015.04.019
30. Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res* 2005;14:1523-32. https://doi.org/10.1007/s11136-004-7713-0
31. Prieto L, Sacristán JA. Problems and solutions in calculating quality-adjusted life years (QALYs). *Health Qual Life Outcomes* 2003;1:1-8. https://doi.org/10.1186/1477-7525-1-1
32. Brazier JE, Roberts J. The estimation of a preference-based measure of health from the SF-12. *Med Care* 2004;42:851-9. https://doi.org/10.1097/01.mlr.0000135827.18610.0d
33. Kim DD, Silver MC, Kunst N, et al. Perspective and costing in cost-effectiveness analysis, 1974–2018. *Pharmacoeconomics* 2020;38:1135-45. https://doi.org/10.1007/s40273-020-00942-2
34. Bootstrapping [Internet]. York: York Health Economics Consortium; 2016. https://yhec.co.uk/glossary/bootstrapping/
35. Fenwick E, Byford S. A guide to cost-effectiveness acceptability curves. *Br J Psychiatry* 2005;187:106-8. https://doi.org/10.1192/bjp.187.2.106
36. R Core Team. *R: A language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing; 2023. https://www.R-project.org/
37. StataCorp. *Stata Statistical Software: Release 17*. College Station, TX: StataCorp LLC; 2023. https://www.stata.com/
38. IBM Corp. *IBM SPSS Statistics for Windows*. IBM Corp; 2020.
39. Cohen JT, Neumann PJ, Weinstein MC. Does preventive care save money? Health economics and the presidential candidates. *N Engl J Med* 2008;358:661-3. https://doi.org/10.1056/NEJMp0708558

40. Laupacis A, Feeny D, Detsky AS, et al. How attractive does a new technology have to be to warrant adoption and utilization? Tentative guidelines for using clinical and economic evaluations. *CMAJ* 1992;146:473-81.
41. MacDonald C, Ilie G, Kephart G, et al. Mediating effects of self-efficacy and illness perceptions on mental health in men with localized prostate cancer: A secondary analysis of the Prostate Cancer Patient Empowerment Program (PC-PEP) randomized controlled trial. *Cancers* 2024;16:2352. https://doi.org/10.3390/cancers16132352
42. Ilie G, Knapp G, Davidson A, et al. The Cancer Patient Empowerment Program: A comprehensive approach to reducing psychological distress in cancer survivors, with insights from a mixed-model analysis, including implications for breast cancer patients. *Cancers (Basel)* 2024;16:3373. https://doi.org/10.3390/cancers16193373
43. Grosse SD. Assessing cost-effectiveness in healthcare: History of the $50,000 per QALY threshold. *Expert Rev Pharmacoecon Outcomes Res* 2008;8:165-78. https://doi.org/10.1586/14737167.8.2.165
44. Neumann PJ, Cohen JT, Weinstein MC. Updating cost-effectiveness—the curious resilience of the $50,000-per-QALY threshold. *N Engl J Med* 2014;371:796-7. https://doi.org/10.1056/NEJMp1405158
45. Kim DD, Wilkinson CL, Pope EF, et al. The influence of time horizon on results of cost-effectiveness analyses. *Expert Rev Pharmacoecon Outcomes Res* 2017;17:615-23. https://doi.org/10.1080/14737167.2017.1331432
46. Al Hussein Al Awamlh B, Wallis CJD, Penson DF, et al. Functional outcomes after localized prostate cancer treatment. *JAMA* 2024;331:302-17. https://doi.org/10.1001/jama.2023.26491
47. Cohen DJ, Reynolds MR. Interpreting the results of cost-effectiveness studies. *J Am Coll Cardiol* 2008;52:2119-26. https://doi.org/10.1016/j.jacc.2008.09.018
48. Anderson RM, Funnell MM. Patient empowerment: Reflections on the challenge of fostering the adoption of a new paradigm. *Patient Educ Couns* 2005;57:153-7. https://doi.org/10.1016/j.pec.2004.05.008
49. Dixon A, Hibbard J, Tusler M. How do people with different levels of activation self-manage their chronic conditions? *Patient Patient-Centered Outcome Res* 2009;2:257-68. https://doi.org/10.2165/11313790-000000000-00000
50. Salvy SJ. Psychological interventions in prostate cancer: A farewell to mind-body dualism. *Prostate Cancer Prostatic Dis* 2021;24:587-8. https://doi.org/10.1038/s41391-021-00350-3

FIGURES AND TABLES

Figure 1. CONSORT 2010 flow diagram. CONSORT: Consolidated Standards of Reporting Trials; PC-PEP: Prostate Cancer Patient Empowerment Program.

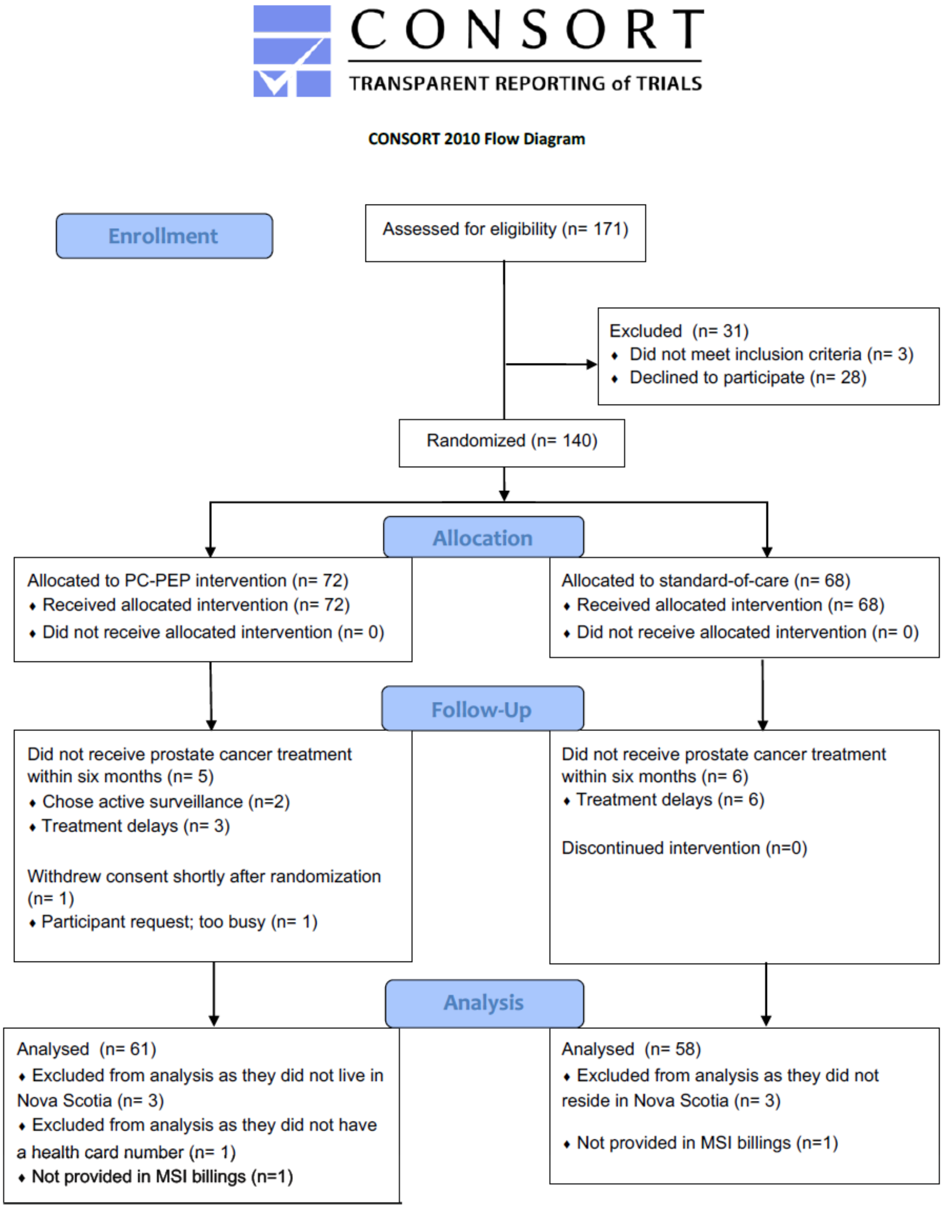


Figure 2. Mean SF-6D health utility index scores for the early and late intervention groups at baseline, six months, and 12 months. The Prostate Cancer Patient Empowerment Program (PC-PEP) logo indicates when each group received the intervention.

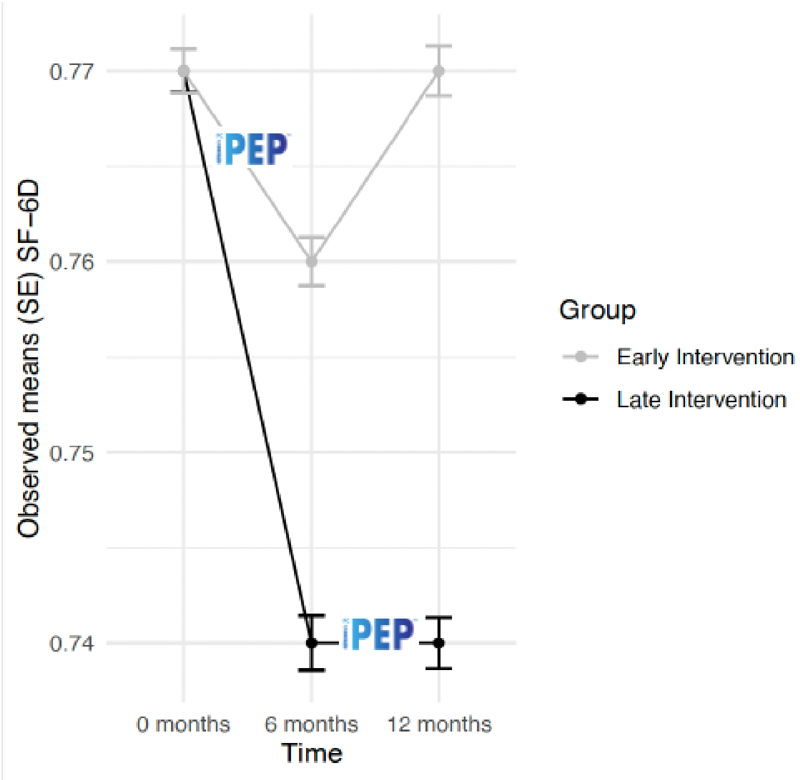
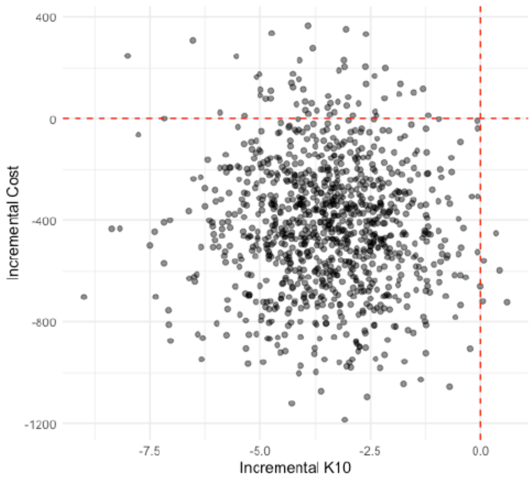


Figure 3. Cost-effectiveness plane showing Incremental Cost-Effectiveness Ratio (ICER) distributions for Prostate Cancer Patient Empowerment Program (PC-PEP) when using non-specific psychological distress (K10) as the effectiveness measure from (A) baseline to six months; and (B) baseline to 12 months.

A.



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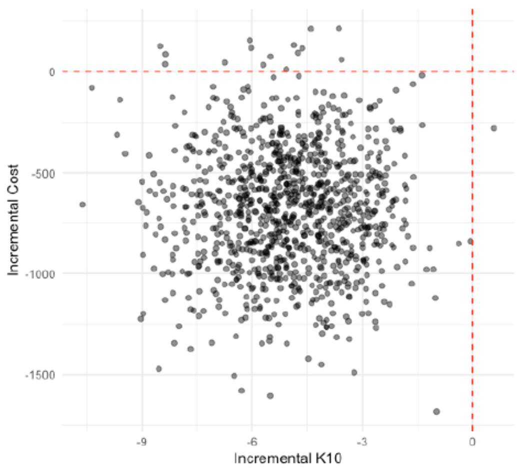

Figure 4. Cost-effectiveness plane showing Incremental Cost-Effectiveness Ratio (ICER) distributions for Prostate Cancer Patient Empowerment Program (PC-PEP) when using quality-adjusted life years (QALYs) as the effectiveness measure from (A) baseline to six months; and (B) baseline to 12 months.

A. **B.**

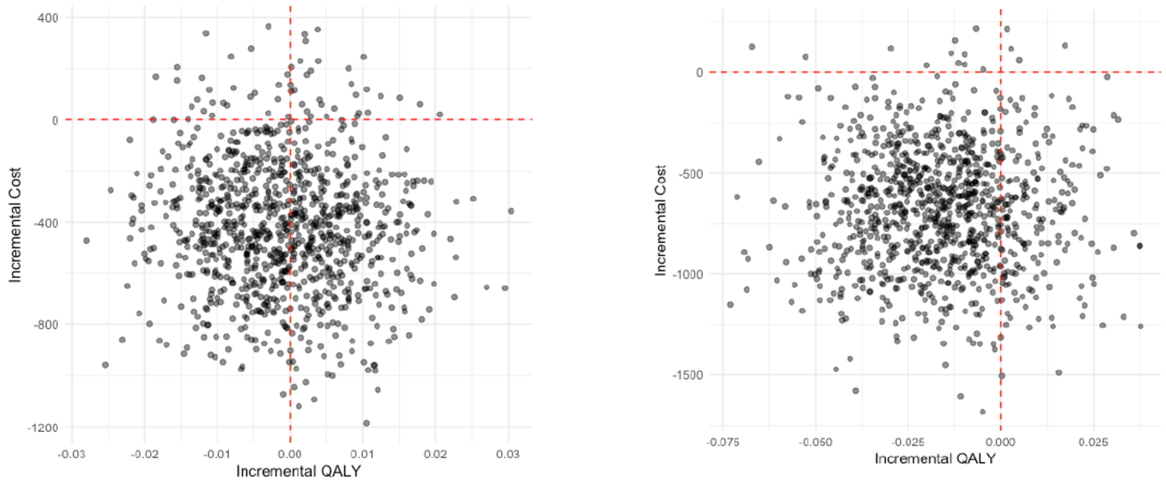

Figure 5. Cost-effectiveness acceptability curves (CEAC) showing the probability that Prostate Cancer Patient Empowerment Program (PC-PEP) is cost-effective across willingness-to-pay (WTP) thresholds when using non-specific psychological distress as the effectiveness measure from (A) baseline to six months; and (B) baseline to 12 months.

A. **B.**

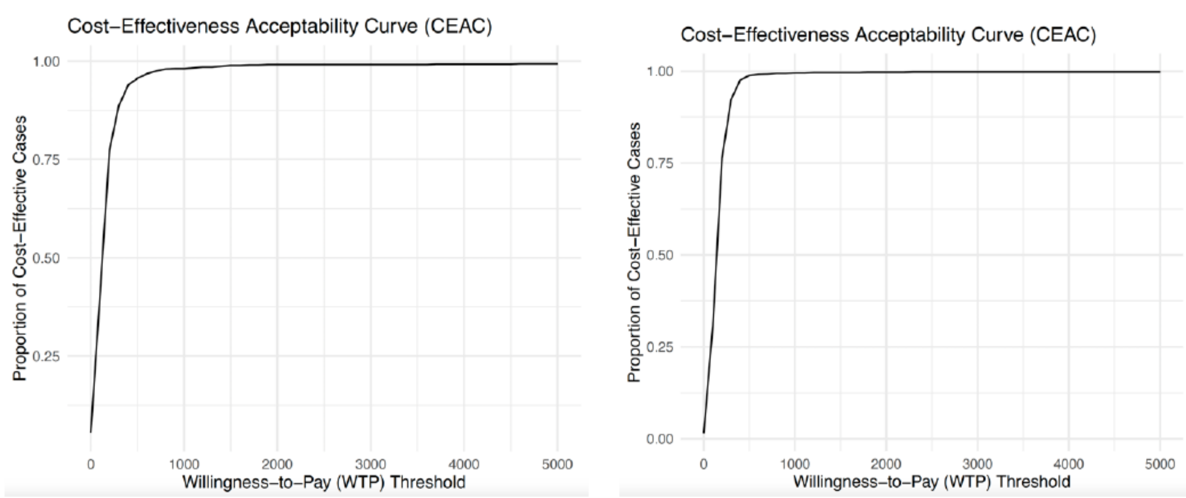

Figure 6. Cost-effectiveness acceptability curves (CEAC) illustrating the probability that Prostate Cancer Patient Empowerment Program (PC-PEP) is cost-effective across willingness-to-pay (WTP) thresholds when using quality-adjusted life years (QALYs) as the effectiveness measure from (A) baseline to six months; and (B) baseline to 12 months.

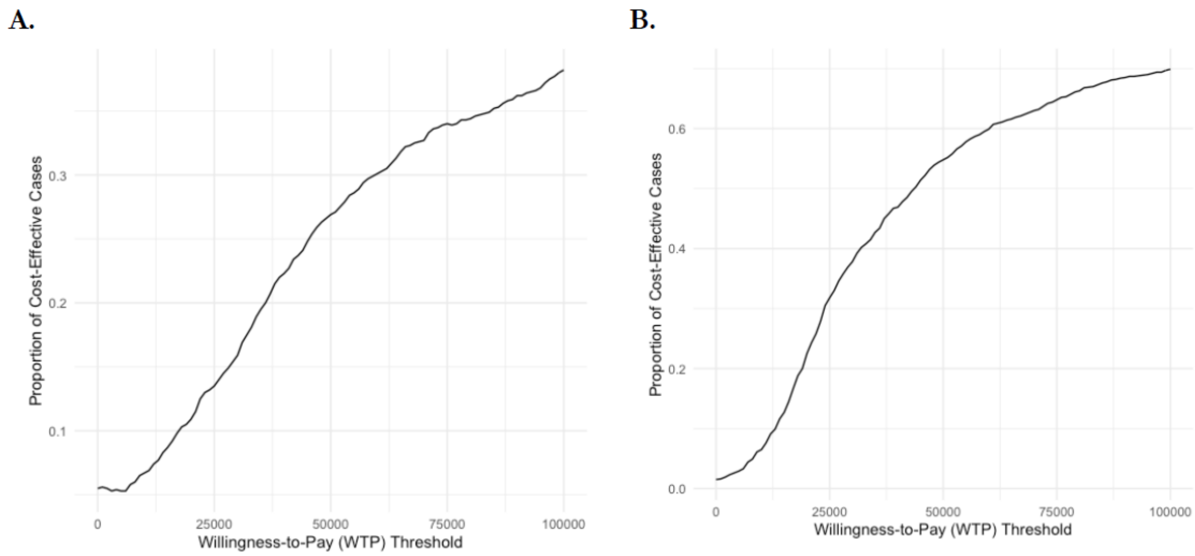

Table 1. Demographic characteristics of 119 participants at baseline in the PC-PEP trial, comparing intervention and waitlist control groups

	PC-PEP (n=61)	**Waitlist control (n=58)**	**p**
Age (yr)	66 ± 6.7	67 ± 7.05	0.2
Body mass index	31 ± 6.9	29 ± 5.8	0.5
Household income > CAD $30 000/year past year	50 (82%)	48 (83%)	0.5
Race, White	55 (90%)	57 (98%)	0.064
Education, university or higher	31 (51%)	33 (57%)	0.2
Employment Status (part- or full-time)	20 (33%)	21 (36%)	0.7
Relationship status (married/currently in a relationship)	54 (89%)	57 (98%)	0.034
Clinically significant nonspecific psychological distress (K10≥20)	8 (13%)	10 (17%)	0.6
SF6D health state sum score	0.77± 0.087	0.77 ± 0.091	1.0
Prescribed androgen deprivation therapy	26 (43%)	18 (31%)	0.4
Treatment modality			0.072
Scheduled for radical prostatectomy	24 (40%)	30 (52%)	
Scheduled for radiation therapy	27 (44%)	26 (45%)	
Scheduled for salvage radiation therapy	10 (16%)	2 (3%)	
Charlson comorbidity index	2.5 ± 1.1	1.6± 0.97	0.5
Self-identified as cigarette smoker	4 (7%)	3 (5%)	0.7
Prescribed medication for depression, anxiety, or both	9 (15%)	7 (12%)	0.3

Data are presented as mean ± standard deviation (SD) or n (%). K10: Kessler's Psychological Distress Scale; PC-PEP: Prostate Cancer Patient Empowerment Program; SF6D: 6-Dimensional health state short-form survey derived from SF-12 short-form health survey.

Table 2. Breakdown of the estimated intervention costs in 2022 for 80 participants is presented in CAD

Items	**Units**	**$/Unit**	**Total cost**
Participant materials			
Inner Balance (Bluetooth model)	30	$183.25	$5497.50
emWave2 (Wired/handheld model)	10	$207.00	$2070.00
Resistance tubing (three tubes/participant)	80	$13.66	$1092.80
Exercise tube assist straps/handles (2/participant)	160	$2.24	$358.80
Exercise tube door anchors	80	$2.59	$207.20
Text messages (3/day for 182 days)*	21840	$0.05	$1179.36
Printing participant handouts	80	$2.50	$200.00
Mailing (50% of participants) **			
Parcel with participant materials	40	$20.00	$800.00
Return HRV device[1]	40	$20.00	$800.00
Envelopes, bubble mailers, stamps	40	$5.00	$200.00
Personnel time***			
Research assistant/coordinator	120 hours	$30.00/hour	$3600.00
Total			**$16 005.66**
Cost per participant			**$200.07**

[1]Inner Balance or emWave 2 Heart Rate Variability (HRV) HeartMath® devices were loaned to participants for six months and are reusable, contributing to cost efficiency. Costs are subject to variation based on fluctuations in the USD-CAD exchange rate. The displayed costs include a bulk discount. *The budget for text messaging reflects an estimated usage by 50% of participants, based on opt-in data from previous cohorts. **Mailing costs are estimated based on a 50% distribution, with half of the participants opting to receive materials by mail and the remaining 50% collecting materials in person. Additional savings could be realized if a greater proportion of participants choose to pick up materials directly. ***Personnel costs are estimated based on maximum projected hours worked and may vary depending on actual time spent on program activities.

Table 3. Intervention and healthcare system costs: Comparative analysis between PC-PEP and waitlist control groups presented in CAD					
Description	**Period**	**PC-PEP (n=61)**	**Waitlist-control (n=58)**	**Incremental cost saved**	**p**
Cost of intervention	6 months	$12 249.41	n/a	n/a	n/a
	12 months	$12 249.41	$11,646.98	n/a	n/a
Cost to healthcare system	6 months	$83 460.89	$114,871.90	n/a	n/a
	12 months	$108 606.90	$153,244.08	n/a	n/a
Total cost	6 months	$95 710.30	$114,871.90	n/a	n/a
	6 months*	$89 285.17	$114,871.90	n/a	n/a
	12 months	$120 856.31	$165,891.06	n/a	n/a
Cost per patient	6 months	$1569.02	$1,980.55	-$411.53	0.045
	6 months*	$1463.69	$1,980.55	-$516.86	
	12 months	$1981.25	$2,642.14	-$660.89	0.18

*Excluding the cost of the HeartMath® device from PC-PEP program delivery. PC-PEP: Prostate Cancer Patient Empowerment Program.

Table 4. Effectiveness of the intervention in reducing non-specific psychological distress (K10): Number of participants screening positive for clinical treatment needs from baseline to six and 12 months				
	PC-PEP (n=61)	**Waitlist control (n=58)**	**Incremental cases prevented**	**p**
Baseline	8	10		
6 months	8	13		**0.043**
Difference (0–6 months)	0	3	3	
12 months	10	15		0.17
Difference (0–12 months)	2	5	3	

PC-PEP: Prostate Cancer Patient Empowerment Program.

Table 5. The effectiveness of the intervention was measured as the average change in QALYs from baseline to six months and baseline to 12 months for the early PC-PEP intervention and waitlist-control (late PC-PEP) groups				
	PC-PEP early group (n=61)	**Waitlist-control late PC-PEP group (n=58)**	**Incremental QALY gain**	**p**
QALY per person at 6 months	-0.0045	-0.018	0.013	0.2
QALY per person at 12 months	0.00021	-0.034	0.034	0.13

PC-PEP: Prostate Cancer Patient Empowerment Program; QALY: quality-adjusted life years.

Table 6. Cost-effectiveness analysis of the early PC-PEP intervention compared to the waitlist-control (late PC-PEP) group revealing a dominant economic model, from baseline to 6 months, and baseline to 12 months, presented in CAD					
Period	**Group**	**Total cost/ patient**	**Number of positive cases (K10)**	**Incremental cost savings per patient**	**Incremental effectiveness**
Baseline to 6 months	PC-PEP	$1569.02	0	$411.53	3
	Standard care	$1980.55	3		
Baseline to 12 months	Early PC-PEP	$1981.25	2	$660.89	3
	Late PC-PEP	$2642.14	5		

Based on screening positive for non-specific psychological distress and need for clinical intervention as measured by the Kessler's Psychological Distress scale (K10) as the effectiveness measure. PC-PEP: Prostate Cancer Patient Empowerment Program

Table 7. Cost-effectiveness analysis of the early PC-PEP intervention compared to the waitlist-control (late PC-PEP) group revealing a dominant economic model, from baseline to 6 months, and baseline to 12 months					
Period	**Group**	**Total cost/patient**	**Effectiveness QALY**	**Incremental cost savings per patient**	**Incremental effectiveness**
Baseline to 6 months	PC-PEP	$1569.02	-0.0045	$411.53	0.013
	Standard care	$1980.55	-0.018		
Baseline to 12 months	Early PC-PEP	$1981.25	0.00021	$660.89	0.034
	Late PC-PEP	$2642.14	-0.034		

Based on QALYs as the effectiveness measure presented in CAD. PC-PEP: Prostate Cancer Patient Empowerment Program; QALY: quality-adjusted life years.

Table 8. Results of subgroup analyses testing cost-effectiveness by age and treatment modality for non-specific psychological distress (K10) and QALYs from baseline to 6 months, and baseline to 12 months			
Time frame	**Effectiveness measure**	**Subgroup**	
		Age	**Treatment modality**
Baseline to 6 months	K10	0.27	**0.016**
	QALYs	0.32	0.061
Baseline to 12 months	K10	0.22	**0.019**
	QALYs	0.82	0.5

QALY: quality-adjusted life years.