Supplementary Materials for: Feasibility and Acceptability of Metaverse-Based Group Psychological Support for Cancer Survivors: A Multicenter Pilot Study

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Table S1. Observed Clinical Outcome Scores by Group and Assessment Week

Outcome / Assessment time	Metaverse[a] (n = 12) M (SD) [95% CI]	In-person[b] (n = 12) M (SD) [95% CI]	Psychoeducation[c] (n = 12) M (SD) [95% CI]
FACT-G			
Week 0	45.00 (21.29) [31.47, 58.53]	53.58 (22.67) [39.18, 67.99]	52.81 (12.67) [44.75, 60.86]
Week 6	52.17 (20.12) [39.38, 64.95]	66.83 (18.89) [54.83, 78.83]	50.83 (17.47) [39.73, 61.93]
Week 12	55.67 (19.25) [43.44, 67.90]	63.17 (21.75) [49.35, 76.99]	46.58 (15.58) [36.69, 56.48]
EQ-5D			
Week 0	10.83 (3.30) [8.74, 12.93]	9.67 (4.68) [6.69, 12.64]	8.92 (2.39) [7.40, 10.44]
Week 6	10.25 (3.72) [7.89, 12.61]	7.42 (2.02) [6.13, 8.70]	9.00 (2.26) [7.57, 10.43]
Week 12	8.75 (2.38) [7.24, 10.26]	7.75 (2.18) [6.37, 9.13]	10.25 (2.34) [8.76, 11.74]
Distress Thermometer			
Week 0	7.08 (1.62) [6.05, 8.11]	7.17 (1.34) [6.32, 8.02]	5.17 (1.34) [4.32, 6.02]
Week 6	4.92 (2.19) [3.52, 6.31]	3.75 (2.45) [2.19, 5.31]	6.42 (2.81) [4.63, 8.20]
Week 12	5.42 (2.19) [4.02, 6.81]	4.17 (2.72) [2.44, 5.90]	5.92 (1.88) [4.72, 7.11]
Endorsed stress-problem count			
Week 0	11.33 (6.50) [7.20, 15.46]	9.92 (6.65) [5.69, 14.14]	11.75 (5.14) [8.49, 15.01]
Week 6	9.00 (4.53) [6.12, 11.88]	7.17 (5.57) [3.63, 10.71]	12.83 (5.04) [9.63, 16.04]
Week 12	9.08 (5.04) [5.88, 12.28]	5.33 (4.54) [2.45, 8.22]	11.67 (4.38) [8.89, 14.45]
PHQ-9			
Week 0	11.83 (7.26) [7.22, 16.45]	10.25 (7.01) [5.80, 14.70]	8.25 (4.35) [5.49, 11.01]
Week 6	7.50 (5.96) [3.71, 11.29]	6.67 (5.35) [3.27, 10.06]	9.25 (5.10) [6.01, 12.49]
Week 12	9.50 (7.55) [4.70, 14.30]	7.25 (6.81) [2.92, 11.58]	10.67 (3.89) [8.19, 13.14]

Outcome / Assessment time	Metaverse[a] (n = 12) M (SD) [95% CI]	In-person[b] (n = 12) M (SD) [95% CI]	Psychoeducation[c] (n = 12) M (SD) [95% CI]
STAI-State			
Week 0	57.92 (11.67) [50.50, 65.33]	53.08 (12.87) [44.91, 61.26]	52.33 (12.89) [44.15, 60.52]
Week 6	52.50 (12.18) [44.76, 60.24]	42.58 (10.31) [36.03, 49.13]	56.00 (11.86) [48.46, 63.54]
Week 12	51.00 (14.33) [41.89, 60.11]	45.08 (12.87) [36.91, 53.26]	53.08 (12.40) [45.21, 60.96]
STAI-Trait			
Week 0	54.67 (9.89) [48.38, 60.95]	50.75 (12.22) [42.99, 58.51]	51.33 (11.36) [44.11, 58.55]
Week 6	52.00 (11.50) [44.69, 59.31]	43.58 (9.77) [37.37, 49.79]	52.33 (9.95) [46.01, 58.65]
Week 12	48.33 (13.06) [40.03, 56.63]	44.42 (14.13) [35.44, 53.39]	51.75 (11.25) [44.60, 58.90]
Insomnia Severity Index			
Week 0	14.33 (7.88) [9.33, 19.34]	12.33 (7.55) [7.54, 17.13]	13.00 (6.40) [8.94, 17.06]
Week 6	12.58 (6.99) [8.14, 17.02]	9.75 (7.36) [5.07, 14.43]	15.08 (7.33) [10.43, 19.74]
Week 12	10.17 (7.08) [5.67, 14.67]	10.00 (8.15) [4.82, 15.18]	14.25 (6.82) [9.91, 18.59]
PCL-5			
Week 0	35.83 (15.70) [25.86, 45.81]	32.00 (18.45) [20.28, 43.72]	33.42 (14.85) [23.98, 42.85]
Week 6	26.92 (10.64) [20.16, 33.68]	20.92 (16.07) [10.71, 31.13]	31.50 (13.72) [22.78, 40.22]
Week 12	27.33 (18.96) [15.29, 39.38]	23.58 (19.80) [11.00, 36.16]	32.25 (13.01) [23.98, 40.52]
FCRI-SF			
Week 0	20.83 (8.66) [15.33, 26.34]	17.17 (10.45) [10.53, 23.81]	18.75 (6.36) [14.71, 22.79]
Week 6	16.50 (6.88) [12.13, 20.87]	12.83 (7.08) [8.33, 17.33]	18.58 (5.35) [15.18, 21.98]
Week 12	16.33 (6.83) [12.00, 20.67]	15.58 (10.44) [8.95, 22.22]	19.83 (6.29) [15.83, 23.83]
PTGI-X			
Week 0	97.33 (25.82) [80.93, 113.74]	85.67 (16.80) [74.99, 96.34]	96.92 (27.10) [79.70, 114.13]
Week 6	99.08 (28.71) [80.84, 117.32]	92.50 (24.88) [76.69, 108.31]	88.58 (32.33) [68.04, 109.12]
Week 12	104.25 (19.72) [91.72, 116.78]	91.83 (18.88) [79.84, 103.83]	88.33 (30.81) [68.76, 107.91]
Perceived Stress Scale			
Week 0	22.58 (6.95) [18.17, 27.00]	22.00 (6.00) [18.19, 25.81]	19.17 (7.71) [14.27, 24.06]
Week 6	19.92 (6.79) [15.60, 24.23]	16.58 (4.14) [13.95, 19.22]	19.67 (3.65) [17.35, 21.99]
Week 12	20.67 (8.16) [15.48, 25.85]	16.83 (6.93) [12.43, 21.23]	19.58 (5.05) [16.37, 22.79]

Note. Values are observed means (SDs) and 95% confidence intervals across the 36 completers in the final analytic cohort (12 per group at each visit; 100.0% scale completeness across Weeks 0, 6, and 12; one in-person group participant who withdrew during Session 2 for health reasons before any Week 6 or Week 12 assessment is not included in the de-identified analytic dataset). Superscripts: a = Metaverse group; b = In-person group; c = Psychoeducation control group. FACT-G = Functional Assessment of Cancer Therapy–General; EQ-5D = EuroQol five-dimension questionnaire; PHQ-9 = Patient Health Questionnaire-9; STAI = State–Trait Anxiety Inventory; PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5; FCRI-SF = Fear of Cancer Recurrence Inventory–Short Form; PTGI-X = Posttraumatic Growth Inventory–Expanded.

Table S2. Outcome Scoring Definitions and Data Processing Procedures

Measure	Score / direction	Calculation	Data processing
FACT-G	25 administered items (Korean validation), 0–100; higher is better	Reverse 11 items (4 − response); sum the 25 administered items.	For one missing GF1 response, prorate the functional domain as observed sum × 7/6. GP2 and GS7 are excluded in the validated Korean form [15].
EQ-5D	5 dimensions (EQ-5D-5L), 5–25; lower is better	Sum the five dimension responses, each coded 1–5.	Analyzed as the unweighted sum across the five dimensions; no utility index conversion is applied.
Perceived Stress Scale (PSS)	10 items, 0–40; lower is better	Reverse items 4, 5, 7, and 8 (4 − response), then sum all 10 items.	Calculated from complete item-level responses across all 10 items.
Other symptom scales	Source-defined coding and direction	Use verified item sums, including reverse coding where required.	Verified against item-level responses across visits; validated scale totals retained.
PTGI-X	25 items, 25–150 (recorded 1–6 coding); higher is better	Sum the recorded 1–6 item responses across all 25 items.	Original 1–6 response coding retained consistently across all visits.
Analysis population	36 completers; 12 per group	One early health-related withdrawal occurred during Session 2 in the in-person group before any Week 6 or Week 12 assessment, and one replacement participant recruited at the same institution was screened using the same eligibility criteria and directly assigned to the vacated in-person slot; the de-identified clinical analysis dataset retained the 36 completers (100.0% scale completion across Weeks 0, 6, and 12).	All 36 completers (12 per group) were analyzed across Week 0, Week 6, and Week 12.

Note. Before statistical modeling, all scale totals were verified against item-level questionnaire records, including reverse-scored items on the FACT-G and Perceived Stress Scale (PSS).

Table S3. Constrained Longitudinal Data Analysis [cLDA] Sensitivity Analysis Compared with the Main Linear Mixed-Effects Models for Quality-of-Life Outcomes

Outcome / Assessment time	Comparison	Main LMM Difference [95% CI]	Unadjusted p	Holm p	cLDA Difference [95% CI]	Unadjusted p	Holm p
FACT-G							
Week 6	Metaverse − Psychoeducation	6.92 [−2.53, 16.37]	.148	.590	7.14 [−2.48, 16.77]	.141	.564
Week 6	Metaverse − In-person	−7.54 [−16.25, 1.17]	.089	.443	−7.21 [−16.09, 1.66]	.107	.537
Week 12	Metaverse − Psychoeducation	**15.03 [5.58, 24.47]**	**0.002***	**0.019***	**14.98 [6.02, 23.94]**	**0.002***	**0.014***
Week 12	Metaverse − In-person	0.02 [−8.70, 8.73]	.997	1.000	−0.33 [−8.47, 7.81]	.935	1.000
EQ-5D							
Week 6	Metaverse − Psychoeducation	0.92 [−1.11, 2.95]	.365	1.000	0.95 [−1.27, 3.17]	.389	1.000
Week 6	Metaverse − In-person	**2.34 [0.52, 4.17]**	**0.013***	.091	**2.33 [0.26, 4.41]**	**0.029***	.200
Week 12	Metaverse − Psychoeducation	−1.90 [−3.93, 0.13]	.066	.395	**−1.81 [−3.49, −0.13]**	**0.035***	.212
Week 12	Metaverse − In-person	0.47 [−1.36, 2.29]	.610	1.000	0.47 [−1.00, 1.93]	.520	1.000

Note. Both modeling frameworks adjust for study site and baseline Distress Thermometer score and report pointwise 95% CIs and unadjusted two-sided p values alongside Holm-adjusted p values controlling the familywise error rate across all eight quality-of-life contrasts. Positive FACT-G differences and negative EQ-5D differences favor the metaverse group. The main linear mixed-effects model analyzes Week-6 and Week-12 scores with baseline (Week 0) outcome and baseline outcome × visit as covariates (Kenward–Roger degrees of freedom), whereas cLDA models Week-0, Week-6, and Week-12 scores jointly while constraining the adjusted baseline group means to be equal (generalized least squares with unstructured covariance and Satterthwaite degrees of freedom). Both LMMs converged without singular-fit warnings, with standardized conditional residuals ranging from −1.93 to +2.63 for the FACT-G and from −1.58 to +2.68 for the EQ-5D; normal Q–Q plot correlation coefficients of normalized residuals in the cLDA models were r = 0.994 (FACT-G) and r = 0.962 (EQ-5D). *p < 0.05. FACT-G = Functional Assessment of Cancer Therapy–General; EQ-5D = EuroQol five-dimension questionnaire; CI = confidence interval.

Table S4. Complete Adjusted Linear Mixed-Effects Model Comparisons for All Ten Secondary Psychological Symptom Outcomes at Weeks 6 and 12

Outcome / Assessment time	Metaverse − Psychoeducation (a − c) Difference [95% CI]	Unadjusted p	Holm p	Metaverse − In-person (a − b) Difference [95% CI]	Unadjusted p	Post-hoc (Holm p)
Distress Thermometer						

Outcome / Assessment time	Metaverse − Psychoeducation (a − c) Difference [95% CI]	Unadjusted p	Holm p	Metaverse − In-person (a − b) Difference [95% CI]	Unadjusted p	Post-hoc (Holm p)
Week 6	**−2.43 [−4.73, −0.14]**	**0.038***	1.000	1.21 [−0.78, 3.19]	.228	**a < c (1.000)**
Week 12	−1.09 [−3.38, 1.20]	.345	1.000	1.28 [−0.71, 3.26]	.203	ns (1.000)
Endorsed stress-problem count						
Week 6	**−3.93 [−7.16, −0.70]**	**0.018***	.730	0.89 [−1.99, 3.77]	.538	**a < c (.730)**
Week 12	−2.75 [−5.98, 0.48]	.093	1.000	**3.06 [0.18, 5.94]**	**0.038***	**b < a (1.000)**
PHQ-9						
Week 6	**−3.66 [−7.26, −0.07]**	**0.046***	1.000	−0.24 [−3.44, 2.96]	.881	**a < c (1.000)**
Week 12	**−3.75 [−7.34, −0.15]**	**0.041***	1.000	0.88 [−2.32, 4.08]	.581	**a < c (1.000)**
STAI-State						
Week 6	−6.02 [−12.38, 0.34]	.063	1.000	5.72 [−0.03, 11.46]	.051	ns (1.000)
Week 12	−5.71 [−12.07, 0.65]	.077	1.000	0.76 [−4.99, 6.50]	.793	ns (1.000)
STAI-Trait						
Week 6	−0.83 [−7.51, 5.86]	.805	1.000	5.36 [−0.56, 11.28]	.075	ns (1.000)
Week 12	−4.94 [−11.62, 1.74]	.144	1.000	−0.35 [−6.27, 5.57]	.906	ns (1.000)
Insomnia Severity Index						
Week 6	−1.31 [−6.01, 3.40]	.579	1.000	0.86 [−3.21, 4.94]	.673	ns (1.000)
Week 12	−2.86 [−7.56, 1.84]	.227	1.000	−1.76 [−5.83, 2.32]	.391	ns (1.000)
PCL-5						
Week 6	−4.65 [−13.65, 4.35]	.303	1.000	3.34 [−4.61, 11.30]	.402	ns (1.000)
Week 12	−5.58 [−14.58, 3.42]	.218	1.000	0.15 [−7.81, 8.10]	.970	ns (1.000)

Outcome / Assessment time	Metaverse − Psychoeducation (a − c) Difference [95% CI]	Unadjusted p	Holm p	Metaverse − In-person (a − b) Difference [95% CI]	Unadjusted p	Post-hoc (Holm p)
FCRI-SF						
Week 6	−2.34 [−6.32, 1.63]	.241	1.000	1.16 [−2.39, 4.72]	.514	ns (1.000)
Week 12	**−4.17 [−8.14, −0.19]**	**0.040***	1.000	−2.47 [−6.02, 1.08]	.169	**a < c (1.000)**
PTGI-X						
Week 6	11.50 [−4.85, 27.86]	.163	1.000	−4.75 [−19.50, 9.99]	.520	ns (1.000)
Week 12	**17.04 [0.69, 33.40]**	**0.041***	1.000	4.52 [−10.22, 19.26]	.541	**a > c (1.000)**
Perceived Stress Scale						
Week 6	−0.53 [−4.67, 3.61]	.797	1.000	3.08 [−0.60, 6.76]	.099	ns (1.000)
Week 12	−1.12 [−5.26, 3.02]	.591	1.000	3.34 [−0.34, 7.02]	.074	ns (1.000)

Note. Estimates are adjusted mean differences [95% CIs] from linear mixed-effects models adjusting for baseline (Week 0) score of the modeled outcome, baseline score × visit interaction, study site, and baseline Distress Thermometer score (for non-DT outcomes), with participant random intercepts and Kenward–Roger degrees of freedom. All ten secondary LMMs converged without singular-fit warnings, and standardized conditional residuals across all models remained within −2.57 to +2.07 (no extreme outliers exceeding ±3.0). Holm-adjusted p values control the familywise error rate across all 40 secondary outcome contrasts. For the PTGI-X, positive differences favor the metaverse group (greater posttraumatic growth); for all other secondary scales, negative differences favor the metaverse group (lower symptom burden). In the Post-hoc column, group superscripts (a = Metaverse, b = In-person, c = Psychoeducation) indicate pairwise contrasts reaching unadjusted $p < 0.05$ (with the corresponding Holm-adjusted p value in parentheses); ns indicates no pairwise contrast reached unadjusted $p < 0.05$ at that visit. *$p < 0.05$. PHQ-9 = Patient Health Questionnaire-9; STAI = State–Trait Anxiety Inventory; PCL-5 = Posttraumatic Stress Disorder Checklist for DSM-5; FCRI-SF = Fear of Cancer Recurrence Inventory–Short Form; PTGI-X = Posttraumatic Growth Inventory–Expanded; CI = confidence interval.