Original Paper

Longitudinal Improvements in Symptom Burden Among Oncology Patients Enrolled in Reimagine Care, a Virtual Care Platform: Retrospective Study

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Abstract

Background: Symptom burden during active cancer treatment is prevalent and clinically significant, yet it frequently goes unmonitored between scheduled care visits. Virtual care platforms offer a promising approach to continuous real-world symptom management, though longitudinal evidence in these settings remains limited.

Objective: The aims of this study were as follows: (1) characterize the demographic and clinical profile of enrolled patients and their baseline symptom burden, (2) estimate population-level symptom trajectories over 180 days, and (3) examine whether platform engagement and cancer-related characteristics moderated symptom change over time.

Methods: This retrospective study analyzed secondary data from 2214 oncology patients enrolled in Reimagine Care between December 2022 and May 2026. Symptom burden was assessed using an adapted version of the Edmonton Symptom Assessment System (ESAS; 10 items, 11-point scale), administered via electronic patient-reported outcome surveys. Longitudinal trajectories were estimated using linear mixed-effects models with repeated electronic patient-reported outcome observations nested within patients over 180 days. Moderation by virtual care center engagement intensity and metastatic disease status was examined using time-by-moderator interaction terms.

Results: The analytic cohort had a mean age of 63.7 (SD 12.9) years, was predominantly female patients (1304/2214, 58.9%), with a mean of 4.22 (SD 4.19) noncancer comorbidities. Breast cancer was the most prevalent diagnosis (630/2214, 28.5%), and 25.3% (561/2214) had documented metastatic disease. Tiredness was the most severe symptom at baseline (mean 4.21, SD 2.85). Total symptom burden declined significantly over 180 days (β=–0.0236, P<.001), with reductions of 2.13 and 4.25 points at 90 and 180 days, respectively. The largest symptom-level improvements occurred in tiredness (β=–0.0056), appetite loss (β=–0.0040), drowsiness (β=–0.0035), and nausea (β=–0.0023). Greater virtual care center engagement was associated with faster overall symptom improvement (β=–0.0050, P<.001) and improvements in appetite loss (β=–0.00078, P=.009) and nausea (β=–0.00087, P<.001), and also with worsening depression (β=0.00052, P=.009) and anxiety trajectories (β=0.00044, P=.03), consistent with greater use among psychologically burdened patients. Patients with metastatic disease demonstrated attenuated improvement in tiredness (β=0.00167, P=.01), drowsiness (β=0.00153, P=.01), appetite loss (β=0.00149, P=.03), and nausea (β=0.00105, P=.048) vs patients with nonmetastatic disease with no significant moderation of total symptom burden (β=0.0024, P=.33).

Conclusions: Total symptom burden declined significantly over 180 days among oncology patients enrolled in Reimagine Care, a virtual care platform, with physical symptoms showing the greatest improvement. Platform engagement and disease stage emerged as clinically relevant moderators of symptom trajectories. Controlled designs using validated instruments are needed to establish causal claims and evaluate clinical significance.

JMIR Cancer 2026;12:e107798; doi: 10.2196/107798

Keywords: oncology; symptom burden; virtual care; patient-reported outcomes; remote symptom monitoring

Introduction

Cancer affects an estimated 2 million people in the United States annually and remains one of the most costly medical conditions to treat, with direct medical expenditures estimated at US $209 billion in 2020 and projected to increase substantially over the coming decade [1-3]. Beyond the financial burden, cancer and its treatment are associated with substantial symptom burden, including pain, fatigue, nausea, and psychological distress. Approximately 90% of patients undergoing active treatment report at least one clinically meaningful symptom, and one-third report 3 or more symptoms in the moderate-to-severe range simultaneously [4]. These symptoms collectively impair quality of life, reduce treatment adherence, and increase acute care use [5,6]. Symptom burden is particularly pronounced during active treatment, when patients frequently experience multiple concurrent symptoms that fluctuate in severity between scheduled clinical visits [4,5]. Despite the clinical significance of these symptoms, monitoring and management remain inconsistent in routine oncology practice, with many patients experiencing unaddressed symptom burden outside of formal care encounters [7]. Unmanaged symptoms are associated with increased emergency department visits, unplanned hospitalizations, and treatment dose reductions, each of which carries high clinical and economic costs for patients and health systems [8].

Electronic patient-reported outcome (ePRO) systems and remote symptom monitoring have emerged as promising approaches to address these gaps. Randomized controlled trials have demonstrated that proactive ePRO-based symptom monitoring, in which clinicians receive automated alerts for severe or worsening symptoms, is associated with improved quality of life, reduced acute care use, and improved overall survival compared with usual care [8-10]. Real-world implementation studies have extended these findings, demonstrating that ePRO-based monitoring programs are scalable across diverse oncology settings and are associated with meaningful reductions in hospitalizations, emergency department visits, and total cost of care [11]. Despite this growing evidence base, most published work has focused on single-symptom or single-condition populations, examined outcomes over short follow-up windows, or relied on trial settings that may not reflect the complexity of real-world oncology care [12].

Virtual oncology care management platforms represent a more integrated model of remote symptom support, combining proactive ePRO-based symptom monitoring with on-demand access to clinician-staffed care teams to deliver continuous, coordinated symptom management outside of scheduled care visits. These platforms are designed to address symptom burden across multiple domains simultaneously and support timely clinical intervention [13]. Emerging evidence suggests that virtual care management models may reduce acute care use and improve patient-reported outcomes in oncology populations [11,14], though real-world longitudinal evidence characterizing multidimensional symptom trajectories among patients enrolled in such platforms remains limited. Reimagine Care is a virtual care platform that uses an AI virtual assistant to integrate proactive ePRO-based symptom monitoring with on-demand access to oncology-trained clinicians 24 hours a day, 7 days a week, serving patients across a range of cancer types and treatment settings. Understanding how symptom burden evolves across the months following enrollment and which symptoms are most responsive to care management support are critical questions for optimizing these programs in real-world settings. Whether patient-level factors such as disease stage or platform engagement modify symptom trajectories over time remains particularly understudied.

The purpose of this study was to characterize real-world symptom burden and longitudinal symptom trajectories among oncology patients enrolled in Reimagine Care, a virtual care platform. We specifically aimed to achieve the following: (1) characterize the demographic and clinical profile of enrolled patients and their baseline symptom burden, (2) estimate population-level symptom trajectories over the first 180 days of enrollment, and (3) examine whether platform engagement and cancer-related characteristics moderated symptom change over time. Findings from this study provide real-world evidence on multidimensional symptom trajectories in a large, clinically heterogeneous oncology population and contribute to the growing evidence base on the potential of a virtual care platform to support symptom burden reduction during active cancer treatment.

Methods

Study Design and Participants

This retrospective study analyzed secondary data from Reimagine Care, a virtual care platform for oncology patients. The platform partners directly with oncology practices and cancer centers, which enroll eligible patients (those on active cancer treatment); eligibility is not limited by cancer type, treatment phase, or modality. Data were collected as part of routine platform operations between December 2022 and May 2026. Patients were eligible for inclusion if they met the following criteria: (1) completed at least one ePRO survey, (2) had at least one malignant *International Classification of Diseases, Tenth Revision* (*ICD-10)*–confirmed cancer diagnosis on record, (3) were US residents, and (4) were aged 18 years or older. This study was conducted and reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational cohort studies (Checklist 1).

Ethical Considerations

The study protocol was reviewed by the Biomedical Research Alliance of New York (BRANY) Institutional Review Board (study ID: 26-089-1708) and determined to qualify for an exemption under US federal regulations (45 CFR 46.104(d)(4)(ii)) [15] governing the secondary analysis of

existing data. Because the study used retrospective, deidentified data and involved no direct participant contact, informed consent procedures were not required. All data were deidentified before analysis. Participants were not provided with compensation.

Reimagine Care Platform

Reimagine Care is a virtual care platform designed to support patients with cancer during active treatment. Services are intended to supplement each patient's existing oncology care team. The platform combines proactive symptom monitoring, on-demand access to oncology-trained clinicians, and an AI-enabled virtual assistant (Remi; Reimagine Care, Inc) to facilitate remote symptom management and reduce avoidable acute care use. The use of Remi is restricted to the following: structured collection and clarification of patient-reported symptoms using plain language, routing patient symptoms into predefined clinical pathways, routine patient check-ins, escalation to virtual care team, and facilitation of patient-care team communication.

Patients are enrolled by their treating oncology practice; upon enrollment, patients receive an automated SMS message from Remi. Throughout care, patients also receive scheduled health status check-ins and symptom assessments, again via SMS. At any time, patients may bypass Remi and connect directly with Reimagine Care's virtual care center (VCC), a clinician-staffed care hub available 24 hours a day, 7 days a week. When a patient reports a severe symptom, an automated SMS prompt offers to connect them with VCC staff. Accepted requests generate a triage alert requiring clinician follow-up within 1 hour for severe symptoms, 4 hours for moderate symptoms, and 8 hours for mild symptoms. VCC clinicians respond by text, telephone, or telehealth to assess the reported symptom, provide management guidance, and refer patients to urgent or emergency care when clinically indicated. All VCC interactions are documented in the patient's electronic health record. The platform does not provide medical diagnosis or treatment. Rather, it supports symptom monitoring and coordinates with the treating clinical team to manage patient concerns remotely. Reimagine Care is designed to operate across cancer types, treatment modalities, and phases of care, treating symptom burden as a common organizing focus rather than tailoring support to any single diagnosis or regimen. Consistent with this symptom-centered design, information on treatment type, treatment modality, or treatment phase was not captured in the platform's data infrastructure and was therefore not included in the present analysis.

Data Sources and Measures

Cancer-related variables were derived from *ICD-10* diagnosis codes documented in patient electronic medical records. Metastatic disease status was coded as a binary variable (present vs absent). Cancer types were categorized into diagnostic groups (eg, breast, gastrointestinal, genitourinary, and hematologic). Cancer type categories were not mutually exclusive, as patients could contribute to more than one group if multiple cancer diagnoses were documented. The total number of noncancer *ICD-10*-coded comorbidities per patient was summed to characterize comorbidity burden. Age was extracted from enrollment records and treated as a continuous variable. Sex was derived from patients' records and coded as a categorical variable (female and male patients).

Symptom Burden

Symptom burden was assessed using Reimagine Care's internally developed ePRO, an adapted version of the Edmonton Symptom Assessment System (ESAS; [16]). The ESAS is a validated instrument originally developed for symptom monitoring in oncology populations. The ePRO survey comprised 10 items assessing pain, tiredness, drowsiness, nausea, appetite loss, shortness of breath, depression, anxiety, diarrhea, and well-being, each rated on an 11-point numeric scale from 0 to 10. For all items except well-being, a score of 0 indicated absence of the symptom and a score of 10 indicated worst possible severity. Scores of 1 to 3 are conventionally interpreted as mild symptom burden, 4 to 6 as moderate, and 7 to 10 as severe, applying severity thresholds consistent with the validated ESAS framework [17]. Although the ePRO draws from the validated ESAS framework, it has not been independently validated in this population, and findings based on this measure should be interpreted with caution. Surveys were administered at irregular intervals throughout enrollment, triggered via SMS through the Remi platform. A total symptom burden score was computed for each survey administration as the sum of all 10 item responses, with possible scores ranging from 0 to 100. The ePRO survey is presented in Multimedia Appendix 1.

Platform Engagement

VCC engagement was operationalized as the total number of VCC symptom-management interactions completed within the first 180 days of enrollment. This variable was standardized (z scored) before inclusion in moderation models to facilitate interpretation of the interaction coefficients.

Statistical Analyses

Analyses were restricted to the first 180 days of enrollment to capture the acute phase of active cancer treatment, during which symptom burden is most dynamic and clinically actionable [8], and to limit the influence of differential attrition associated with longer observation windows. Descriptive statistics were used to characterize the analytic cohort at baseline. Continuous variables are reported as means and SDs, and categorical variables are reported as counts and percentages. Baseline symptom burden was defined as each patient's score on their earliest available ePRO survey.

Longitudinal symptom trajectories over 180 days were examined using linear mixed-effects models with repeated ePRO observations nested within patients. A separate model was estimated for each of the 10 symptom outcomes and for total symptom burden. Days since enrollment were entered as a continuous fixed effect, with age and sex included as covariates. A random intercept for the patient was included to account for within-person correlation across repeated observations. The fixed-effect coefficient for days

since enrollment represents the estimated average daily rate of change in symptom burden across the analytic sample. Estimated symptom change at 90 and 180 days was derived by multiplying this coefficient by 90 and 180, respectively. False discovery rate (FDR) correction using the Benjamini-Hochberg procedure was applied across the 10 symptom-specific models. The FDR procedure controls the expected proportion of false positives among rejected hypotheses, providing a less conservative correction than the Bonferroni method while limiting inflation of Type I error across multiple comparisons [18]. To evaluate potential floor effects among patients with minimal symptoms at enrollment, symptom trajectory models were additionally reestimated among patients with moderate-or-greater baseline symptom burden for the corresponding symptom (baseline score≥4). To assess robustness to individual variability in rates of symptom change, models were further reestimated using random slope specifications that allowed patient-specific rates of change over time.

Moderation of symptom trajectories by VCC engagement and metastatic disease status was tested by adding a time-by-moderator interaction term to each model. Days since enrollment, the moderator, and their interaction were entered as fixed effects, with age and sex retained as covariates. A random intercept for patient was included. Separate interaction models were estimated for each symptom outcome and for total symptom burden, for each moderator. The interaction coefficient represents the degree to which the daily rate of symptom change differed as a function of the moderator. FDR correction was applied within each moderator set across the 10 symptom models.

Missing data were handled using maximum likelihood estimation within mixed-effects models, allowing all available observations to contribute to parameter estimation under a missing-at-random assumption. Patients with missing covariate data required for adjusted models were excluded from those specific analyses. All analyses were conducted in R (version 4.4.2; R Foundation for Statistical Computing) using the lme4 and lmerTest packages.

Bias Mitigation

Fit Minded, Inc, uses a standardized bias mitigation protocol across all industry-partnered research, applied prospectively and independent of study outcomes. The following safeguards were implemented for this study. First, research questions were developed by the Fit Minded scientific team based on scientific merit and were not prescribed by the client. Second, study outcomes were not guaranteed as contractual deliverables. Third, the analysis plan was prespecified prior to data access. Fourth, data analysis and interpretation were led by Fit Minded authors operating independently of Reimagine Care. Fifth, findings were reviewed collaboratively across the full author team. Sixth, missingness bias due to irregular survey completion was addressed by restricting each analytic model to observations with complete data for the relevant outcome and covariates and by estimating models under full maximum likelihood, which allows all available observations to contribute to parameter estimation under a missing-at-random assumption.

Results

Data Availability and Descriptive Characteristics

All of the 4704 enrolled patients in the dataset were US residents over age 18 years. Of these, 4448 completed at least one ePRO survey, and 4386 met the 180-day enrollment window criterion. The primary analytic cohort was further restricted to patients with at least one malignant *ICD-10*-confirmed diagnosis, yielding 2214 patients available for longitudinal symptom analyses (Figure 1). Ongoing engagement beyond the first ePRO survey was not a requirement for cohort inclusion. Reflecting this, the proportion of patients contributing ePRO data declined across the follow-up window: 85.3% (1889/2214) at 30 days, 65.2% (1443/2214) at 90 days, and 26.8% (593/2214) at 180 days. This decline reflects a combination of disengagement, treatment completion, and variable enrollment duration relative to the 180-day observation window. All available ePRO observations, regardless of an individual patient's total follow-up duration, contributed to trajectory estimation under maximum likelihood.

The mean age was 63.7 (SD 12.9) years, and 58.9% (1304/2214) of patients identified as female. Patients carried a mean of 4.22 (SD 4.19) noncancer *ICD*-coded comorbidities, and 25.3% (561/2214) had documented metastatic disease. The mean duration of program enrollment was 371.0 (SD 268; median 293.5, IQR 161-527) days, and the mean number of distinct cancer groups per patient was 1.31 (SD 0.51). Breast cancer was the most prevalent diagnosis (630/2214, 28.5%), followed by gastrointestinal (528/2214, 23.8%), genitourinary (297/2214, 13.4%), and hematologic cancers (266/2214, 12.0%). The mean ePRO completion rate (number completed divided by the number triggered for the patient) was 56.5% (SD 30.9%). Patients averaged 2.27 (SD 2.84) VCC symptom-management interactions at 90 days and 2.87 (SD 3.86) VCC symptom management interactions at 180 days. Cohort characteristics are summarized in Table 1.

Figure 1. Patient enrollment and ePRO follow-up flow diagram. ePRO: electronic patient-reported outcome.

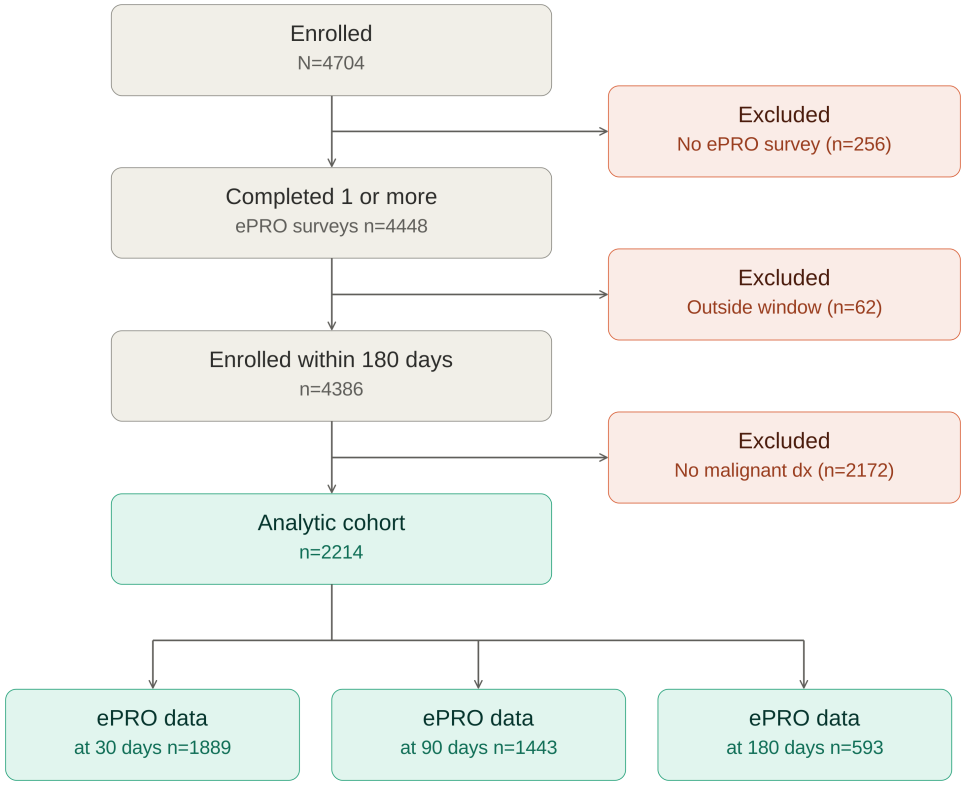


Table 1. Cohort characteristics (N=2214).

Characteristics	Values
Sex, n (%)	
Female	1304 (58.9)
Male	885 (39.9)
Missing	25 (1.1)
Types of cancer per patient, mean (SD)	1.31 (0.51)
Patients with metastatic disease, n (%)	561 (25.3)
Noncancer *ICD*[a] conditions, mean (SD)	4.22 (4.19)
VCC[b] engagement intensity	
90 days, mean (SD)	2.27 (2.84)
180 days, mean (SD)	2.87 (3.86)
ePRO[c] data availability over time, n (%)	
Contributed data at 30 days	1889 (85.3)
Contributed data at 90 days	1443 (65.2)
Contributed data at 180 days	593 (26.8)
Cancer group distribution, n (%)	
Breast	630 (28.5)
Other	586 (26.5)
GI[d]	528 (23.8)
GU[e]	297 (13.4)
Hematologic	266 (12.0)
Lung/thoracic	241 (10.9)
Gynecologic	146 (6.6)
Head/neck	82 (3.7)
Skin	74 (3.3)
Sarcoma/soft tissue	25 (1.1)
Brain/CNS[f]	15 (0.7)

Characteristics	Values
Age (y), mean (SD)	63.7 (12.9)
Baseline symptom burden, mean (SD)	
Tiredness	4.21 (2.85)
Well-being	2.99 (2.85)
Drowsiness	2.87 (2.76)
Pain	2.60 (2.80)
Appetite loss	2.55 (2.88)
Anxiety	1.92 (2.57)
Shortness of breath	1.45 (2.30)
Nausea	1.42 (2.40)
Depression	1.41 (2.28)
Diarrhea	1.13 (2.25)

[a]*ICD*: *International Classification of Diseases*.
[b]VCC: virtual care center.
[c]ePRO: electronic patient-reported outcome.
[d]GI: gastrointestinal.
[e]GU: genitourinary.
[f]CNS: central nervous system.

At baseline, tiredness was the most severe symptom reported (mean 4.21, SD 2.85), meeting the established threshold for moderate symptom burden (score ≥4). Well-being (mean 2.99, SD 2.85), drowsiness (mean 2.87, SD 2.76), pain (mean 2.60, SD 2.80), and appetite loss (mean 2.55, SD 2.88) each fell in the mild-to-moderate range. Anxiety, shortness of breath, nausea, depression, and diarrhea were rated mild at baseline (all mean <2.0).

Longitudinal Symptom Trajectories

Linear mixed-effects models with repeated observations nested within patients demonstrated significant longitudinal improvement in overall symptom burden across the observation period. Total symptom burden decreased at an estimated rate of 0.0236 points per day (β=–0.0236, *P*<.001), corresponding to estimated reductions of 2.13 points at 90 days and 4.25 points at 180 days.

Symptom-specific analyses revealed significant improvement across multiple physical symptom domains (Table 2). Significant improvement was observed for tiredness (β=–0.0056, *P*<.001), well-being (β=–0.0017, *P*<.001), drowsiness (β=–0.0035, *P*<.001), and appetite loss (β=–0.0040, *P*<.001). Pain and anxiety did not demonstrate significant longitudinal change after correction for multiple comparisons (both *P*>.05). Shortness of breath (β=0.00055) and depression (β=0.00091) showed small but statistically significant worsening trajectories over time (both *P*<.01). Significant improvement was also observed for nausea (β=–0.0023, *P*<.001) and diarrhea (β=–0.0012, *P*<.001). Estimated reductions across improving symptoms ranged from approximately 0.2 to 1.0 points on the symptom burden scale.

Table 2. Longitudinal symptom trajectory estimates over 90 and 180 days[a].

Symptom	β (95% CI)	*P* value	Estimated change at 90 days	Estimated change at 180 days
Tiredness	–0.00558 (–0.00605 to –0.00512)	<.001	–0.50	–1.00
Well-being	–0.00174 (–0.00221 to –0.00127)	<.001	–0.16	–0.31
Drowsiness	–0.00354 (–0.00398 to –0.00311)	<.001	–0.32	–0.64
Pain	–0.00023 (–0.00064 to 0.00018)	.29	–0.02	–0.04
Appetite loss	–0.00399 (–0.00447 to –0.00351)	<.001	–0.36	–0.72
Anxiety	–0.00016 (–0.00050 to 0.00019)	.37	–0.01	–0.03
Shortness of breath	0.00055 (0.00021 to 0.00090)	.002	+0.05	+0.10
Nausea	–0.00229 (–0.00268 to –0.00191)	<.001	–0.21	–0.41
Depression	0.00091 (0.00059 to 0.00124)	<.001	+0.08	+0.16
Diarrhea	–0.00122 (–0.00162 to –0.00082)	<.001	–0.11	–0.22

[a]Negative β coefficients indicate symptom improvement over time, whereas positive β coefficients indicate worsening symptom burden over time. Estimated 90-day and 180-day changes were derived by multiplying the daily slope estimate by 90 and 180 days, respectively. False discovery rate (FDR) correction using the Benjamini-Hochberg procedure was applied to account for multiple comparisons across the 10 symptom models; adjusted values are reported. Models were adjusted for age and sex. Models included 2189 patients after exclusion of 25 patients with missing sex data.

Sensitivity analyses restricting models to patients with moderate-or-greater baseline symptom burden (score ≥4) revealed significant improvement across all symptom domains, including pain, anxiety, depression, and shortness of breath, suggesting that primary estimates for these symptoms were attenuated by floor effects among patients with minimal baseline burden. Models reestimated using random slope specifications yielded substantively identical conclusions. Full sensitivity results are presented in Table S2 (Multimedia Appendix 2) and Table S3 (Multimedia Appendix 3).

Moderators of Symptom Change

At the level of total symptom burden, greater VCC engagement intensity was associated with significantly faster improvement over time (β=–0.0050, SE=0.0010; *P*<.001). At the symptom level, VCC engagement was not significantly associated with tiredness, well-being, or drowsiness trajectories. Pain showed a nonsignificant trend toward worsening with higher engagement (β=0.00029, *P*=.29). Higher VCC engagement was associated with faster improvement in appetite loss (β=–0.00078, *P*=.009) and nausea (β=–0.00087, *P*<.001) trajectories, and with worsening anxiety (β=0.00044, *P*=.03) and depression (β=0.00052, *P*=.009) trajectories over time (Table 3).

Table 3. Moderating effects of virtual care center (VCC) engagement and metastatic disease status on symptom trajectories[a].

Symptom	Interaction β (95% CI)	*P* value
VCC engagement		
Tiredness	–0.00010 (–0.00055 to 0.00036)	.69
Well-being	–0.00009 (–0.00055 to 0.00037)	.69
Drowsiness	–0.00025 (–0.00068 to 0.00017)	.38
Pain	0.00029 (–0.00011 to 0.00069)	.29
Appetite loss	–0.00078 (–0.00125 to –0.00032)	.009
Anxiety	0.00044 (0.00011 to 0.00078)	.03
Shortness of breath	0.00020 (–0.00014 to 0.00054)	.38
Nausea	–0.00087 (–0.00125 to –0.00050)	<.001
Depression	0.00052 (0.00020 to 0.00083)	.009
Diarrhea	–0.00022 (–0.00061 to 0.00017)	.39
Metastatic disease		
Tiredness	0.00167 (0.00060 to 0.00274)	.01
Well-being	0.00122 (0.00013 to 0.00230)	.055
Drowsiness	0.00153 (0.00052 to 0.00254)	.01
Pain	–0.00032 (–0.00127 to 0.00062)	.57
Appetite loss	0.00149 (0.00039 to 0.00259)	.03
Anxiety	–0.00026 (–0.00105 to 0.00053)	.57
Shortness of breath	–0.00031 (–0.00111 to 0.00049)	.57
Nausea	0.00105 (0.00015 to 0.00194)	.048
Depression	–0.00098 (–0.00173 to –0.00023)	.03
Diarrhea	0.00033 (–0.00060 to 0.00126)	.57

[a]Interaction terms represent the degree to which the daily rate of symptom change differed by moderator level (VCC engagement, standardized; metastatic disease, present vs absent). Positive interaction β coefficients indicate attenuated improvement (or worsening) associated with higher VCC engagement or metastatic disease; negative coefficients indicate faster improvement. False discovery rate (FDR) correction using the Benjamini-Hochberg procedure was applied within each moderator set across the 10 symptom models; adjusted *P* values are reported. Models were adjusted for age and sex. CIs shown are from the individual (unadjusted) models and are not corrected for multiple comparisons; near-threshold cases (eg, well-being under metastatic disease) may therefore show a CI that excludes zero alongside a nonsignificant FDR-adjusted *P* value. Models included 2189 patients after exclusion of 25 patients with missing sex data.

Metastatic disease status did not significantly moderate total symptom burden trajectories (β=0.0024, SE=0.0025; *P*=.33). At the symptom level, patients with metastatic disease demonstrated significantly attenuated improvement in tiredness (β=0.00167, *P*=.01), drowsiness (β=0.00153, *P*=.01), appetite loss (β=0.00149, *P*=.03), and nausea (β=0.00105, *P*=.048) relative to patients with nonmetastatic disease. Metastatic status was also associated with a faster improvement in depression trajectories (β=–0.00098, *P*=.03), a finding that warrants cautious interpretation, given the small effect size and the absence of a validated depression measure.

Discussion

Principal Findings

This retrospective study examined real-world symptom burden and longitudinal trajectories among 2214 oncology

patients enrolled in Reimagine Care, a virtual care platform. The analytic cohort was predominantly female and older adults managing multiple concurrent noncancer conditions alongside their cancer diagnosis. Tiredness was the most severe symptom at baseline, followed by well-being, drowsiness, pain, and appetite loss. Across the observation period, overall symptom burden declined significantly, with the largest improvements observed for tiredness, appetite loss, drowsiness, and nausea; depression and shortness of breath worsened modestly over time. Greater VCC engagement was associated with faster overall symptom improvement, though it was also associated with worsening depression and anxiety trajectories, consistent with greater use of supportive care among patients with escalating psychological burden. Patients with metastatic disease showed slower improvement in physical symptoms relative to patients with nonmetastatic disease, though metastatic status did not moderate total symptom burden trajectories.

The sample was predominantly female and older adults, which is consistent with the demographic profile previously documented in real-world oncology care management studies [19]. The high number of concurrent noncancer comorbidities reflects the clinical complexity typical of this population, in which cancer rarely presents in isolation and comorbid conditions may compound symptom burden and complicate symptom management [20,21]. One in four patients had documented metastatic disease, reflecting the substantial and growing burden of metastatic disease among individuals receiving active oncology care in the United States [22]. At baseline, tiredness was the only symptom meeting the threshold for moderate burden, followed by well-being, drowsiness, pain, and appetite loss in the mild-to-moderate range. This pattern mirrors findings from prior ESAS-based studies of oncology outpatients, in which fatigue and tiredness consistently emerge as the most prevalent and severe symptoms at care initiation [23,24]. The predominance of physical over psychological symptoms at baseline, with depression and anxiety both rated mild, may reflect either genuinely lower psychological symptom burden at enrollment or underreporting of distress in the context of cancer care, a well-documented phenomenon in oncology populations [25]. These baseline characteristics underscore the clinical heterogeneity of patients enrolled in virtual platforms for oncology care and have direct implications for how symptom monitoring programs should be designed and interpreted in real-world settings.

Across the observation period, total symptom burden declined significantly, though these findings should be interpreted in the context of an unvalidated instrument. The largest improvements were observed for tiredness, appetite loss, drowsiness, and nausea, a pattern consistent with evidence that proactive symptom monitoring combined with on-demand clinical access reduces physical symptom burden during active treatment, though the mechanisms driving improvement cannot be determined from the present data [8]. This pattern suggests that virtual care platforms such as Reimagine Care may be associated with reductions in patient-reported physical symptom burden over time, though confirmation using validated instruments is needed before clinical conclusions can be drawn [7,8]. While clinically important difference thresholds have not been established for this adapted ePRO measure, a study by Hui et al [26] identified a minimal clinically important difference of 1 for the original Edmonton Symptom Assessment, suggesting that most of the symptom differences observed in the present study may not equate to clinical significance. Additional validation of the adapted measure used is needed to determine the true threshold for clinically important difference.

Depression and shortness of breath showed small but statistically significant worsening over time, which may reflect the progressive nature of disease burden, known treatment-related side effects, or greater patient disclosure of psychological distress over the course of extended platform engagement [27,28]. Notably, sensitivity analyses restricted to patients with more severe baseline symptom burden demonstrated significant improvement across all domains, including depression and shortness of breath, suggesting that the primary worsening trajectories observed for these symptoms may have been driven by floor effects among patients with minimal baseline burden rather than true symptom deterioration among affected patients. Future research using fully validated instruments will be needed to determine whether the magnitude of symptom change observed here is clinically meaningful for patients.

Among the moderators examined, VCC engagement was significantly associated with symptom trajectory, with greater clinician interaction associated with faster overall symptom improvement over the observation period. At the symptom level, higher engagement was associated with faster improvement in appetite loss and nausea trajectories. These findings are consistent with evidence that proactive clinician-facilitated symptom management is associated with reductions in treatment-related physical symptom burden in oncology populations [7]. Conversely, worsening depression and anxiety trajectories over time were associated with higher VCC engagement. This pattern may reflect selective engagement, whereby patients experiencing escalating psychological distress may have sought more frequent clinician contact, aligning with a well-documented phenomenon in oncology supportive care research [29]. The availability of on-demand clinician access through the VCC may lower the threshold for patients to seek support when psychological symptoms worsen, which could account for the observed association between higher engagement and worsening depression and anxiety trajectories. Patients with metastatic disease demonstrated significantly attenuated improvement in tiredness, drowsiness, appetite loss, and nausea relative to patients with nonmetastatic disease, suggesting greater persistence of physical symptom burden in the context of more advanced disease. This finding is consistent with evidence that metastatic disease is associated with higher and more refractory physical symptom burden over time, driven by disease progression, systemic treatment effects, and greater physiological vulnerability [30]. However, metastatic disease status did not significantly moderate total symptom burden trajectories, suggesting that

while the rate of improvement differed for specific physical symptoms, the overall trajectory of symptom burden across the observation period was not substantially altered by disease stage. The absence of a metastatic moderation effect on total symptom burden likely reflects heterogeneity across cancer types and treatment phases within the metastatic subsample, and disease-specific cohorts are needed to clarify this relationship. Future research should prioritize prospective designs with matched control conditions, validated outcome instruments, and standardized assessment schedules to establish causal claims and determine the clinical significance of observed symptom changes in this population.

Strengths and Limitations

This study had several strengths. First, the large, real-world sample of 2214 *ICD*-confirmed oncology patients enrolled across multiple cancer types supports robust estimation of population-level symptom trajectories and strengthens the external relevance of findings relative to single-site or trial-based studies. Second, the use of linear mixed-effects models accommodated the unbalanced, repeated-measures structure inherent to real-world platform data, enabling all available observations to contribute to trajectory estimation without requiring complete follow-up. Third, the breadth of symptom coverage across 10 ePRO domains provides a multidimensional characterization of symptom burden that is rarely captured in routine oncology care management research. Fourth, the robustness of primary findings was supported by sensitivity analyses, both of which yielded conclusions consistent with the primary analyses.

This study also had several limitations. First, the observational, retrospective design precludes causal inference. The absence of a control group means that observed improvements in symptom burden cannot be attributed to Reimagine Care's care model alone. Factors such as natural symptom fluctuation over the course of treatment, regression to the mean, concurrent clinical management, and unmeasured treatment-related variables, including regimen type, regimen intensity, and time since treatment initiation, cannot be ruled out as contributors to the observed trajectories. Future research should incorporate matched control designs or propensity score methods to support stronger causal claims. Second, the ePRO instrument used in this study is an adapted version of the ESAS and has not been independently validated in this population. Because established minimal clinically important difference thresholds have not been derived for this adapted measure, the clinical significance of the observed changes cannot be formally evaluated. Future work should prioritize validation of the instrument against established patient-centered benchmarks. Third, the number of patients contributing data declined substantially over the follow-up window, with only 26.8% (593/2214) of patients contributing data at 180 days. This level of attrition raises the possibility of survivorship bias, whereby patients who remained engaged and contributed data at later timepoints may have systematically differed from those who disengaged, potentially inflating apparent improvements in symptom burden. Notably, attrition in this population may also reflect treatment completion rather than disengagement, as patients enrolled at or near chemotherapy initiation may have concluded active treatment within the observation window. Fourth, ePRO surveys were administered at irregular, platform-triggered intervals rather than at standardized timepoints, which limits comparability of observations across patients and timepoints and may introduce measurement variability into trajectory estimates. Fifth, the VCC engagement variable was operationalized as the total interaction count with the VCC, which does not capture the content, quality, or clinical nature of those interactions and is subject to reverse causality; patients with greater symptom burden may seek more frequent clinician contact, making it difficult to disentangle engagement as a driver of improvement from engagement as a marker of disease severity. Additionally, platform engagement with Remi (ie, the AI-enabled virtual assistant serving as the primary patient-facing touchpoint for symptom check-ins and outreach) was not captured, potentially underestimating overall platform use and limiting the interpretability of engagement as a moderator of symptom trajectories.

Conclusions

This study provides real-world evidence characterizing symptom burden and longitudinal symptom trajectories among oncology patients enrolled in Reimagine Care, a virtual care platform. Total symptom burden declined significantly over 180 days, with the largest improvements in tiredness, appetite loss, drowsiness, and nausea; greater VCC engagement was associated with faster improvement, and patients with metastatic disease showed attenuated physical symptom recovery relative to patients with nonmetastatic disease. These findings contribute to a growing body of real-world evidence suggesting that virtual care platforms such as Reimagine Care are associated with reductions in patient-reported physical symptom burden during active cancer treatment. Platform engagement and disease stage were clinically relevant moderators of symptom trajectories and warrant further investigation. Future research should prioritize prospective designs with matched control conditions, validated outcome instruments, and standardized assessment schedules to establish causal claims and determine the clinical significance of observed symptom changes in this population.

Generative AI Use

Generative AI (GenAI) tools (ie, Claude (Opus 5.5; Anthropic)) were used in a limited capacity during the preparation of this manuscript, including to review and confirm editorial changes and language revisions. GenAI was not used to generate, draft, or substantively write any portion of the manuscript. All content was written and approved by the authors, and all authors take full responsibility for the integrity and accuracy of the content presented.

Funding

This study was not externally funded. Data were provided by Reimagine Care as part of an ongoing scientific partnership with Fit Minded, Inc. Fit Minded, Inc, received compensation for services rendered as the embedded scientific team for Reimagine Care, independent of the conduct or outcomes of this research. The article processing fee was covered by Reimagine Care.

Data Availability

The data set used for this retrospective analysis is not publicly available, given Reimagine Care's privacy policy for patient data. Requests for aggregated, deidentified data should be directed to the corresponding author, KM, at publications@fit-minded.com and will be evaluated on a case-by-case basis, subject to a data use agreement with Reimagine Care and approval from Fit Minded, Inc.

Authors' Contributions

Conceptualization: CJ, KM, JH
Formal analysis: CJ, LH, EK
Methodology: CJ, KM, LH, EK
Supervision: JH
Writing – original draft: CJ, EK, JH
Writing – review & editing: CJ, KM, LH, EK, JH

Conflicts of Interest

Fit Minded, Inc, served as the embedded scientific team for Reimagine Care and received compensation for those services. JH is the founder and CEO of Fit Minded, Inc, and KM, LH, EK, and CJ are employees of Fit Minded, Inc. No author's employment status or compensation is contingent upon the direction or outcome of the findings. The other authors report no conflicts of interest.

Multimedia Appendix 1

Electronic patient-reported outcome assessment.
[DOCX File (Microsoft Word File), 7 KB-Multimedia Appendix 1]

Multimedia Appendix 2

Sensitivity analysis of symptom trajectories among patients with moderate-or-greater baseline symptom burden.
[DOCX File (Microsoft Word File), 9 KB-Multimedia Appendix 2]

Multimedia Appendix 3

Sensitivity analysis of symptom trajectories using random slope mixed-effects models.
[DOCX File (Microsoft Word File), 9 KB-Multimedia Appendix 3]

Checklist 1

STROBE checklist.
[DOCX File (Microsoft Word File), 1755 KB-Checklist 1]

References

1. Mariotto AB, Yabroff KR, Shao Y, Feuer EJ, Brown ML. Projections of the cost of cancer care in the United States: 2010-2020. J Natl Cancer Inst. Jan 19, 2011;103(2):117-128. [doi: 10.1093/jnci/djq495] [Medline: 21228314]
2. Mariotto AB, Enewold L, Zhao J, Zeruto CA, Yabroff KR. Medical care costs associated with cancer survivorship in the United States. Cancer Epidemiol Biomarkers Prev. Jul 2020;29(7):1304-1312. [doi: 10.1158/1055-9965.EPI-19-1534] [Medline: 32522832]
3. Cancer facts & figures 2024. American Cancer Society; 2024. URL: https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/annual-cancer-facts-and-figures/2024/2024-cancer-facts-and-figures-acs.pdf [Accessed 2026-06-17]
4. Cleeland CS, Zhao F, Chang VT, et al. The symptom burden of cancer: evidence for a core set of cancer-related and treatment-related symptoms from the Eastern Cooperative Oncology Group Symptom Outcomes and Practice Patterns study. Cancer. Dec 15, 2013;119(24):4333-4340. [doi: 10.1002/cncr.28376] [Medline: 24114037]
5. Greystoke A, Daumont MJ, Rault C, et al. Real-world treatment patterns and outcomes for patients with non-metastatic non-small cell lung cancer: retrospective analyses in Canada, England, and Germany. BMC Pulm Med. May 27, 2025;25(1):265. [doi: 10.1186/s12890-025-03715-9] [Medline: 40426148]
6. Lee M, Kang D, Kang E, et al. Efficacy of the PRO-CTCAE mobile application for improving patient participation in symptom management during cancer treatment: a randomized controlled trial. Support Care Cancer. May 6, 2023;31(6):321. [doi: 10.1007/s00520-023-07779-3] [Medline: 37148373]

7. Basch E, Schrag D, Henson S, et al. Effect of electronic symptom monitoring on patient-reported outcomes among patients with metastatic cancer: a randomized clinical trial. JAMA. Jun 28, 2022;327(24):2413-2422. [doi: 10.1001/jama.2022.9265] [Medline: 35661856]
8. Basch E, Deal AM, Dueck AC, et al. Overall survival results of a trial assessing patient-reported outcomes for symptom monitoring during routine cancer treatment. JAMA. Jul 11, 2017;318(2):197-198. [doi: 10.1001/jama.2017.7156] [Medline: 28586821]
9. Denis F, Basch E, Septans AL, et al. Two-year survival comparing web-based symptom monitoring vs routine surveillance following treatment for lung cancer. JAMA. Jan 22, 2019;321(3):306-307. [doi: 10.1001/jama.2018.18085] [Medline: 30667494]
10. Salz T, Dressler EV, Kittel C, et al. Impact of an electronic patient-reported outcome-informed clinical decision support tool on clinical discussions with head and neck cancer survivors: findings from the HN-STAR randomized controlled trial (WF-1805CD). JCO Oncol Pract. Dec 2025;21(12):1786-1799. [doi: 10.1200/OP-25-00867] [Medline: 41118619]
11. Patt DA, Patel AM, Bhardwaj A, et al. Impact of remote symptom monitoring with electronic patient-reported outcomes on hospitalization, survival, and cost in community oncology practice: the Texas Two-Step study. JCO Clin Cancer Inform. Sep 2023;7:e2300182. [doi: 10.1200/CCI.23.00182] [Medline: 37897263]
12. Seow H, Barbera L, Sutradhar R, et al. Trajectory of performance status and symptom scores for patients with cancer during the last six months of life. J Clin Oncol. Mar 20, 2011;29(9):1151-1158. [doi: 10.1200/JCO.2010.30.7173] [Medline: 21300920]
13. Chae S, Street WN, Ramaraju N, Gilbertson-White S. Prediction of cancer symptom trajectory using longitudinal electronic health record data and long short-term memory neural network. JCO Clin Cancer Inform. Mar 2024;8(8):e2300039. [doi: 10.1200/CCI.23.00039] [Medline: 38471054]
14. Hammad A, Davis LE, Mahar AL, et al. Symptom trajectories and predictors of severe symptoms in pancreatic adenocarcinoma at the end-of-life: a population based analysis of 2,538 patients. HPB (Oxford). Dec 2019;21(12):1744-1752. [doi: 10.1016/j.hpb.2019.04.016] [Medline: 31300337]
15. US Department of Health and Human Services. Protection of human subjects: exempt research (45 CFR § 46.104). Electronic Code of Federal Regulations (eCFR). URL: https://www.ecfr.gov/current/title-45/subtitle-A/subchapter-A/part-46/section-46.104 [Accessed 2026-10-08]
16. Bruera E, Kuehn N, Miller MJ, Selmser P, Macmillan K. The Edmonton Symptom Assessment System (ESAS): a simple method for the assessment of palliative care patients. J Palliat Care. 1991;7(2):6-9. [Medline: 1714502]
17. Hui D, Bruera E. The Edmonton Symptom Assessment System 25 years later: past, present, and future developments. J Pain Symptom Manage. Mar 2017;53(3):630-643. [doi: 10.1016/j.jpainsymman.2016.10.370] [Medline: 28042071]
18. Haynes W. Benjamini–Hochberg method. In: Dubitzky W, Wolkenhauer O, Cho KH, Yokota H, editors. Encyclopedia of Systems Biology. Springer; 2013:78. [doi: 10.1007/978-1-4419-9863-7_1215]
19. Bilenduke E, Lancki N, Mai Q, et al. Electronic patient-reported outcomes (ePRO) completion rates and health care resource use (HCRU) among cancer survivors in a large health system. JCO Oncol Pract. Oct 2025;21(10_suppl):389. [doi: 10.1200/OP.2025.21.10_suppl.389]
20. Harris C, Hammer MJ, Conley YP, et al. Impact of multimorbidity on symptom burden and symptom clusters in patients receiving chemotherapy. Cancer Med. Feb 2025;14(3):e70418. [doi: 10.1002/cam4.70418] [Medline: 39910913]
21. Ritchie CS, Zhao F, Patel K, et al. Association between patients' perception of the comorbidity burden and symptoms in outpatients with common solid tumors. Cancer. Oct 1, 2017;123(19):3835-3842. [doi: 10.1002/cncr.30801] [Medline: 28608952]
22. Gallicchio L, Devasia TP, Tonorezos E, Mollica MA, Mariotto A. Estimation of the number of individuals living with metastatic cancer in the United States. J Natl Cancer Inst. Nov 14, 2022;114(11):1476-1483. [doi: 10.1093/jnci/djac158] [Medline: 35993614]
23. Kang YE, Yoon JH, Park NH, Ahn YC, Lee EJ, Son CG. Prevalence of cancer-related fatigue based on severity: a systematic review and meta-analysis. Sci Rep. Aug 7, 2023;13(1):12815. [doi: 10.1038/s41598-023-39046-0] [Medline: 37550326]
24. Zeng L, Koo K, Zhang L, et al. Fatigue in advanced cancer patients attending an outpatient palliative radiotherapy clinic as screened by the Edmonton Symptom Assessment System. Support Care Cancer. May 2012;20(5):1037-1042. [doi: 10.1007/s00520-011-1179-8] [Medline: 21538097]
25. Bergerot C, Jacobsen PB, Rosa WE, et al. Global unmet psychosocial needs in cancer care: health policy. EClinicalMedicine. Dec 2024;78:102942. [doi: 10.1016/j.eclinm.2024.102942] [Medline: 39634034]
26. Hui D, Shamieh O, Paiva CE, et al. Minimal clinically important differences in the Edmonton Symptom Assessment Scale in cancer patients: a prospective, multicenter study. Cancer. Sep 1, 2015;121(17):3027-3035. [doi: 10.1002/cncr.29437] [Medline: 26059846]

27. Shin J, Hammer M, Cooley ME, et al. Common and distinct risk factors that influence more severe and distressing shortness of breath profiles in oncology outpatients. Cancer Med. Feb 2024;13(3):e7013. [doi: 10.1002/cam4.7013] [Medline: 38400684]
28. Konieczny M, Sawicka J, Gąska I, et al. Anxiety and depression in breast cancer patients before and after chemotherapy: a pre-post study without a control group. J Clin Med. Nov 16, 2025;14(22):8105. [doi: 10.3390/jcm14228105] [Medline: 41303141]
29. Mohr DC, Kwasny MJ, Meyerhoff J, Graham AK, Lattie EG. The effect of depression and anxiety symptom severity on clinical outcomes and app use in digital mental health treatments: meta-regression of three trials. Behav Res Ther. Dec 2021;147:103972. [doi: 10.1016/j.brat.2021.103972] [Medline: 34600398]
30. Budhwani S, Moineddin R, Wodchis WP, Zimmermann C, Howell D. Longitudinal symptom burden trajectories in a population-based cohort of women with metastatic breast cancer: a group-based trajectory modeling analysis. Curr Oncol. Feb 14, 2021;28(1):879-897. [doi: 10.3390/curroncol28010087] [Medline: 33617505]

Abbreviations

BRANY: Biomedical Research Alliance of New York
ePRO: electronic patient-reported outcome
ESAS: Edmonton Symptom Assessment System
FDR: false discovery rate
***ICD-10*:** *International Classification of Diseases, Tenth Revision*
STROBE: Strengthening the Reporting of Observational Studies in Epidemiology
VCC: virtual care center

Edited by Matthew Balcarras; peer-reviewed by Jonas Wolf; submitted 23.Jul.2026; final revised version received 21.Sep.2026; accepted 22.Sep.2026; published 17.Nov.2026

Please cite as:
Jewell C, McAlister K, Huffman L, Knight E, Huberty J
Longitudinal Improvements in Symptom Burden Among Oncology Patients Enrolled in Reimagine Care, a Virtual Care Platform: Retrospective Study
JMIR Cancer 2026;12:e107798
URL: https://cancer.jmir.org/2026/1/e107798
doi: 10.2196/107798

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