



A Randomized Controlled Trial of mHealth Mindfulness Intervention for Cancer Patients and Informal Cancer Caregivers: A Feasibility Study Within an Integrated Health Care Delivery System

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Abstract

Purpose: To assess feasibility and preliminary efficacy of a mobile/online-based (mHealth) mindfulness intervention for cancer patients and their caregivers to reduce distress and improve quality of life (QoL). **Material and Methods:** Two-arm randomized controlled trial within Kaiser Permanente Northern California targeting cancer patients who received chemotherapy and their informal caregivers. The intervention group received a commercially available mindfulness program for 8 weeks. The wait-list control group received usual care. We assessed feasibility using retention and adherence rates and obtained participant-reported data on distress, QoL, sleep, mindfulness, and posttraumatic growth before and immediately after the intervention. **Results:** Ninety-seven patients (median age 59 years; female 69%; 65% whites) and 31 caregivers (median age 63 years; female 58%; 77% whites) were randomized. Among randomized participants, 74% of the patients and 84% of the caregivers completed the study. Among those in the intervention arm who initiated the mindfulness program, 65% practiced at least 50% of the days during the intervention period. We observed significantly greater improvement in QoL among patients in the intervention arm compared with controls. Caregivers in the intervention group experienced increased mindfulness compared with controls. Participants appreciated the convenience of the intervention and the mindfulness skills they obtained from the program. **Conclusion:** We demonstrated the feasibility of conducting a randomized trial of an mHealth mindfulness intervention for cancer patients and their informal caregivers. Results from fully powered efficacy trials would inform the potential for clinicians to use this scalable intervention to help improve QoL of those affected by cancer and their caregivers.

Keywords

mindfulness, cancer, clinical trial, chemotherapy, caregivers, quality of life

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Introduction

A cancer diagnosis is associated with high levels of distress, particularly anxiety, depression, fear of recurrence, and low quality of life (QoL), in both patients and caregivers.¹⁻³ The National Comprehensive Cancer Network (NCCN) definition of distress is “a multifactorial unpleasant emotional experience of a psychological (cognitive, behavioral, emotional), social, and/or spiritual nature that may interfere with the ability to cope effectively with cancer, its physical symptoms, and its treatment.”⁴ Screening for psychosocial

distress became a Commission on Cancer accreditation requirement in 2015.⁵ Due to this requirement, it is likely that more patients will be identified as “distressed,” and providers will need efficient and affordable strategies to offer support to those who are in need. Research indicates that cancer patients’ levels of psychosocial stress and depression not only affect QoL but also survival and prognosis.⁶ Distress extends along a continuum, and although an estimated 35% of cancer patients experience such psychological distress,⁷ clinicians are often at a loss as to how to address the QoL of cancer patients and their families. To



help cope with the distress associated with the diagnosis, disease symptoms, and treatment, cancer patients are increasingly turning to integrative medicine,⁸⁻¹² including mindfulness practices or meditation.

Mindfulness, a psychological process of bringing one's attention to the present moment with an attitude of nonjudgment, acceptance, and openness,¹³⁻¹⁵ appears to be an effective intervention for reducing symptoms of depression and anxiety in many populations.¹⁶⁻²⁰ Through mindfulness meditation and practices, individuals are encouraged to turn toward and observe negative experiences, which they may have previously avoided, thus improving their ability to tolerate negative experiences such as cancer symptoms and anxiety about the future. Previous meta-analyses of mindfulness interventions in cancer patients/survivors have demonstrated that these interventions result in significant improvement in mood, anxiety, and QoL.²¹⁻²⁶ Most of the previously studied mindfulness interventions used programs based on Jon Kabat-Zinn's Mindfulness-Based Stress Reduction (MBSR) program or its variant, Mindfulness-Based Cancer Recovery program (MBCR),²⁷ and often targeted early-stage breast cancer patients who had completed active treatment. Despite the established efficacy, logistical requirements of these traditional class-based mindfulness trainings reduce their potential to help distressed cancer patients who are sick or undergoing active treatment because these programs require patients to attend over 30 hours of in-person sessions together with 45 minutes of home practice daily. Caregivers, often overburdened with caregiving duties, may lack the time or energy to attend these in-person classes.^{28,29} In addition to physical challenges, logistical barriers such as distance, lack of transportation, and scheduling conflicts have been reported as reasons for nonadherence or refusal to participate in behavioral intervention research studies.³⁰⁻³³ In addition, in-person classes are costly for the patients and the health care system and not readily available in rural areas, which are other important barriers against wide dissemination. Therefore, it is necessary to identify effective, low-cost, and convenient interventions that meet patients' and caregivers' needs.

Mobile health (mHealth) technology is emerging as an important platform for the delivery of behavioral interventions. mHealth interventions offer an innovative mode of treatment delivery using mobile technologies such as cell phones, handheld tablets, and other wireless devices. Mobile phones are nearly ubiquitous, with 73% of Americans aged 50 to 64 years owning a smartphone.³⁴ The

widespread prevalence of smartphones underscores their potential to deliver cost-effective interventions that can be easily integrated into the lives of sick cancer patients or busy caregivers who are unable to attend regular in-person classes. Importantly, many of the app-based mindfulness programs provide shorter but more frequent programs, making it more feasible for users than intense, in-person programs. For instance, the program we used for this study requires a 10- to 20-minute daily practice each day, while MBSR requires 2 to 2.5 hours of in-person instruction per week along with 45 minutes of daily home practice. In addition, mHealth interventions can integrate text messaging and self-monitoring tools that are acceptable and enjoyable to patients.³⁵ Finally, mHealth devices can collect objective and accurate measures of adherence without troubling participants to keep diaries. We previously demonstrated the feasibility of offering an mHealth mindfulness intervention for cancer patients actively undergoing chemotherapy and their primary caregivers.³⁶ Based on the promising results from the pilot study, we conducted a pilot randomized controlled trial of an mHealth mindfulness program using a commercially available mindfulness mobile app within an integrated health care delivery system.

Methods

Setting

The POEM (Practice Of Embracing each Moment) study was conducted within Kaiser Permanente Northern California (KPNC), an integrated health care delivery system that provides comprehensive health care to a large, diverse community-based population of over 4.1 million individuals. KPNC provides coverage for approximately 31% of the northern California population, and its membership is similar demographically, ethnically, and socioeconomically to the area's overall population. The only exception is with regard to income; KPNC members underrepresent the very poor and the very wealthy.^{37,38} Participants for the POEM study were recruited from 7 KPNC oncology clinics in the San Francisco Bay Area.

Participants

We included patients with a diagnosis of cancer who were currently receiving or had received chemotherapy, targeted therapies, or immunotherapy in the prior 6 months. The inclusion criteria for both patients and caregivers included age ≥ 18

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years; owning a smartphone, tablet, or computer with internet access; and understanding English. Primary informal caregivers of the patients were also eligible and invited to participate. We excluded persons who regularly meditated or prayed at least 3 times per week, were currently participating in another type of stress reduction program, were severely hearing impaired, or had severe mental illness.

Procedures

This 2-arm randomized controlled pilot trial was conducted between October 2017 and November 2018. Participants completed an online informed consent form, and study protocols and procedures were approved by the KPNC Institutional Review Board. The study was registered on ClinicalTrials.gov (NCT03078608).

Recruitment. Patients were recruited using several strategies, including clinic referrals from oncologists, oncology social workers, and nurses; brochures at each clinic; and invitation emails, followed up with phone calls. Eligible patients were identified using the KPNC electronic health record. Caregivers were recruited by patient participant referral. Patients could participate with or without caregiver participation, and caregivers could also participate without an enrolled patient. Participants who completed the study received a \$40 gift card and a year's subscription to the mindfulness program used for this trial.

Randomization. Participants were allocated to the 2 study groups using simple balanced blocked randomization, stratified by facility. Randomization was implemented by use of allocation assignment concealed in a set of sequentially numbered opaque envelopes filled by research personnel not affiliated with the trial. Caregivers who enrolled with a patient participant were assigned to the same arm as the patient.

Intervention. Participants in the intervention arm received free access to a commercially available mindfulness program, Headspace™ (www.headspace.com), for 8 weeks. Headspace is a self-paced program that provides guided mindfulness meditation instructions via a website or mobile application (iOS and Android). A recent review identified Headspace as the most user-friendly commercial mindfulness mobile application.³⁹ Recent studies in various populations have found use of the Headspace app improved mood^{40,41} and positive affect,⁴⁰ decreased stress,^{41,42} improved general well-being,⁴² and increased mindfulness.⁴³

Research staff emailed participants randomized to the intervention arm device-specific instructions for downloading the Headspace app and information about the program. Research staff checked in with participants over the phone a few days after emailing the instructions and provided support for setting up Headspace over the phone, if needed.

Participants were asked to complete Headspace sessions on a daily basis during the 8-week intervention. They were encouraged to first complete the 30-day Foundation Course, which teaches users the basics of mindfulness meditation, then the cancer pack, which was designed specifically for individuals affected by cancer. They also had the option to choose other 10- to 30-day courses that are more condition- or situation-specific, such as “Anxiety,” “Stress,” “Acceptance,” “Relationships,” or “Sleep,” or single meditation sessions. All Headspace courses teach mindfulness using various basic techniques, including breathing exercises, body scan (to mindfully pay attention to different parts of one's body—one of the most basic exercises in the MBSR program), noting (being aware of any emotions that may be arising at the moment), and visualization (visualizing images such as sun shining on the entire body). The length of the sessions can be set from 10 to 20 minutes. The length was initially set to 10 minutes for all participants. In addition to the daily, progressive audio instruction, there are short (1-2 minutes) lecture videos every several days designed to increase the understanding of mindfulness and to encourage its integration into daily life. Headspace can be set up to send reminders using push notifications, and study staff made phone calls if an intervention participant completed fewer than 3 Headspace sessions in a week.

Wait-list Control Arm. Participants randomized to the wait-list control arm received usual care and were asked not to start any stress reduction programs during the study period. On completion of the 8-week survey, the control participants were provided with a year's subscription to Headspace and instructions on downloading the app.

Outcome Measures

Retention. The retention rate was measured as the proportion of enrolled participants who completed the 8-week survey (the primary outcome time point).

Adherence. The Headspace program automatically collects adherence data, including date, time, length, and name of each session to which participants listened, identified by a study ID. Headspace transferred these adherence data to the researchers monthly during the study. Using these data, we calculated the proportion of days during the 8-week intervention period that each participant used the program for any amount of time.

Participant-Reported Measures. We collected outcome data using self-administered online surveys using DatStat software (DatStat Ilume, version 6.1.18.19, Seattle, WA) at the time of consent (baseline survey) and immediately post-intervention (8-week survey) using validated questionnaires as follows. Score ranges for each item are shown in Table 2.

Distress. The NCCN Distress Thermometer was used to assess current distress level.^{44,45} Respondents were asked to rate their level of distress during the past week by choosing a number, with 0 indicating no distress and 10 extreme distress.

Anxiety and depression. We used the 14-item Hospital Anxiety and Depression Scale (HADS) to assess anxiety and depression.⁴⁶ Higher scores indicate greater anxiety and depression.

Pain. The PROMIS Pain Intensity numeric rating scale asks participants to rate average pain level in the past 7 days on a scale of 0 (“no pain”) to 10 (“worst imaginable pain”). The 8-item PROMIS Pain Interference scale assesses extent to which pain interfered with functional activities during the past 7 days.⁴⁷ Higher scores indicate more interference due to pain.

Sleep quality. The 8-item PROMIS Sleep Disturbance scale assesses sleep disturbance during the past 7 days.⁴⁸ A higher summary score indicates worse sleep disturbance.

Quality of life. We used the 27-item Functional Assessment of Cancer Therapy General Scale (FACT-G) to assess QoL in patients. FACT-G asks respondents to rate their QoL in 4 domains (physical, social/family, emotional, and functional well-being).^{49,50} Caregiver QoL was determined using the Caregiver Quality of Life Index–Cancer (CQOLC) scale.⁵¹ The CQOLC gauges the daily and overall impact caregiving has on respondents’ QoL. Higher scores indicate better QoL on both scales.

Fatigue. The 9-item Brief Fatigue Inventory assesses the severity and impact of fatigue on various aspects of life in the past 24 hours.⁵² Higher scores indicate greater fatigue.

Posttraumatic growth. The 21-item Posttraumatic Growth Inventory (PTGI) assesses 5 factors of posttraumatic growth, positive change experienced because of a traumatic event or crisis—relating to others, new possibilities, personal strength, spiritual change, and appreciation of life. Respondents are asked to rate to what extent they have seen the listed changes as a result as a crisis in their lives. We modified the wording to ask about changes as a result of their (patients) or their loved one’s (caregivers) cancer diagnosis.⁵³ Higher scores indicate greater post-traumatic growth.

Mindfulness. The 24-item Five Facet Mindfulness Questionnaire–Short Form (FFMQ-SF) measures 5 factors representing elements of mindfulness: observing, describing, acting with awareness, nonjudging of inner experience, and nonreactivity to inner experience. Higher scores indicate greater mindfulness.⁵⁴

Post-Intervention Interview. We conducted phone interviews with participants after they completed the 8-week

intervention period to obtain qualitative feedback regarding the study. Question topics included benefits of using Headspace, things they liked about Headspace or thought could be improved, suggestions for improving the experience of study participants, and experience being in the wait-list control arm.

Data Analyses

Data from patient participants and caregiver participants were analyzed separately. We described baseline distributions between arms. Retention rates were calculated by dividing the number of participants who completed the 8-week surveys by the number of randomized participants. We used the program usage data collected by Headspace to calculate intervention adherence rates—the percent of days within the 8-week intervention period that participants engaged in at least one Headspace session of any length.

To obtain preliminary efficacy results, we performed repeated measures analysis of variance tests comparing change in outcome measures between baseline and 8-week follow-up survey between intervention and control arms using all participants who completed both surveys. Cohen’s *d* effect size was calculated by taking the difference between group mean change scores and dividing by the pooled standard deviation. All analyses were intent-to-treat. As a pilot study, this randomized clinical trial was not adequately powered to detect statistically significant differences between groups. As such, standardized effect sizes were calculated to demonstrate effects and trends. Effect sizes of approximately 0.2, 0.5, and 0.8 are generally considered small, medium, and large effects, respectively.⁵⁵

As a supplementary analysis, we conducted dose-response per-protocol analyses, repeating the analysis but stratifying intervention participants by level of adherence to the mindfulness intervention protocol (percent of days during intervention period used Headspace: <50% and ≥50%) and comparing with the control participants.

Interviews were transcribed and uploaded into Nvivo 12 software. Inductive thematic analysis was employed to identify and develop codes on themes related to mindfulness benefits, the interface experience, the cancer patients’/caregivers, perspective of mindfulness. One primary coder (MM) initially coded each interview and met with a secondary coder (AA) to discuss the coding, identify disagreements, and ensure accuracy of codes. This article focuses on the feasibility component of the qualitative interviews.

Results

Participant Characteristics

Table 1 describes the baseline demographic and clinical characteristics of all individuals who completed the study.

Patients in the intervention arm were more likely to be men, have postgraduate education, and have higher income compared with controls. Most patients were diagnosed with breast or a hematologic cancer, such as non-Hodgkin's lymphoma. About 54% were receiving or had received supportive chemotherapy, and 50% were diagnosed within a year of their enrollment in the current study.

Participant Enrollment and Flow. Figure 1 shows the overall flow of participants through the study. The most common reasons for ineligibility included already having a meditation practice, not having cancer or not having received chemotherapy in the past 6 months, not speaking English, and being uncomfortable using technology. The most common reasons given for declining to join the study were being too busy and lack of interest. Only one potential participant declined participation in the study because of the possibility that she would be randomized to the wait-list control arm.

Thirty-five (36.1%) participants identified a potential caregiver to participate in the study with them. In addition, 3 caregivers joined the study without a patient after we attempted to recruit the patient by phone. Another 3 caregivers self-referred after seeing a study brochure. Ten of the caregivers approached declined participation in the study; the most common reason was lack of interest in participating.

Retention Rate. A total of 97 patients and 31 caregivers enrolled in the study; 72 patients (74%; intervention $n = 40$, control $n = 32$) and 26 caregivers (84%; intervention $n = 13$, control $n = 13$) completed the study. Similar proportions of patients discontinued study participation in the control and intervention arms (25.9% and 25.6%, respectively). Reasons provided for discontinuation included the following: too sick from the side effects of chemotherapy; never established a meditation practice; illness progressed; caregiving responsibility increased; holiday schedules interfered; and death. No participants reported discontinuing study participation because they were randomized to the wait-list control group.

Adherence. Among the participants in the intervention arm who completed the study, 20 (50%) patients and 8 (61.5%) caregivers practiced the mindfulness program at least 50% of the days during the 8-week study period, and 13 (32.5%) patients and 5 (38.5%) caregivers practiced at least 70% of the days. Nine (22.5%) patients and 1 (7.7%) caregiver did not initiate the Headspace program. Of the 31 patients who completed at least 1 Headspace session, 20 (64.5%) and 13 (41.9%) practiced the mindfulness program at least 50% and at least 70% of the days during the 8-week study period, respectively. Of the 12 caregivers who actively used Headspace, 8 (66.7%) completed at least 50% and 5 (41.7%) completed at least 70% of the days. In addition,

approximately 70% of patients and all caregivers continued to use the program after the completion of the study.

Participant-Reported Outcomes

Patient baseline and post-intervention scores for the outcome measures by study arm are shown in Table 2. Compared with controls, patients in the intervention arm had statistically significantly greater improvements between baseline and post-intervention in the FACT-G emotional well-being ($P = .03$) and overall well-being scores ($P = .03$). Although the results were of borderline significance, patients in the intervention arm experienced greater improvements on the PROMIS pain base scale ($P = .08$), PTGI spiritual change ($P = .07$), and FFMQ acting with awareness ($P = .06$) and nonreactivity scores ($P = .09$) compared with controls. No statistically significant differences in change in anxiety, depression, sleep, and fatigue were observed between study arms.

Baseline and post-intervention outcome measure scores for caregivers in each arm are shown in Table 3. The only significant difference in change between baseline and post-intervention between the treatment arms was in the FFMQ observing mindfulness domain score ($P = .03$). Caregiver participants in the intervention arm also had greater improvements compared with controls in the PTGI new possibilities ($P = .06$), personal strength ($P = .06$), and overall scores ($P = .05$), although these differences were of borderline significance.

Exploratory Dose-Response Analyses

We explored whether the effect sizes differed by differences in intervention adherence rates. Compared with controls, participants in the intervention group who had practiced mindfulness at least 50% of the days in the intervention period showed greater improvements in FACT-G emotional well-being ($P = .01$; Supplemental Figure 2, available online), PROMIS pain interference ($P = .02$; Supplemental Figure 3), HADS depression ($P = .04$; Supplemental Figure 4), PTGI spiritual change ($P = .05$, data not shown), FFMQ nonjudging of inner experience ($P = .03$, data not shown), and FACT-G overall well-being ($P = .03$, data not shown) scores compared with those who practiced mindfulness less frequently (<50%).

Post-Intervention Interview

During the interviews, participants commented on several factors related to study feasibility. Of the 82 participants who participated in the interviews, 74 reported that they had not engaged in any stress reduction practices other than the intervention during the study period. None of the wait-list control participant had engaged in stress reduction practices during the waiting period. Participants raised several

Table 1. Baseline demographic and clinical characteristics of participants.

	Patients		Caregivers	
	Intervention Arm (n = 54)	Control Arm (n = 43)	Intervention Arm (n = 17)	Control Arm (n = 14)
Age, mean (SD)	59.3 (14.1)	56.7 (14.7)	57.1 (17.4)	58.2 (18.6)
Female, n (%)	33 (62.3)	33 (76.7)	9 (52.9)	9 (64.3)
Marital status, n (%)				
Married	38 (71.7)	23 (57.5)	14 (82.4)	7 (53.9)
Living as married/domestic partner	1 (1.9)	2 (5.0)	1 (5.9)	3 (23.1)
Widowed	3 (5.7)	1 (2.5)	0 (0)	0 (0)
Separated/divorced	6 (11.3)	9 (22.5)	0 (0)	1 (7.7)
Never married	5 (9.4)	5 (12.5)	2 (11.8)	2 (15.4)
Race, n (%)				
White	36 (66.7)	27 (62.8)	15 (88.2)	9 (64.3)
African American	5 (9.3)	1 (2.3)	0 (0)	1 (7.1)
Asian	4 (7.4)	3 (7.0)	0 (0)	2 (14.3)
Other	8 (14.8)	9 (20.9)	2 (11.8)	2 (14.3)
Unknown/not reported	1 (1.9)	3 (7.0)	0 (0)	0 (0)
Education, n (%)				
Some college or less	18 (34.0)	19 (44.2)	6 (35.3)	5 (35.7)
College graduate	15 (28.3)	18 (41.9)	6 (35.3)	4 (28.6)
Postgraduate degree	20 (37.7)	6 (14.0)	5 (29.4)	5 (35.7)
Income, n (%)				
Less than \$75 000	11 (22.9)	21 (53.9)	2 (13.3)	3 (30.0)
\$75 000 to \$99 999	7 (14.6)	5 (12.8)	3 (20.0)	3 (30.0)
\$100 000 to \$149 999	18 (37.5)	8 (20.5)	5 (33.3)	1 (10.0)
\$150 000 or more	12 (25.0)	5 (12.8)	5 (33.3)	3 (30.0)
Primary delivery of the mindfulness program, n (%)				
iOS (iPad or iPhone)	13 (39.4)		8 (61.5)	
Android	4 (12.1)		1 (7.7)	
Computer with internet	16 (48.5)		4 (30.8)	
Cancer type, n (%)				
Breast	13 (25.5)	15 (38.5)		
Hematologic	13 (25.5)	8 (20.5)		
Gastrointestinal	10 (19.6)	2 (5.1)		
Genitourinary	5 (9.8)	7 (17.9)		
Head and neck	4 (7.8)	1 (2.6)		
Skin	3 (5.9)	1 (2.6)		
Lung	0 (0.0)	3 (7.7)		
Other	2 (3.9)	1 (2.6)		
Sarcoma	1 (2.0)	1 (2.6)		
Time since diagnosis, n (%)				
<1 year	24 (47.1)	21 (53.8)		
1+ year	27 (52.9)	18 (46.2)		
Intent of chemotherapy, n (%)				
Curative	24 (44.4)	21 (48.8)		
Palliative	30 (55.6)	22 (51.2)		
Caregiver relationship to the patient				
Spouse/partner			8 (47.1)	11 (78.6)
Child			4 (23.5)	1 (7.1)
Other relative			2 (11.8)	0 (0.0)
Friend			3 (17.6)	2 (14.3)

Table 2. Baseline and postintervention outcome measures of patients.

	Possible Score Range	Intervention Arm (n = 40)		Wait-List Control Arm (n = 32)		Intervention Effect		Effect Size, Cohen's <i>d</i>
		Baseline, Mean (SD)	Post-Intervention, Mean (SD)	Baseline, Mean (SD)	Post-Intervention, Mean (SD)	<i>F</i>	<i>P</i>	
Distress Thermometer	0-10	4.9 (2.3)	4.2 (2.6)	4.9 (1.7)	4.4 (2.0)	0.18	.67	-0.11
Hospital Anxiety and Depression Scale								
Depression	0-21	5.7 (3.5)	4.6 (3.6)*	4.9 (3.2)	4.9 (3.1)	2.58	.11	-0.401
Anxiety	0-21	8.7 (4.3)	7.2 (3.9)*	8.0 (3.1)	6.6 (3.3)*	0	1.00	0.01
PROMIS Pain scales								
Pain Intensity	0-10	3.2 (2.4)	2.4 (2.1)*	2.4 (2.2)	2.5 (2.4)	3.24	.08	-0.427
Pain Interference	8-40	19.2 (7.2)	16.8 (8.1)	18.1 (7.3)	18.3 (7.7)	1.36	.25	-0.364
PROMIS Sleep Disturbance	8-40	22.1 (8.8)	20.5 (8.3)	21.0 (7.2)	21.2 (7.7)	1.35	.25	-0.276
Brief Fatigue Inventory	0-10	4.0 (2.5)	3.5 (2.4)	3.2 (2.2)	3.2 (2.2)	1.41	.24	-0.281
Functional Assessment of Cancer Therapy General Scale (Quality of Life)								
Physical well-being	0-28	18.7 (5.6)	20.3 (5.9)*	19.3 (5.4)	19.6 (5.4)	1.89	.17	0.339
Social/family well-being	0-28	22.2 (5.2)	22.5 (5.2)	21.1 (5.8)	20.3 (5.5)	1.88	.18	0.325
Emotional well-being	0-24	14.3 (5.3)	16.4 (5.2)*	17.1 (4.0)	17.2 (4.3)	5.18	.03	0.542
Functional well-being	0-28	17.2 (5.6)	18.4 (5.7)	18.1 (4.9)	18.2 (5.2)	1.25	.27	0.265
Overall well-being	0-108	72.4 (18.4)	77.8 (19.0)*	75.6 (14.2)	75.4 (16.0)	4.88	.03	0.537
Posttraumatic Growth Inventory								
Relating to others	0-35	20.6 (8.5)	22.3 (8.8)	22.1 (7.4)	22.9 (6.6)	0.54	.46	0.186
New possibilities	0-25	9.7 (6.2)	12.0 (6.3)*	10.3 (4.7)	11.1 (5.5)	2.14	.15	0.362
Personal strength	0-20	9.5 (5.0)	10.8 (5.9)	12.5 (5.0)	12.2 (5.0)	2.41	.13	0.393
Spiritual change	0-10	3.7 (3.1)	4.6 (3.5)*	4.2 (3.4)	4.2 (3.0)	3.30	.07	0.467
Appreciation of life	0-15	9.9 (3.7)	10.1 (4.0)	10.3 (2.7)	10.5 (2.9)	0.01	.94	0.019
Total	0-105	52.5 (23.2)	59.5 (26.0)*	59.4 (19.0)	61.0 (18.8)	2.79	.10	0.454
Five Facet Mindfulness Questionnaire								
Observing	4-20	14.3 (3.8)	15.1 (2.8)	14.4 (3.6)	14.6 (3.9)	0.74	.39	0.226
Describing	5-25	17.5 (4.4)	18.1 (3.7)	17.2 (3.2)	17.2 (3.6)	0.56	.46	0.182
Acting with awareness	5-25	17.2 (3.8)	18.5 (3.5)*	17.4 (3.5)	17.2 (3.2)	3.74	.06	0.434
Nonjudging of inner experience	5-25	17.3 (4.9)	18.4 (4.2)*	17.5 (4.3)	17.4 (4.5)	2.30	.13	0.373
Nonreactivity	5-25	14.9 (3.7)	16.6 (3.3)*	16.1 (3.2)	16.6 (3.3)	2.94	.09	0.451

*Within group difference $P \leq .05$; and bolded values indicate statistically significant differences in change between baseline and post-intervention between intervention and control groups.

suggestions for improving the study, including providing an in-person orientation to Headspace and assistance downloading the app at the chemotherapy clinic; sending daily meditation reminders; and providing assistance in creating a meditation schedule. Though most participants appreciated the personalized practice and flexibility of the Headspace app, some participants also noted wanting a more social experience. Eleven of 57 participants (19.3%) said that they would be interested in participating in a webinar-based mindfulness program for this reason. Based on this input, we have added a mindfulness webinar option in the next phase of our study, which targets advanced cancer patients. The results from this study will provide further information regarding the acceptability of and adherence to an online, teacher-led mindfulness classes.

Many individuals noted that the reminder calls from study staff were helpful in encouraging them to pursue their

meditation practice. Nearly all intervention participants found the Headspace app to be useful (76 of 82 respondents) and would recommend the program to other cancer patients and caregivers (75 of 82 respondents). When asked about their experience waiting 8 weeks for the mindfulness program, wait-list control participants did not express that this wait was distressing or a barrier to participating although about half would have preferred to start the program earlier.

Discussion

To our knowledge, this is one of the first studies investigating the feasibility of conducting a randomized trial using a commercially available online mindfulness program to improve QoL of cancer patients who recently underwent chemotherapy and their primary caregivers. Our findings demonstrate that it is feasible to conduct a randomized trial

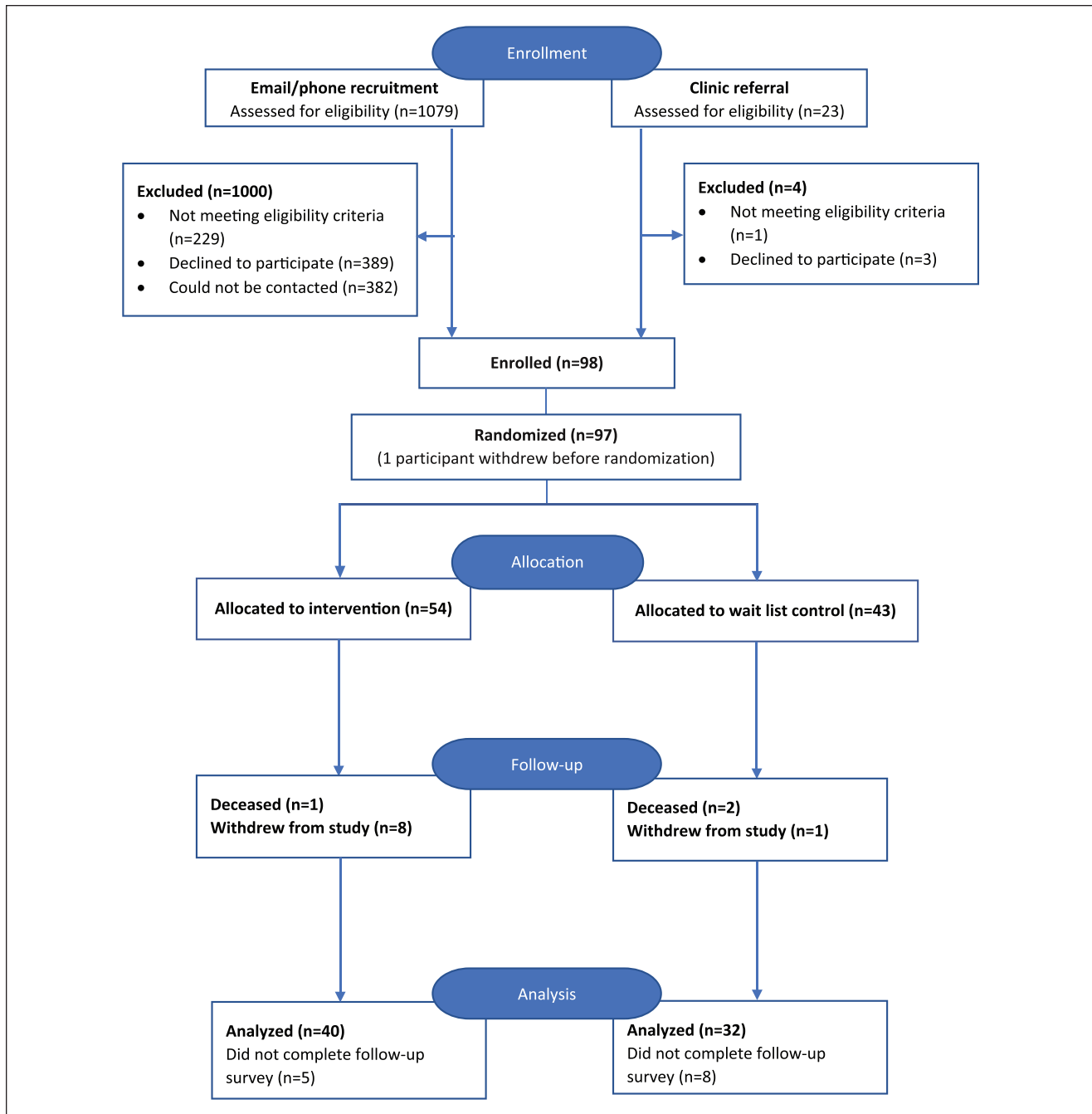


Figure 1. Overall flow of patient participants through the study.

using a mobile-based, self-paced mindfulness program in this population. Although not designed as an efficacy trial, the preliminary results suggested improvement in QoL among patients and mindfulness among caregivers. Participants who practiced mindfulness more frequently reported greater improvements in QoL, pain interference, and depression compared with intervention participants who practiced less frequently. In post-intervention interviews, participants stated that they appreciated the

convenience of using a self-paced program that could be easily incorporated into their daily lives that were dominated by medical appointments and the stress associated with cancer treatment. Our protocol and results provide a practical strategy for conducting a larger, fully powered comparative effectiveness trial.

Our study extends existing knowledge in the area of mindfulness interventions for cancer patients in several ways. First, we used an mHealth intervention and targeted

Table 3. Baseline and postintervention outcome measures of caregivers.

	Possible Score Range	Intervention Arm (n = 13)		Wait-List Control Arm (n = 13)		Intervention Effect		Effect Size, Cohen's <i>d</i>
		Baseline, Mean (SD)	Post-Intervention, Mean (SD)	Baseline, Mean (SD)	Post-Intervention, Mean (SD)	<i>F</i>	<i>P</i>	
Distress Thermometer	0-10	4.7 (2.1)	4.0 (2.1)	5.0 (1.9)	5.1 (2.7)	0.53	.47	-0.259
Hospital Anxiety and Depression Scale								
Depression	0-21	5.1 (3.4)	4.2 (2.6)	5.6 (2.9)	5.7 (3.3)	1.17	.29	-0.421
Anxiety	0-21	8.1 (2.9)	8.2 (3.3)	8.7 (3.0)	8.5 (3.6)	0.07	.79	-0.265
PROMIS Pain scales								
Pain Intensity	0-10	1.5 (1.5)	1.9 (1.5)	2.5 (1.9)	2.3 (1.9)	0.92	.35	0.402
Pain Interference	8-40	12.9 (5.5)	14.4 (7.7)	12.9 (5.3)	12.4 (3.8)	0.8	.39	0.489
PROMIS Sleep Disturbance	8-40	20.0 (5.9)	19.2 (7.6)	20.5 (5.2)	20.8 (6.3)	0.17	.69	-0.16
Brief Fatigue Inventory	0-10	3.2 (2.1)	2.4 (1.8)*	2.6 (1.9)	2.6 (1.9)	1.54	.23	-0.458
Caregiver Quality of Life Index–Cancer	0-140	92.8 (10.0)	93.7 (19.4)	91.5 (13.9)	94.6 (14.6)	0.33	.59	1.139
Posttraumatic Growth Inventory								
Relating to others	0-35	14.3 (6.3)	14.5 (8.0)	18.0 (7.4)	15.0 (7.1)	1.84	.19	0.527
New possibilities	0-25	5.0 (3.2)	5.5 (3.8)	7.5 (5.2)	4.8 (4.5)	3.93	.06	0.73
Personal strength	0-20	5.9 (4.9)	7.0 (4.8)	8.9 (3.8)	6.7 (4.9)	3.9	.06	0.741
Spiritual change	0-10	2.5 (2.7)	2.7 (2.7)	3.6 (3.3)	2.8 (3.0)	0.52	.48	0.238
Appreciation of life	0-15	6.9 (3.3)	7.3 (3.8)	8.5 (3.6)	7.2 (4.5)	1.28	.27	0.426
Total	0-105	33.6 (15.8)	38.3 (20.2)	45.2 (20.1)	37.8 (20.5)	4.29	.05	0.864
Five Facet Mindfulness Questionnaire								
Observing	4-20	13.6 (1.8)	13.6 (2.0)	14.3 (3.0)	12.6 (4.0)*	5.53	.03	0.922
Describing	5-25	18.5 (3.1)	18.6 (2.7)	17.7 (3.5)	17.8 (3.7)	0	.95	-0.031
Acting with awareness	5-25	16.0 (3.3)	16.4 (3.3)	16.5 (3.5)	16.1 (4.6)	0.59	.45	0.302
Nonjudging of inner experience	5-25	18.1 (3.1)	18.6 (3.5)	17.1 (4.2)	19.2 (5.1)*	1.17	.29	-0.47
Nonreactivity	5-25	14.9 (2.7)	15.2 (1.6)	15.4 (2.8)	15.6 (2.6)	0.02	.89	-0.211

*Within group difference $P \leq .05$; and bolded values indicate statistically significant differences in change between baseline and post-intervention between intervention and control groups.

cancer patients who are actively undergoing or recently underwent chemotherapy treatment. Because the majority of previous mindfulness intervention studies targeting cancer patients included only early-stage breast cancer patients who had completed treatment, accessibility of in-person mindfulness classes was less of a concern. However, the few previous in-person mindfulness studies that included patients with advanced cancers or those undergoing active treatment reported that recruitment and retention were challenging due to patients' difficulties in committing to an 8-week, in-person schedule^{30,56} and concluded that there is a need to tailor interventions to make them less intensive and more accessible for sick cancer patients.³⁰ Our studies, including our previous pilot trials using CD- and MP3-based mindfulness programs,⁵⁷ provided preliminary evidence that self-paced, technology-delivered mindfulness training could fill this gap because of the greater accessibility and lower intensity. Even though the traditional in-person programs such as MBSR or MBSR may be considered the "gold standard," if participants cannot adhere to

the program, it is unlikely the intervention will result in beneficial outcomes for patients. Our study participants greatly appreciated the ease of using the mobile application, especially during blocks of time when they might otherwise be unoccupied and anxious, such as time spent in waiting rooms to see their oncologists and while receiving chemotherapy infusions.

Second, our study differs from previous studies because we also included informal caregivers of the cancer patients.⁵⁸⁻⁶¹ Even though it is known that caregivers of patients with cancer sometimes report greater distress than the patients themselves,⁶² overburdened caregivers seldom seek mental health care to promote emotional well-being, and clinical support is seldom offered.⁶²⁻⁶⁴ Higher distress may lead to poorer health among caregivers, reducing their ability to effectively provide care for the patients.^{65,66} Given the significant reciprocal emotional relationship between caregivers and patients, it is imperative to offer caregivers psychosocial and educational support to improve their own QoL and physical and mental health.⁶⁷

Third, our sample population included a diverse group of patients: we successfully recruited men, non-whites, and patients with different types of cancer; 30% of patients were male, 31% were non-white, and over 60% of patients had cancers other than breast cancer. This may be at least partially because of KPNC's diverse membership, but it could also be due to the greater accessibility of an mHealth mindfulness intervention. Ongoing treatment and concerns about the disease course itself cause substantial distress for both patients of advanced cancer and their loved ones, and these populations have been comparatively understudied.^{1-3,68} Because previous in-person mindfulness studies primarily included white females with early-stage breast cancer, little is known regarding the efficacy of mindfulness interventions for males, non-whites, or those with cancers other than breast or advanced stage diseases. A recent study reported that many Americans suffering from depression, stress, or anxiety prefer internet-based mindfulness training compared with in-person sessions.^{31,32} Our mHealth delivery of the mindfulness intervention may have helped recruit some of these understudied populations because of greater accessibility and the private nature of the program. Mobile applications are also more interactive and easier to use than CDs or MP3s, which previous self-paced mindfulness studies used.⁵⁷

Last, although this study was not powered to examine dose-effect or mediation, our data suggested that those who adhered to the mindfulness intervention experienced greater benefits than those who had lower adherence. Future studies may aim to increase adherence to achieve greater efficacy of the intervention and to examine this potential dose-effect relationship in more detail. Regarding the role of mindfulness, we only observed significant improvement in mindfulness (observing) in caregivers. In the patients, the associations were of borderline significance, though still suggesting that improvement in mindfulness may mediate the association between the intervention and the outcomes. It is possible that we did not observe significant change in mindfulness measures because patients' baseline mindfulness was high. We conducted a subanalysis using only patients with low mindfulness (below median) and saw significant improvements in the FFMQ describing ($P = .022$) and nonreactivity ($P = .018$) scores. A larger study to formally test the mechanism is warranted.

Several limitations should be considered. First, because this study was conducted within a large integrated health care delivery system where everyone had access to health care, the rate of access to a mobile device or the internet may be higher than in the general population. However, mobile devices and the internet are increasingly used by all segments of the population, including those in lower socioeconomic status and minority populations.⁶⁹ Second, we used a usual-care control group instead of a time- and attention-matched or active control group. Active control utilizes an intervention that mimics the theoretically inactive elements (eg,

placebo) but not the active elements of the intervention of interest.⁷⁰ Although placebo controls are perfectly appropriate for pharmaceutical trials, many active-control group options are not appropriate for mind-body research because there are rarely obvious placebo or "sham" interventions that mimic mindfulness.⁷¹ Even when a satisfactory placebo exists, employing usual-care controls would be of great value for pragmatic trials evaluating treatments to improve clinical care.⁷² A final limitation is that rather than having 2 researchers independently code the post-intervention interview transcripts, we had one person primarily coding, with another investigator verifying the assigned codes, which may increase the risk of bias in the results.

Conclusions

Despite these limitations, our study provides encouraging preliminary evidence regarding the feasibility of conducting a randomized clinical trial using a commercially available self-paced mindfulness program for cancer patients undergoing or who have recently completed chemotherapy. Unlike in-person mindfulness programs, mHealth programs do not require health care delivery systems to hire teachers or secure physical locations for classes. Such benefits make mHealth mindfulness programs widely scalable and cost-effective. This easy access to support for psychosocial distress benefits patients with cancer, caregivers, and providers, especially those in remote locations. Fully powered trials are needed to establish the efficacy of the intervention.

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Supplemental Material

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