BMJ Open

Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-073251
Article Type:	Original research
Date Submitted by the Author:	27-Feb-2023
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Keywords:	Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, REHABILITATION MEDICINE, QUALITATIVE RESEARCH

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Title

Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

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Running Head

Lung Cancer Survivors' Views on Telerehabilitation

MeSH

Telemedicine, survivorship, rehabilitation, exercise, veterans' health

ABSTRACT *(296 words)*

Objectives: To inform personalized home-based rehabilitation interventions that will improve health-related quality of life, we sought to gain in-depth understanding of lung cancer survivors' 1) attitudes and perceived self-efficacy towards telemedicine; 2) knowledge of the benefits of rehabilitation and exercise training; 3) perceived facilitators and preferences for telerehabilitation; and 4) health goals following curative intent therapy.

Design: We conducted semi-structured interviews guided by the Social Cognitive Theory and used directed content analysis to identify salient themes.

Setting: A single U.S. Veterans Affairs Medical Center.

Participants: We enrolled 20 stage I-IIIA lung cancer survivors who completed curative intent therapy in the prior one to six months.

Results: Participants viewed telemedicine as convenient, however impersonal and technologically challenging, with most reporting low self-efficacy in their ability to use technology. Most reported little to no knowledge of the potential benefits of specific exercise training regimens, including those directed towards reducing dyspnea, fatigue, or falls. If they were to design their own telerehabilitation program, participants had a predominant preference for live and one-on-one interaction with a therapist, to enhance therapeutic relationship and ensure correct learning of the training techniques. Most participants had trouble stating their explicit health goals, with many having questions or concerns about their lung cancer status. Some wanted better control of symptoms and functional challenges or engage in healthful behaviors.

Conclusions: Features of telerehabilitation interventions for lung cancer survivors following curative intent therapy may need to include strategies to improve self-efficacy and skills with telemedicine. Education to improve knowledge of the benefits of rehabilitation and exercise training, with alignment to patient formulated goals, may increase uptake. Lung cancer survivors preferred exercise training with live and one-on-one therapist interaction, which may enhance learning, adherence, and completion. Future work should determine how to incorporate these features into telerehabilitation programs.

Strengths and limitations of this study

- A contemporary sample of lung cancer survivors within six months of curative intent therapy.
- Use of the Social Cognitive Theory to guide study design, analysis, and interpretation, enhancing transferability.
- In-depth illustrations of participants' views, with almost all of participants having had experience with telemedicine, enhancing credibility.
- Absence of subgroup comparisons to better understand health goals and fear about lung cancer status.
- Feasibility and acceptability of telerehabilitation intervention not evaluated.

Text

INTRODUCTION

Lung cancer is the second-most frequently diagnosed cancer in the United States (U.S.)[1] and the world.[2] In the U.S., forty to 50% of lung cancers are diagnosed at stage I-IIIA,[3,4] most of which are eligible for curative intent therapy through a combination of surgery, definitive radiation, and/or concurrent chemoradiation, with or without neo-/adjuvant therapy.[5,6] The number of lung cancer survivors eligible for curative intent therapy is expected to increase alongside efforts to improve lung cancer screening uptake[7] to reduce lung cancer mortality,[8] and additional advances in diagnostic[9,10] and therapeutic modalities[11-15] to improve lung cancer survival rates beyond those significantly-made in the past two decades.[16] Following curative intent therapy, many survivors (i.e., anyone living with or beyond a lung cancer diagnosis) experience significant symptom burden,[17] impairments in physical and psychological function,[18] disability,[19] and poor health-related quality of life.[20] As such, approaches are needed to improve these survivorship outcomes.[21]

Exercise training and rehabilitation for lung cancer survivors following surgical treatment increase exercise capacity and may improve physical function and symptom control.[22,23] However, there is a need for home-based interventions, particularly with personalization,[23] to increase uptake, adherence, and completion. Telerehabilitation is an emergent model to increase uptake and completion of rehabilitation services.[24] Little is known about lung cancer survivors' views on telerehabilitation following curative intent therapy to personalize interventions and better meet their needs.

Therefore, we conducted this formative qualitative study to gain in-depth understanding of lung cancer survivors' views on telerehabilitation following curative intent therapy. Our research questions were: What are lung cancer survivors' 1) attitudes and perceived self-

efficacy towards telemedicine; 2) knowledge of the benefits of rehabilitation and exercise training; 3) perceived facilitators and preferences towards telerehabilitation; and 4) health goals following curative intent therapy.

METHODS

Context & Sampling: Between April and October 2022, we recruited lung cancer survivors who received care at the Rocky Mountain Regional Veterans Affairs Medical Center (RMR VAMC). The RMR VAMC is a hub site for the Lung Precision Oncology Program, providing lung cancer care for U.S. veterans from Eastern and Western Colorado, Wyoming, and Montana. We obtained verbal informed consent from all participants. We estimated that 20 participants would be needed to identify salient themes to answer our research questions. The Colorado Multiple Institutional Review Board approved this study (21-4701). We followed the Standards for Reporting Qualitative Research recommendations[25] to report this study.

We recruited patients from: 1) pulmonary nodule conference and clinic; 2) scheduled bronchoscopies for suspected or diagnosed lung cancer; 3) thoracic surgery clinic; and 4) multi-disciplinary tumor board. We enrolled veterans with stage I-IIIA lung cancer who completed the primary mode of curative intent therapy (i.e., surgical resection, definitive radiation, or concurrent chemoradiation) in the prior one to six months. We excluded patients with severe cardiopulmonary disease (i.e., heart failure with reduced ejection fraction < 25% or any condition requiring > 6 liters/minute of supplemental oxygen), any neurologic (e.g., dementia) or psychiatric disorders (e.g., psychosis) precluding informed consent, or with an estimated life expectancy < six months.

Researcher Characteristic: Three researchers (DMH, MAN, RPK) conducted semi-structured interviews, coding, and data analysis. No researcher self-identified as a lung cancer survivor, veteran, or as having strong views on telemedicine.

Qualitative Approach: We used a formative qualitative research approach[26,27] to explore lung cancer survivors' views prior to conducting a telerehabilitation intervention, guided by the Social Cognitive Theory (SCT).[28] The SCT postulates that knowledge of health risks and benefits initiates the process of possible behavior change, with behavior influenced by 1) perceived self-efficacy, 2) facilitators and impediments, 3) outcome expectations, and 4) goals (E-Figure 1).[28] The SCT has been applied to increase physical activity among cancer survivors[29] with moderate and sustained effects.[30] We adapted the SCT (with modifications in parentheses) to gain in-depth understanding of lung cancer survivors' 1) (attitudes and) perceived self-efficacy towards telemedicine; 2) (knowledge of accurate) outcome expectations (e.g., benefits) of rehabilitation and exercise training; 3) perceived facilitators (and preferences) towards telerehabilitation; and 4) health goals following curative intent therapy (E-Figure 1).

Data Collection & Processing: We developed interview questions guided by the SCT, with additional questions on posttreatment experience, sociodemographic characteristics, home internet access, and patient-reported measures on health literacy and frailty (E-Table 1). We conducted and audio-recorded semi-structured interviews using Microsoft Teams® (Microsoft Corporation). We transcribed interviews verbatim, sixteen of which were with institutionally-approved professional transcription services, and four with Microsoft Teams® transcription. Following each interview, we used a debrief guide (E-Table 2) to reflect and document feelings on how the interviews went, what was heard, and potential codes.

Data Analysis: We used directed content[31] and primarily deductive[32] qualitative data analysis guided by the SCT. We developed codes *a priori* based on our research and interview questions, along with a list of operational definitions of terminologies to guide analysis and

interpretation, including to distinguish “telerehabilitation” (i.e., the delivery of therapeutic rehabilitation at a distance or offsite using telecommunications technologies) from “telemedicine” (i.e., the delivery of health services via remote telecommunications) (E-Table 3). We first conducted team-based coding, with all three researchers coding the same transcript. After discussion of this transcript, we agreed on codes and thereafter, conducted individual coding. We merged all coded transcripts and queried transcripts using codes mapped to our interview guide and research questions. To identify themes,[33] we reviewed codes across and within transcripts, conducted weekly team meetings to discuss and obtain consensus, and identify illustrative quotes reflective of themes. We additionally used a cancer survivorship care framework (on cancer recurrence, physical and psychosocial effects of cancer and treatment, chronic conditions, and health promotion and disease prevention)[34] to consolidate findings on health goals. For analyses, we used ATLAS.ti-22 (ATLAS.ti GmbH).

After analysis of 20 transcripts, we assessed thematic saturation,[35] and with a base size of four themes (centered around SCT constructs) and run length of two (potential) additional interviews, we decided there was a very low probability of acquiring new meaningful information, particularly with themes defined as prevalent among half of participants.[33]

Patient and Public Involvement: This study involved semi-structured interviews with patients, but neither the patients nor the public were involved in the design, conduct, reporting, or dissemination plans of this research.

RESULTS

We identified 31 stage I-IIIA lung cancer survivors, excluded two (due to patient preference of not undergoing lung cancer treatment), with five patients unable to be reached within the eligibility period; three declined enrollment due to hearing difficulties, and another reported

competing priorities. Among 20 participants enrolled (Table 1), 85% had prior experience with telemedicine. The median interview duration was 37 (range 19-46) minutes. We identified four salient themes to describe lung cancer survivors' views on telerehabilitation following curative intent therapy: 1) telemedicine is convenient, however impersonal and technologically challenging, with most perceiving low self-efficacy towards telemedicine; 2) limited knowledge of the benefits of rehabilitation and exercise training; 3) live therapist interaction as a facilitator and a predominant preference for one-on-one over group telerehabilitation; and 4) somewhat poorly formulated and no predominant health goals following curative intent therapy, with common questions and concerns about lung cancer status.

1) Telemedicine is convenient (Table 2A), however impersonal (Table 2B) and technologically challenging (Table 2C), with most reporting low perceived self-efficacy towards telemedicine.

Many participants viewed telemedicine as convenient, less time consuming, and easier to access: "I actually think [my doctor and I] accomplish more in a small[er] amount of time because of the fact I didn't have to drive [to the medical center], wait until…my turn, then get in [the medical office] and tell the doctor everything [was] alright. I enjoy [telemedicine]…I think it's great" (Participant-18). Others viewed telemedicine as a solution to overcome distance barriers: "[I think telemedicine] is a great way [to receive health care]. It saves…time, gas, and travel expenses […] (Participant-7). However, many participants also voiced concerns about the impersonality of remote care, preferring live and in-person contact to develop a therapeutic relationship: "I don't like [telemedicine]…[when] people talk to me, I want to see their eyes. I want to hear…from them [in person], not out of the television screen" (Participant-6). Some were reluctant to receive care remotely: "I'm…old-fashioned. I like person-to-person [visits] with a doctor […]" (Participant-2). Most participants voiced concerns about their ability to use

technology to access health care, with several reporting being not 'tech savvy': "I…got this smartphone…about two years ago. I'm still trying to figure out how to use [it], and setting up that video connect (software platform for telemedicine visits at RMR VAMC) call…I didn't have a clue how to do that" (Participant-7); and others simply not wanting to use telemedicine: "I'd rather do it (receive care) in person. I'm not very technical" (Participant-15).

2) Limited knowledge of potential benefits of rehabilitation and exercise training (Table 3A).

Most participants reported no knowledge of the types of exercises or how they could improve health following lung cancer treatment: "I have no knowledge at all" (Participant-3). There was also limited knowledge of exercise training regimens to address specific symptoms or impairments: "I wasn't even aware that there was an exercise you could do to deal with [shortness of breath]" (Participant-7); and "I don't know much about [the specific types of exercises] that would help with shortness of breath, fatigue, or falls" (Participant-18). Among those who received lung cancer resection surgery, a few recalled their hospital discharge instructions on the importance of physical activity to prevent respiratory symptoms: '[to walk] at a good [and] calm pace…around the block [so that] phlegm [wouldn't] build up in [the] lungs' (Participant-20). Others drew from common knowledge: "[Exercise] keeps you healthy, except for cancer; it doesn't do anything to alleviate cancer" (Participant-17); or, when asked about reasons why they engaged in exercise – the benefits they experienced: "[I exercise] for state of mind" (Participant-4), "to maintain what I have" (Participant-15); or their beliefs about it: "If I… don't move around…eventually I'm [going to] die…[sitting] on the couch" (Participant-7).

Moreover, most participants viewed rehabilitation as primarily to improve physical health, to "make [one's] body better" (Participant-11), or "get back to…as good a shape [as] before"

(Participant-5). Most equated the terms “rehabilitation” or “rehab” as physical, not psychological (i.e., for substance use disorder) rehabilitation. In addition, all reported neutral to positive views, with no participant raising concerns about the terms “rehabilitation” or “rehab” being negative or stigmatizing. These views were true even in the context of substance use: “[To me these terms are generally] positive…especially physically…with the drug situation, it’s a harder nut to crack…but both of them are beneficial” (Participant-17) (Table 3B).

3) Live interaction with a therapist as a perceived facilitator (Table 4A) and a predominant preference for one-on-one over group-based telerehabilitation (Table 4B).

There was a predominant preference for live and one-on-one rehabilitation, with many participants raising concerns about learning the correct training techniques: “[Telerehabilitation] takes away the hands-on…you get better understanding of what the therapist…is trying to tell you…when you…get hands-on treatment…they show you what to do” (Participant-16). Participants were open to telerehabilitation if there were live therapist interaction to ensure they were learning the correct training techniques: “I think [live interaction] is [very] important, so [that] I can find out if I am even doing [the exercises] right” (Participant-3). Participants also viewed that live interaction would help them stay motivated and accountable: “as long [as] I was being viewed [I would be willing to participate]…I wouldn't want [a situation] where I was telling [the therapist] I was doing something, and I wasn't. [I want] accountability” (Participant-8). In addition, live and one-on-one therapy was viewed as enhancing communication: “I would prefer one-on-one…it makes it a little easier…to communicate back and forth. If you’ve got six people…and they’re all asking different questions, it’s a little hard” (Participant-7). Another facilitator was readiness to engage in exercise training, with several participants reported being “reasonably ready” to “very ready,” particularly among those with little to no significant health issues posttreatment (Participants-2/3/7/8/9). A few were open to group-based telerehabilitation

with therapist interaction: “Live interaction, that would be great. Either one-on-one or in a group [is fine]) (Participant-17).

4a) Somewhat poorly formulated and no predominant health goal within 1-6 months following curative intent therapy, with common questions or concerns about lung cancer status (Table 5A).

When asked about their health goals in the next few months and beyond, most participants had trouble verbalizing their explicit health goals, with some simply stating to “stay healthy” (Participants-4/17) or “alive” (Participants-15/19), while others reporting that health goals were “not something [they]…[thought] about” (Participant-5), or that they “[had] none (health goals)” (Participant-6). A common concern participants voiced was uncertainty about their lung cancer status. Many reported being in a state of waiting for the next computed tomography (CT) scan to determine if their lung cancer were in remission: “I guess they kind of left me hanging. I don’t know if I still have [lung cancer] or if [the treatment] worked…I won’t get another CT scan until October, so I really don’t know what my situation is” (Participant-9). Some expressed fear about treatment failure:

> ‘They’re [going to] do a CT scan on me on the first [of the month], and we’ll be able to determine then whether or not they’ve got it – the cancer beat or not. Personally, it makes me wonder if the radiation…has done any good…if I’m [going to] be terminal or are they [going to] cure this thing [...]. You’re kind of out here in no man’s land, and until we get the CT scan back…we just don’t know for sure’ (Participant-13).

4b-i) Physical and psychosocial functioning, and comorbid conditions: While most participants lacked explicit health goals, some expressed wanting control of symptoms and functional challenges: “I would like to be able to walk better, have more energy, and breathe

better" (Participant-3). Another participant reported wanting to have "more control over [his] breathing," to "get rid of the swelling in the feet," get back to "[doing] the things [he] enjoyed doing," and have "better [physical] stability at work" (Participant-2). Some also reported wanting to address specific conditions beyond lung cancer: "[My health goals are to] basically start working on the other things that are wrong with me, like managing the COPD (chronic obstructive pulmonary disease) better" (Participant-18). One participant reported sequential goals: "I'd like to get a clean bill of health on my cancer for one…and then get my knee taken care of (replaced), and [then] I can get out and exercise" (Participant-16) (Table 5B-i).

(4b-ii) Health promotion and disease prevention: Some participants spoke about maintaining an active lifestyle: "Three days a week…I go over to the YMCA and play pickleball […]. I think it's important…to keep exercising" (Participant-1). Others spoke about positive changes: "I'd like to be able to quit smoking. I'd like to be more [physically] active than I am" (Participant-9); or "see if I can [quit smoking] and lose some weight" (Participant-15). Some also reported having survived lung cancer as a reason for change: "Because I had lung cancer…I feel like I need the exercise more" (Participant-13), and with another participant, to return to previous behavior: "this [lung cancer]…has kind of forced me to go back to using the bicycle four or five times a week" (Participant-11). One participant wanted to reduce substance use: "I'm trying to cut down on the alcohol use" (Participant-7); and another, improve sleep: "I need to work on my sleep habits […]. I get up [in the morning] and I go back to sleep" (Participant-8) (Table 5B-ii).

DISCUSSION

In this study, we found that lung cancer survivors perceived telemedicine as convenient, however impersonal and technologically challenging, with most reporting low self-efficacy in their ability to use technology to access health care. Almost all had little to no knowledge of the

potential benefits of specific exercise training regimens to reduce dyspnea, fatigue, or falls. If they were able to design their own telerehabilitation program, participants strongly preferred live and one-on-one interaction with a therapist to enhance therapeutic relationship and ensure correct learning of the exercise training regimens. Participants were often unable to formulate health goals, with many having questions or concerns about their lung cancer status. These findings have important implications in the design of telerehabilitation interventions to improve the physical and psychological function of lung cancer survivors following curative intent therapy.

The contrasting views on telemedicine we identified are similar to a previous meta-synthesis of qualitative studies, in which adult cancer survivors identified the convenience and burden of telemedicine interventions.[36] Similar to our findings, a meta-synthesis reported that while telemedicine enabled survivors to feel more connected with clinicians, many also perceived it as impersonal.[36] These contrasting views have been described in systematic reviews involving patients with COPD,[37] cardiovascular disease,[38] and care across different healthcare settings,[39] and may reflect subgroup or individual perspectives, or differences in context (e.g., telemedicine modality, purpose).

There is paucity of knowledge on lung cancer survivors' views on telemedicine to deliver rehabilitation services (i.e., telerehabilitation) following curative intent therapy. One study with lung cancer survivors within two years of surgical resection found that approximately half were willing to use a prototype, web-based exercise program, with higher perceived acceptance of a mobile-based symptom and activity monitoring system.[40] Another study of stage I-IIIA lung cancer survivors' perspectives on a prototype mindfulness-based mobile application identified convenience and potential health benefits as attractive features, with concerns also raised about technological challenges and absence of live therapist interaction.[41] The predominant preference for live and one-on-one telerehabilitation we identified contrasts with previous

studies reporting varied preferences on physical activity programming,[42-45] possibly due to the telerehabilitation context, shorter time since treatment completion, patient cultural, and/or organizational characteristics. The importance of supervision by an exercise or physiotherapy professional for training has been reported, albeit not in the telerehabilitation context[42,43,46] or exclusively involving lung cancer survivors.[47]

Lung cancer survivors in our study also had limited knowledge regarding the role of exercise training regimens to address specific symptom or functional challenges, including shortness of breath, fatigue, or falls, all of which are highly-prevalent and important to stage I-III survivors.[48] Moreover, most patients equated rehabilitation as a strategy to improve physical, not psychological function. This view is in contrast with the definition and intention of "pulmonary rehabilitation" – "a comprehensive intervention…designed to improve the physical and psychological condition of people with chronic lung disease…"[49] – and could reflect low accessibility or utilization of pulmonary rehabilitation services. In addition, patients in our study had no concern about the terms "rehabilitation" or "rehab" being negative or stigmatizing. These positive-to-neutral views are in contrast to a prior editorial[50] reporting that patients with COPD voiced concerns about "rehab," due to common media stories of popular television personalities undergoing treatment for substance use disorders. These findings have important implications on the proper messaging related to rehabilitation services.

Many survivors in our study had questions or concerns about their lung cancer status, with some understandably fearing treatment failure. Fear of cancer recurrence – common among cancer survivors[51] including among those without comorbid psychiatric disorders[52] – has been associated with lower engagement in healthful behaviors,[53] higher physical and psychological impairment,[54] and increased healthcare utilization.[55] These findings suggest that, following curative intent therapy and prior to the guideline-recommended, six-month interval, surveillant chest CT,[21] strategies to manage worry or fear of treatment failure or cancer

recurrence[56] may also be needed. Such strategy could be delivered concurrently or sequentially,[57] depending on patient needs,[58] to arrive at multi-targeted rehabilitation.[59]

The perceived low self-efficacy towards telemedicine suggests that hybrid strategies of remotely-delivered and in-person rehabilitation may be needed to enhance therapeutic relationships and ensure delivery of essential components (i.e., exercise training, education, and behavioral support).[24,49] Education could enhance knowledge or learning about the potential benefits of exercise training regimens on impairments (e.g., inspiratory muscle training to alleviate dyspnea)[60] and self-management skills.[61] Behavior change support may incorporate techniques that align with the SCT (e.g., formulate goals).[30] Psychological interventions to reduce worry or fear may also be beneficial.

Strengths and limitations

Strengths of our study include trustworthiness: we developed codes *a priori* and used multiple interviewers and coders (enhancing dependability); provided in-depth illustrations of participants' views, with almost all of participants having had experience with telemedicine (credibility); and adapted the SCT to guide study design, analysis, and interpretation (transferability). Additional strengths include a real-world and contemporary sample of lung cancer survivors within six months of curative intent therapy, providing valuable insights into this unique patient population at an often-overlooked period, with implications to improve downstream survivorship outcomes.

Our study is limited by the absence of subgroup comparisons (e.g., by age, upstream time from possible to diagnosed lung cancer, prior life-threatening diagnoses including another cancer), with limited time elapsed posttreatment, precluding definitive conclusions on worry or fear. In addition, we did not use other theoretical frameworks nor conduct longitudinal

interviews, which may be important to inform intervention design. Further, we included participants from a single U.S. Veterans Affairs Medical Center, most of whom were male, with significant cigarette smoking, and comorbid COPD, limiting transferability. Last, we do not know the feasibility or acceptability of a telerehabilitation intervention in this population.

CONCLUSION

Features of telerehabilitation interventions for lung cancer survivors following curative intent therapy may need to include strategies to improve self-efficacy and skills in telemedicine. Education to improve knowledge of potential benefits of rehabilitation and exercise training may increase uptake. Exercise training with live therapist interaction, to target specific symptoms, physical and psychological impairments, and/or facilitate comorbidity control, with alignment to patient formulated goals, may enhance learning, adherence, and completion. Future work should determine how to incorporate these features into telerehabilitation programs.

Author Contributions

DMH, MAN, RPK, and LMH contributed substantially to the study design, data analysis and interpretation, writing, and/or final approval of the manuscript. DBB, MLN, SKR, JES-L, JLS, AVP, and RLK contributed substantially to the study design, interpretation, writing, and/or final approval of the manuscript.

Competing interest

All authors declare that no competing interest exists.

Funding

This work was directly supported by Career Development Award (1IK2RX003661, PI Ha) from the United States (U.S.) Department of Veterans Affairs, Rehabilitation Research and Development Service. Dr Ha is also supported by the American Lung Association Lung Cancer Discovery Award (820773). The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs, the U.S. government, or the American Lung Association. The following authors were employed (job title) at the Rocky Mountain Regional Veterans Affairs Medical Center, Aurora, Colorado: DMH, DBB, MLN, SKR (Staff Physician/Surgeon); RLK (Associate Chief of Staff, Research Service); MAN and RPK (Health Sciences Specialist); LMH (Health Research Scientist); and JES-L (GRECC Researcher). DMH, LMH, DBB, MLN, SKR, JSL, JES-L, AVP, and RLK also hold academic appointments at the University of Colorado School of Medicine.

Data Availability Statement

Not applicable – this study is not a clinical trial and does not meet requirements for data sharing per *Tier 2* journal policy.

Abbreviations

COPD = chronic obstructive pulmonary disease; CT = computed tomography; FEV_1 = forced expiratory volume in one second; FVC = forced vital capacity; OSA = obstructive sleep apnea; SBRT = stereotactic body radiotherapy; RMR VAMC = Rocky Mountain Regional Veterans Affairs Medical Center; SCT = Social Cognitive Theory; SD = standard deviation

Tables

Table 1: Participant Characteristics

Characteristic (N=20)	Value
Age, *years*, mean (SD)	71.2 (5.5)
Age ≥ 65 years, *%*	80
Male sex, *%*	90
White, non-Hispanic, *%*	95
Married marital status, *%*	65
College education or higher, *%*	65
Employed status, *%*	10
Marginal or limited health literacy (BRIEF scale), *%*	40
Frail status (FRAIL scale), *%*	40
Home access to internet, *%*	85
Rural living environment*, *%*	25
Prior experience with telemedicine†, *%*	85
Smoking status, *%*	
Current	45
Former	55
Comorbidities, *%*	
COPD‡	90
Oxygen therapy (1-6 liters/minute)	40
OSA	25
Psychiatric illness§	40
Lung cancer characteristics, *%*	
Screen-detected	35
Adenocarcinoma‖/squamous/small-cell/presumed	60/25/5/10
Collaborative stage IA/IIA/IIIA	75/10/15
Curative intent therapy modality, *%*	
Surgical resection¶	40
SBRT	40
Chemoradiation	20
Time since primary treatment completion, months, median (range)	2 (1-6)

**Defined by the Veterans Health Administration Office of Rural Health (i.e., areas with < 30% of the population residing in an urbanized area) using zip code of residence.*
†Via telephone or video visits.
‡Defined as post-bronchodilator FEV_1/FVC < 70%.
§Defined as clinically diagnosed depression, anxiety, post-traumatic stress disorder, bipolar, or schizophrenia.
‖Including 1 case of adeno-squamous carcinoma.
¶Of which 6 were lobectomies and 2 sub-lobar (1 segmentectomy; 1 wedge) resections.

COPD = chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in one second; FVC = forced vital capacity; OSA = obstructive sleep apnea; SBRT = stereotactic body radiotherapy; SD = standard deviation

Table 2: Attitudes and Perceived Self-Efficacy Towards Telemedicine

Illustrative Quotes	Participant ID
(A) Telemedicine is convenient	
"It's nice to have a [telemedicine visit], talk about things and not have to worry about showing up somewhere…100-and-some miles away. I think [telemedicine is very] darn convenient."	Participant 7
"I think [telemedicine] is a good idea. Some people…come in-person to see an actual physician, but if they can see [the physician] on the phone, talk to [him or her remotely], I think it works out great."	Participant 2
"Some appointments…have to be physical, but unless [the doctor's] physical presence is required, I'm going to, as much as possible, work on video appointments."	Participant 12
"I think [telemedicine] is a great idea…it keeps everybody safer [because] people aren't driving to the hospital sick…to go in for a meeting [with a clinician]."	Participant 18
"I think [telemedicine] would be a lot more convenient, rather than having to go to a building [for in-person visits]."	Participant 13
(B) Telemedicine is impersonal	
"Depending on the [health] issues…you have to [be in person] to see what's going on. You can't listen to breathing over [the] internet [or] phone…I'd rather have a one-to-one in-person appointment."	Participant 2
"I like the face-to-face [visits]. When it comes to issues like what I have, I want face-to-face [visits]. I want to feel comfortable with who I'm talking to…[telemedicine] is too cold and sterile."	Participant 17
"[I've had experience with telemedicine (video and telephone)], and I think that the video takes away [the hands-on interaction]. In-person visits [are] better."	Participant 16
"I'd rather go physically [for my appointments] and have them talk to my face."	Participant 20
"I've talked to my heart doctor now and again about changing my medicine [over the phone]. But that's about it [regarding my experience with telemedicine]. Otherwise, I go to the VA [physically for my appointments]. I'm very happy with the VA. I'd rather [have my visits] in-person."	Participant 15
"[I am hesitant to use telemedicine]. I like the one-on-one health experiences."	Participant 10
(C) Telemedicine is technologically challenging	
"[I've had experience with remote care] a couple of times…with video, and as far as the technology, I had a [heck] of a time with it. I had to actually go into the VA and have the nurse show me how to do it because I'm not really [technical]."	Participant 7
"[I've received care remotely], via video…[but at times needed] to use the telephone]. I'm just not computer literate […]. I did get a tablet from the VA [for remote care]…but now I don't know my password. I forgot it."	Participant 3
"[I've not received remote care via video because] I'm not too computer savvy."	Participant 9

“My computer skills are limited…I would have to have hands-on teaching [to have video visits].”	Participant 8
“[I anticipate that with video visits, I would have] my standard problems (with the software) and beat[ing] my head against the wall trying to get it going, but I’ll get it going if I need to.”	Participant 11
“I don’t know how to use the computers. I’m challenged with the computer …[I would be more comfortable with video visits if] somebody [could] walk [me] through it, like over the phone.”	Participant 5
“[I’ve received care remotely], over the phone…I’m probably not as versed as most people [with video visits]. [For video visits,] I [would] get my daughter over here and help me, maybe.”	Participant 10

Table 3: Knowledge of Benefits of Rehabilitation and Exercise Training

Illustrative Quotes	Participant ID
(A) Limited knowledge of benefits of rehabilitation/exercise training	
"You're talking in strange territory there [about the types of exercises or how to do them]. I've had no instructions whatsoever…other than the spirometer. About breathing exercises or any of that stuff, I just haven't had any [instructions]."	Participant 1
"I really don't have any [understanding of the types of exercises and how they can or cannot help with my health]."	Participant 9
"The only [type of exercise] I can think of is cardio […]. Rehab [for me has to] have something to exercise the lungs […]. If there were exercises that would help me with my falls, yeah [I'd also be interested to learn]; I've got scars all over my face."	Participant 17
"I really learned to exercise in the Army. I don't use them all, but I exercise once in a while."	Participant 6
(B) Neutral-to-positive views on rehabilitation	
"I think [of rehabilitation as] a physical therapy thing, not getting over being a drunk [or substance use disorder]…for me, [rehabilitation is] to keep my body working the way it's supposed to be working."	Participant 1
"[Rehabilitation or exercise would help] quite a bit [with my health]. I would feel better. Anytime I exercise it helps me feel better."	Participant 3
"Rehabilitation means…to get yourself better, to work yourself through something to make your life better."	Participant 18
"Rehab would be trying to make my lungs better and techniques to be more comfortable, and hopefully I can deal with the issues from lung cancer much better, like breath control…things that I could use if I start getting short of breath."	Participant 2
"My thing with rehabilitation is if you have a problem, you need to get somebody to help you solve your problem. That's rehabilitation. I don't care if drugs or alcohol, eating disorder, or something, all kinds of stuff out there. People need rehab, they need it."	Participant 6
"To me [rehabilitation is] extremely positive."	Participant 12

Table 4: Perceived Facilitators and Preferences Towards Telerehabilitation

Illustrative Quotes	Participant ID
(A) Live therapist interaction as a facilitator	
"[It is] absolutely important [to have live interaction with a therapist […]. By having [live interaction with] a PT person, [the therapy is] more specifically tailored for me...." "	Participant 12
"[Having live interaction with a therapist is] very important to make sure if I'm doing things the right way, [particularly] if there's some kind of technique or twisting or bending motion."	Participant 2
"[Telerehabilitation] would be fine as long as they could view me while the session was going on…I think it would be very important to [to have live interaction with a therapist]."	Participant 8
"[Having live interaction with a therapist is] the ideal for me."	Participant 6
"If there is not an instructor or something, I probably wouldn't do it."	Participant 3
(B) Predominant preference for one-on-one over group telerehabilitation	
"I prefer one-on-one's. I've always been that way…I'm kind of shy in front of big groups…I don't like being around a lot of people…I feel like everybody is staring at me."	Participant 18
"[My ideal telerehabilitation program] would be face-to-face conference…[one-on-one] if the clinician isn't overworked."	Participant 11
"If you had a bunch of other people [in telerehabilitation together], I'd feel kind of inadequate...I'm not tech savvy."	Participant 13
"I think having one-on-one is probably ideal, but I think you could probably get the same message, especially if it's people that had the same surgery and they're recovering from the same thing, then the group would probably work fine."	Participant 5

Table 5: Health Goals Following Curative Intent Therapy of Lung Cancer

Illustrative Quotes	Participant ID
(A) Common questions or concerns about lung cancer status	
"I'm thinking about [recovering]. I'm [going to] find out…in a couple of weeks whether or not this [radiation treatment] did any good."	Participant 7
"I haven't seen anybody since my treatment. I don't have an appointment… until the 23rd of September…when I go in…to do another CT scan to see if they got all of the cancer […]. Then on the 27th or 29th (of September) [my oncologist] will go ahead and give me the results of the CT scan and let me know, 'hey, it's all gone', or 'hey, there's still something there' or what we're [going to] do next."	Participant 18
"The only concern I have [is about] the lung cancer coming back."	Participant 17
"I'm kind of in a limbo until I know [about my lung cancer status]. And once I know one way or another, what the deal is, I'll remain in limbo. After I find out for sure what's happening [with my lung cancer status], then I can be more [purposeful] as far as what my aspirations are."	Participant 13
"Well, naturally, [my goal is] to improve. Hopefully the radiation…has done its job and taken care of it – the lung cancer that I had, the spot wasn't that big."	Participant 4
"I'm basically doing pretty good right now […]. I just won't know [about my lung cancer status] until July."	Participant 6
(B-i) Physical and psychosocial functioning, comorbidity control	
"I'd like to have better balance [with walking]."	Participant 8
"I'd like to improve my mobility […]. I'm [also] hoping to relieve some pain […]. I walk about 15 minutes and…I'm spent."	Participant 10
"[My goal is to be] able to get around without breathing hard."	Participant 14
"Hopefully the neuropathy will dissipate, and I can go back to doing my needlework (art craft)."	Participant 2
"I'm getting TMS (transcranial magnetic stimulation, an approach to treat anxiety and depression) so I want to finish that."	Participant 3
"I have arthritis; I try to walk one mile every morning."	Participant 15
(B-ii) Health promotion and disease prevention	
"My health goals are to stay healthy […]. I'm 64 years old, and because I've taken care of myself and [have] had plenty of exercise, I'm still pretty healthy."	Participant 17
"I'd like to get out a little bit more […]. I like going to the park but I get a little bit apprehensive to get out and walk too long."	Participant 20
"I'm a smoker, so I'm trying to quit. That's my big goal."	Participant 15
"[My goal is to try] to quit smoking."	Participant 4

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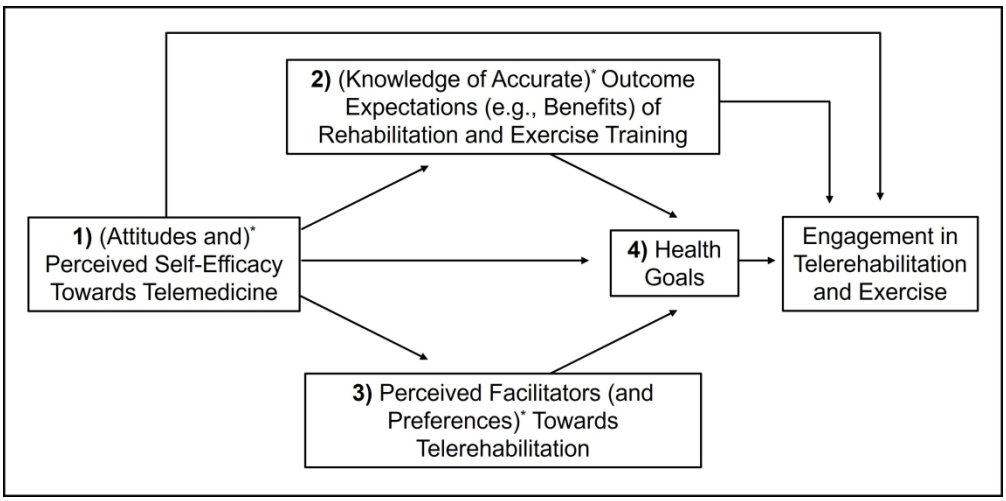

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Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

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ONLINE SUPPLEMENT

E-Figure 1: The Social Cognitive Theory[1] Adapted to Inform Telerehabilitation

*Additional constructs or modifications to the SCT that could influence engagement in telerehabilitation and exercise.

E-Table 1: Semi-structured Interview Questions Guided by the Social Cognitive Theory[1]

Thank you for taking your time to help us with these questions. In this interview, we will ask you about your health goals, knowledge on exercise and rehabilitation, and views on technology. We will also ask you about your level of health literacy, frailty, and basic demographics. These interviews typically take about 30-45 minutes. We will use the results to help design an ideal telerehabilitation program for Veterans who recently completed lung cancer treatment.

(*Opening question*) To begin, we will start with a broad question – When were you diagnosed with lung cancer?

- What treatment did you receive? (surgery, chemo, radiation, etc.)
- When did you complete the treatment? (1-6 months ago)

How has your experience been following lung cancer treatment?

- Have there been any new diagnosis or any new medical issues/concerns following your treatment?

What **heath issues** (new symptoms, new limitations to daily activities/daily life; shortness of breath, poor sleep, or fatigue, neuropathy) have you had to deal with since completing lung cancer treatment? [possible probes: Can you tell me more about…; Can you describe…more?]

- How have symptoms impacted your day-to-day activities, hobbies, or ability to complete tasks?
- Have you had any falls since completing your treatment (related or non-related to treatment)?
- What concerns you most about these health issues that you've had to deal with (since completing lung cancer treatment)?
- What is the most important (health) issue you think we should know about your experience following lung cancer treatment?

Thank you for sharing your experience. Now, we will ask you a few questions about your current and future goals.

What are your **health goals** in the next few months and beyond? [possible probes: Can you describe more about…; Can you explain…more?]

- What are your goals for the next few months to get your life activities to where you would like them to be?
- How are your (health) goals similar or different compared to before your lung cancer treatment? [possible probes: Describe…more for me; Explain…]
- How ready do you feel about taking steps to meet these goals? What are some possible challenges?

What else would you like to add that you think might be important for us to know about your health since you completed lung cancer treatment.

Thank you for sharing with us your health issues and goals. Next, we would like to understand more about your knowledge of exercise and rehabilitation.

What, if any, have you been **told about exercise** after lung cancer treatment? [possible probes: Tell me more about…; Explain…]

- What is your understanding about what types of exercises there are and how they can or cannot help with your health?
- What is your understanding about how much exercise can or cannot help with symptoms we previously discussed (e.g., shortness of breath, poor sleep, or fatigue)?
- What is your understanding about what types of exercises can reduce falls? How are these important to you, if at all?

When clinicians use the word "rehabilitation", what does that mean to you? [possible probes: Tell me more about…; Explain…]

- How is the **meaning of "rehabilitation"** similar or different compared to some of the health services that you may have received in the past, like physical or occupational therapy, or pulmonary or cardiac rehabilitation?
- Sometimes people think that "rehab" or "rehabilitation" is for substance use or abuse; how is the meaning of "rehabilitation" negative, positive, or neutral to you?

How do you **feel rehabilitation and exercise** can help you achieve your health goals, if at all? [possible probes: Can you tell me more about…; Describe…]

- How are your exercise levels different, if at all, after lung cancer treatment?
- What are some reasons why you exercise or not?
- How ready do you feel to participate in rehabilitation and exercise in the next few months?

Thank you sharing these thoughts. Part of the reason why are doing this is to help design a telerehabilitation program for Veterans who recently completed lung cancer treatment. So the next set of questions will ask you about using **technology for health care**.

Recently, a lot of Veterans have had experience receiving care remotely through telephone or video – where you can see a picture on your phone or computer screen. In the VA, this is called VA Video Connect, or VVC.

- Have you received care remotely in VA? Over telephone or video? If you did not do it over video, why is that?
- How comfortable do you feel about using computers and the internet for health care services?
- What are some challenges you expect to have with video technology? What would help you feel more comfortable using it?
- How do you feel about exercise or rehabilitation services delivered remotely using video technology?

Since our goal is to design a telerehabilitation program for Veterans with lung cancer following treatment,

- If you could design your **ideal telerehabilitation program**, what would that look like?

How important is having live interaction with a therapist (and one-on-one or in group setting)? Why or why not?
How do you feel about self-help videos for exercises? How can they help or not?

The next set of questions are surveys. Unlike the previous questions, these next questions do not need detailed or lengthy answers since we can only check the answer options available on the surveys.

This first survey assesses your level of **health literacy**.[2]

1) How often do you have someone help you read hospital materials?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

2) How often do you have problems learning about your medical condition because of difficulty understanding written information?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

3) How often do you have a problem understanding what is told to you about your medical condition?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

4) How confident are you filling out medical forms by yourself?

___Not at all confident (1) ___A little bit (2) ___Somewhat (3) ___Quite a bit (4)

___Extremely confident (5)

This next survey assesses your level of **frailty**.[3]

1) How much of the time during the past 4 weeks did you feel tired?

___All of the time ___Most of the time ___Some of the time ___A little of the time ___None of the time

2) By yourself and not using aids, do you have any difficulty walking up 10 steps without resting?

___Yes ___No

3) By yourself and not using aids, do you have any difficulty walking a couple of blocks (e.g., several hundred yards)?

___Yes ___No

4) Did a doctor ever tell you that you have these illnesses? (*check each illness*)
___hypertension, ___diabetes, ___chronic lung disease, ___heart attack, ___congestive heart failure, ___angina, ___asthma, ___arthritis, ___stroke, and ___kidney disease. How many?
[Total number of illnesses, then add 1 for (lung) cancer]: ____

5) How much do you weigh?____

6) One year ago, how much did you weigh?____

7) Have you been admitted to the hospital in the past 3 months? ___Yes ___No

This last set of questions are on your basic **demographics**.

1) Are you

___Married/living with partner; ___Divorced/separated; ___Widowed; or ___Single/Never married?

2) What is your highest level of education?

___Some high school ___Completed high school ____Some college

____Completed college ___Graduate or doctorate degree

3) What is your employment status?

___Employed (part- or full-time) ___Retired ___Disabled ___Unemployed

4) Do you have access to internet at home? ___Yes ___No

This completes our interview today. Thank you again your time. Please let us know if you have any questions for us?

E-Table 2: Post-Interview Debrief Guide

In general, how did the interview process go? (e.g., how engaged was the participant; how candid were the responses; how was your own comfort level?)

What were the main **health issues** and **health goals** that came up?

- Health Issues:
- Health Goals:

What were participants' **knowledge** on exercise and rehabilitation?

- How was their understanding on the types and roles (purpose) of exercise?
- How did they view and define rehabilitation?
- How did they feel about rehabilitation and exercise?

How did participants feel about using **technology** for health care?

- How did they feel about using technology to access health care?
- How did they feel about using technology for rehabilitation services?
- What were key program designs?

Did anything surprise you?

Did anything **new** come up?

Should we change anything about the interview process?

Should we change anything on the interview guide?

Codes to consider:

E-Table 3: Operational Definitions of Terminologies for Data Analysis and Interpretation

Terminology	Definition
Exercise	Physical activity which is usually regular and done with the intention of improving or maintaining physical fitness or health.[4]
Goal	The end (or result or achievement) toward which effort is directed.[5,6]
Rehabilitation	Restoration of human functions to the maximum degree possible in a person or persons suffering from disease or injury.[7]
Self-efficacy	*General:* 1) Participant's belief about his/her ability to perform actions necessary to produce a given effect [8]; and 2) Participant's perception that he/she can exercise control over his/her health habits.[1] *Specific to this study:* Participant's belief about his/her ability to use technology to access health care.
Telemedicine	The delivery of health services via remote telecommunications.[9]
Telerehabilitation	The delivery of therapeutic rehabilitation at a distance or offsite using telecommunication technologies.[10]

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10. National Library of Medicine - Medical Subject Headings (MeSH): "Telerehabilitation" (https://www.ncbi.nlm.nih.gov/mesh/?term=telerehabilitation).

Standards for Reporting Qualitative Research (SRQR) Checklist

No.	Topic	Item
S1	Title	We provided a concise description of the nature and topic of the study identifying the study as qualitative research.
S2	Abstract	We provided a summary of key elements of the study using the abstract format of the intended publication.
S3	Problem formulation	We provided a description and significant of the problem studied in the Introduction.
S4	Purpose and research question	We described the purpose of the study and specific research questions in the Introduction.
S5	Qualitative approach and research paradigm	We described the qualitative research approach (i.e., informative) and guiding theory (Social Cognitive Theory).
S6	Researcher characteristics and reflexivity	We provided a description of the researcher characteristics.
S7	Context	We described the setting/site and salient contextual factors.
S8	Sampling strategy	We provided description of the sampling of research participants.
S9	Ethical issues pertaining to human subjects	We provided documentation of the approval of the appropriate ethics review board and participant consent.
S10	Data collection methods	We provided description of types of data collection including dates of analysis.
S11	Data collection instruments and technologies	We provided description of the interview guide and technology used for recording.
S12	Units of study	We provided the number and relevant characteristics of the participants.
S13	Data processing	We provided descriptions of methods of processing data prior to analysis including transcription and coding.
S14	Data analysis	We described in detail the process by which themes were identified.
S15	Techniques to enhance trustworthiness	We provided descriptions of techniques that enhanced the trustworthiness of study findings.
S16	Synthesis and interpretation	We described the main findings of salient themes.
S17	Units to empirical data	We provided evidence using illustrative quotes to substantiate analytic findings.
S18	Integration with prior work, implications, transferability, and contribution to the field	We provided detailed integration of study findings to existing literature, discussed transferability, implications, and contribution to the field.
S19	Limitations	We provided descriptions of trustworthiness and limitations of study findings.
S20	Conflicts of interest	We provided a statement of conflict of interest.
S21	Funding	We provided description of funding.

BMJ Open

Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-073251.R1
Article Type:	Original research
Date Submitted by the Author:	16-May-2023
Complete List of Authors:	Ha, Duc; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus Nunnery, Mary; Rocky Mountain Regional VA Medical Center Klocko, Robert; Rocky Mountain Regional VA Medical Center Haverhals, Leah; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus Bekelman, David; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus New, Melissa; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus Randhawa, Simran; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus Stevens-Lapsley, Jennifer; University of Colorado Denver - Anschutz Medical Campus, Physical Medicine & Rehabilitation; Rocky Mountain Regional VA Medical Center Studts, Jamie; University of Colorado Cancer Center; University of Colorado Anschutz Medical Campus Prochazka, Allan; University of Colorado Anschutz Medical Campus Keith, Robert; Rocky Mountain Regional VA Medical Center; University of Colorado Anschutz Medical Campus
Primary Subject Heading:	Oncology
Secondary Subject Heading:	Rehabilitation medicine, Qualitative research, Patient-centred medicine, Respiratory medicine
Keywords:	Telemedicine < BIOTECHNOLOGY & BIOINFORMATICS, REHABILITATION MEDICINE, QUALITATIVE RESEARCH

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Title

Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

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Running Head

Lung Cancer Survivors' Views on Telerehabilitation

MeSH

Telemedicine, survivorship, rehabilitation, exercise, veterans' health

ABSTRACT *(300 words)*

Objectives: To inform personalized home-based rehabilitation interventions, we sought to gain in-depth understanding of lung cancer survivors' 1) attitudes and perceived self-efficacy towards telemedicine; 2) knowledge of the benefits of rehabilitation and exercise training; 3) perceived facilitators and preferences for telerehabilitation; and 4) health goals following curative intent therapy.

Design: We conducted semi-structured interviews guided by Bandura's Social Cognitive Theory and used directed content analysis to identify salient themes.

Setting: One U.S. Veterans Affairs Medical Center.

Participants: We enrolled 20 stage I-IIIA lung cancer survivors who completed curative intent therapy in the prior one to six months. Eighty-five percent of participants had prior experience with telemedicine, but none with telerehabilitation or rehabilitation for lung cancer.

Results: Participants viewed telemedicine as convenient, however impersonal and technologically challenging, with most reporting low self-efficacy in their ability to use technology. Most reported little to no knowledge of the potential benefits of specific exercise training regimens, including those directed towards reducing dyspnea, fatigue, or falls. If they were to design their own telerehabilitation program, participants had a predominant preference for live and one-on-one interaction with a therapist, to enhance therapeutic relationship and ensure correct learning of the training techniques. Most participants had trouble stating their explicit health goals, with many having questions or concerns about their lung cancer status. Some wanted better control of symptoms and functional challenges or engage in healthful behaviors.

Conclusions: Features of telerehabilitation interventions for lung cancer survivors following curative intent therapy may need to include strategies to improve self-efficacy and skills with telemedicine. Education to improve knowledge of the benefits of rehabilitation and exercise training, with alignment to patient formulated goals, may increase uptake. Exercise training with live and one-on-one therapist interaction may enhance learning, adherence, and completion. Future work should determine how to incorporate these features into telerehabilitation.

Strengths and limitations of this study

- A contemporary sample of lung cancer survivors within six months of curative intent therapy.
- Use of Bandura's Social Cognitive Theory to guide study design, analysis, and interpretation, enhancing transferability.
- In-depth illustrations of participants' views, with almost all of participants having had experience with telemedicine, enhancing credibility.
- Absence of subgroup comparisons, including by age, sex, socio-environmental factors, to better understand perceived self-efficacy, facilitators/preferences, health goals, and fear about lung cancer status.
- Feasibility and acceptability of telerehabilitation intervention not evaluated.

Text

INTRODUCTION

Lung cancer is the second-most frequently diagnosed cancer in the United States (U.S.)[1] and the world.[2] In the U.S., forty to 50% of lung cancers are diagnosed at stage I-IIIA,[3,4] most of which are eligible for curative intent therapy through a combination of surgery, definitive radiation, and/or concurrent chemoradiation, with or without neo-/adjuvant therapy.[5,6] The number of lung cancer survivors eligible for curative intent therapy is expected to increase[7] alongside efforts to improve lung cancer screening uptake,[8] additional advances in diagnostic,[9,10] and therapeutic modalities.[11-15] Following curative intent therapy, many survivors (i.e., anyone living with or beyond a lung cancer diagnosis) experience significant symptom burden,[16] impairments in physical and psychological function,[17] disability,[18] and poor health-related quality of life.[19] As such, approaches are needed to improve these survivorship outcomes.[20]

Exercise training and rehabilitation for lung cancer survivors following surgical treatment increase exercise capacity and may improve physical function and symptom control.[21,22] However, there is a need for home-based interventions, particularly with personalization,[22] to increase uptake, adherence, and completion. Telerehabilitation is an emergent model to increase uptake and completion of rehabilitation services.[23] Telerehabilitation has also been used in cancer care to improve adherence and maintain intervention goals.[24] However, little is known about lung cancer survivors' views on telerehabilitation following curative intent therapy, to personalize interventions and better meet their needs.

Therefore, we conducted this formative qualitative study to gain in-depth understanding of lung cancer survivors' views on telerehabilitation following curative intent therapy. Our research questions were: What are lung cancer survivors' 1) attitudes and perceived self-

efficacy towards telemedicine; 2) knowledge of the benefits of rehabilitation and exercise training; 3) perceived facilitators and preferences towards telerehabilitation; and 4) health goals following curative intent therapy.

METHODS

Context & Sampling: Between April and October 2022, we recruited lung cancer survivors who received care at the Rocky Mountain Regional Veterans Affairs Medical Center (RMR VAMC). The RMR VAMC is a hub site for the Lung Precision Oncology Program, providing lung cancer care for U.S. Veterans from Eastern and Western Colorado, Wyoming, and Montana. We obtained verbal informed consent from all participants. The Colorado Multiple Institutional Review Board approved this study (21-4701). We followed the Standards for Reporting Qualitative Research recommendations[25] to report this study.

We recruited patients from: 1) pulmonary nodule conference and clinic; 2) scheduled bronchoscopies for suspected or diagnosed lung cancer; 3) thoracic surgery clinic; and 4) multi-disciplinary tumor board. We enrolled U.S. Veterans with stage I-IIIA lung cancer who completed the primary mode of curative intent therapy (i.e., surgical resection, definitive radiation, or concurrent chemoradiation) in the prior one to six months. We excluded patients with severe cardiopulmonary disease (i.e., heart failure with reduced ejection fraction < 25% or any condition requiring > 6 liters/minute of supplemental oxygen), any neurologic (e.g., dementia) or psychiatric disorders (e.g., psychosis) precluding informed consent, or with an estimated life expectancy < six months.

Researcher Characteristic: Three researchers (DMH, MAN, RPK) conducted semi-structured interviews, coding, and data analysis. DMH is a pulmonologist and physician investigator. MAN

and RPK are health sciences specialists with qualitative research expertise. No researcher self-identified as a lung cancer survivor, Veteran, or as having strong views on telemedicine.

Qualitative Approach: We used a formative qualitative research approach[26,27] to explore lung cancer survivors' views prior to conducting a telerehabilitation intervention, guided by Bandura's Social Cognitive Theory (SCT).[28] The SCT postulates that knowledge of health risks and benefits initiates the process of possible behavior change, with behavior influenced by 1) perceived self-efficacy, 2) facilitators and impediments, 3) outcome expectations, and 4) goals (E-Figure 1).[28] The SCT has been applied to increase physical activity among cancer survivors[29] with moderate and sustained effects.[30] We adapted the SCT (with modifications in parentheses) to gain in-depth understanding of lung cancer survivors' 1) (attitudes and) perceived self-efficacy towards telemedicine; 2) (knowledge of accurate) outcome expectations (e.g., benefits) of rehabilitation and exercise training; 3) perceived facilitators (and preferences) towards telerehabilitation; and 4) health goals following curative intent therapy (E-Figure 1).

Data Collection & Processing: We developed interview questions guided by the SCT, with additional questions on posttreatment experience, sociodemographic characteristics, home internet access, and patient-reported measures on health literacy and frailty (E-Table 1). We also asked about participants' views on the terms "rehabilitation" or "rehab", due to concerns for stigma associated with these terms[31] which may hinder uptake of rehabilitation services. We conducted and audio-recorded semi-structured interviews using Microsoft Teams® (Microsoft Corporation). We transcribed interviews verbatim, sixteen of which with institutionally-approved professional transcription services, and four with Microsoft Teams® transcription. Following each interview, we used a debrief guide (E-Table 2) to reflect and document feelings on how the interviews went, what was heard, and potential codes.

Data Analysis: We used directed content[32] and primarily deductive[33] qualitative data analysis guided by the SCT. We developed codes *a priori* based on our research and interview

questions, along with a list of operational definitions of terminologies to guide analysis and interpretation, including to distinguish "telerehabilitation" (i.e., the delivery of therapeutic rehabilitation at a distance or offsite using telecommunications technologies) from "telemedicine" (i.e., the delivery of health services via remote telecommunications) (E-Table 3). We first conducted team-based coding, with all three researchers coding the same transcript. After discussion of this transcript, we agreed on codes and thereafter, conducted individual coding. We merged all coded transcripts and queried transcripts using codes mapped to our interview guide and research questions. To identify themes,[34] we reviewed codes across and within transcripts, conducted weekly team meetings to discuss and obtain consensus, and identify illustrative quotes reflective of themes. To consolidate findings on health goals, we additionally used a cancer survivorship care framework (on cancer recurrence, physical and psychosocial effects of cancer and treatment, chronic conditions, and health promotion and disease prevention).[35] For analyses, we used ATLAS.ti-22 (ATLAS.ti GmbH).

Sample Size: We estimated that 20 participants would be needed to identify salient themes to answer our four research questions (i.e., on self-efficacy, benefits, facilitehicators/preferences, and health goals). This estimate was based on a suggested range of 20-30 interviews for qualitative inquiry[36] and supported by a systematic analysis of 214 published qualitative studies in which the median sample sizes ranged 15-31 interviews.[37] After analysis of 20 transcripts, we assessed thematic saturation using an evidence-derived approach consisting of three primary elements – Base Size, Run Length, and New Information Threshold.[38] We used a Base Size of four themes (centered around the four SCT constructs), Run Length of two (potential) additional interviews, and decided there was a very low probability of acquiring New Meaningful Information, particularly with themes defined as prevalent among half of participants.[34]

Patient and Public Involvement: This study involved semi-structured interviews with patients, but neither the patients nor the public were involved in the design, conduct, reporting, or dissemination plans of this research.

RESULTS

We identified 31 stage I-IIIA lung cancer survivors, excluded two (due to patient preference of not undergoing lung cancer treatment), with five patients unable to be reached within the eligibility period; three declined enrollment due to hearing difficulties, and another reported competing priorities. Among 20 participants enrolled (Table 1), 85% had prior experience with telemedicine; none participated in a rehabilitation or telerehabilitation program for lung cancer The median (and range) interview duration was 37 (19-46) minutes.

We identified four salient themes to describe lung cancer survivors' views on telerehabilitation following curative intent therapy: 1) telemedicine is convenient, however impersonal and technologically challenging, with most perceiving low self-efficacy towards telemedicine; 2) limited knowledge of the benefits of rehabilitation and exercise training; 3) live therapist interaction as a facilitator and a predominant preference for one-on-one over group telerehabilitation; and 4) somewhat poorly formulated and no predominant health goals following curative intent therapy, with common questions and concerns about lung cancer status.

1) Telemedicine is convenient (Table 2A), however impersonal (Table 2B) and technologically challenging (Table 2C), with most reporting low perceived self-efficacy towards telemedicine.

Many participants viewed telemedicine as convenient, less time consuming, and easier to access: “I actually think [my doctor and I] accomplish more in a small[er] amount of time because of the fact I didn’t have to drive [to the medical center], wait until…my turn, then get in [the medical office] and tell the doctor everything [was] alright. I enjoy [telemedicine]…I think it's great” (Participant 18). Others viewed telemedicine as a solution to overcome distance barriers: “[I think telemedicine] is a great way [to receive health care]. It saves…time, gas, and travel expenses […] (Participant 7). However, many participants also voiced concerns about the impersonality of remote care, preferring live and in-person contact to develop a therapeutic relationship: “I don’t like [telemedicine]…[when] people talk to me, I want to see their eyes. I want to hear…from them [in person], not out of the television screen” (Participant 6). Some were reluctant to receive care remotely: “I’m…old-fashioned. I like person-to-person [visits] with a doctor […]” (Participant 2). Most participants voiced concerns about their ability to use technology to access health care, with several reporting being not ‘tech savvy’: “I…got this smartphone…about two years ago. I’m still trying to figure out how to use [it], and setting up that video connect (software platform for telemedicine visits at RMR VAMC) call…I didn’t have a clue how to do that” (Participant 7); and others simply not wanting to use telemedicine: “I’d rather do it (receive care) in person. I’m not very technical” (Participant 15).

2) Limited knowledge of potential benefits of rehabilitation and exercise training (Table 3A).

Most participants reported no knowledge of the types of exercises or how they could improve health following lung cancer treatment: “I have no knowledge at all” (Participant 3). There was also limited knowledge of exercise training regimens to address specific symptoms or impairments: “I wasn’t even aware that there was an exercise you could do to deal with [shortness of breath]” (Participant 7); and “I don’t know much about [the specific types of

exercises] that would help with shortness of breath, fatigue, or falls" (Participant 18). Among those who received lung cancer resection surgery, a few recalled their hospital discharge instructions on the importance of physical activity to prevent respiratory symptoms: '[to walk] at a good [and] calm pace…around the block [so that] phlegm [wouldn't] build up in [the] lungs' (Participant 20). Others drew from common knowledge: "[Exercise] keeps you healthy, except for cancer; it doesn't do anything to alleviate cancer" (Participant 17); or, when asked about reasons why they engaged in exercise – the benefits they experienced: "[I exercise] for state of mind" (Participant 4), "to maintain what I have" (Participant 15); or their beliefs about it: "If I… don't move around…eventually I'm [going to] die…[sitting] on the couch" (Participant 7).

Moreover, most participants viewed rehabilitation as primarily to improve physical health, to "make [one's] body better" (Participant 11), or "get back to…as good a shape [as] before" (Participant 5). Most equated the terms "rehabilitation" or "rehab" as physical, not psychological (i.e., for substance use disorder) rehabilitation. In addition, all reported neutral to positive views, with no participant raising concerns about the terms "rehabilitation" or "rehab" being negative or stigmatizing. These views were true even in the context of substance use: "[To me these terms are generally] positive…especially physically…with the drug situation, it's a harder nut to crack…but both of them are beneficial" (Participant 17) (Table 3B).

3) Live interaction with a therapist as a perceived facilitator (Table 4A) and a predominant preference for one-on-one over group-based telerehabilitation (Table 4B).

There was a predominant preference for live and one-on-one rehabilitation, with many participants raising concerns about learning the correct training techniques: "[Telerehabilitation] takes away the hands-on…you get better understanding of what the therapist…is trying to tell you…when you…get hands-on treatment…they show you what to do" (Participant 16). Participants were open to telerehabilitation if there were live therapist interaction to ensure they

were learning the correct training techniques: “I think [live interaction] is [very] important, so [that] I can find out if I am even doing [the exercises] right” (Participant 3). Participants also viewed that live interaction would help them stay motivated and accountable: “as long [as] I was being viewed [I would be willing to participate]…I wouldn't want [a situation] where I was telling [the therapist] I was doing something, and I wasn't. [I want] accountability” (Participant 8). In addition, live and one-on-one therapy was viewed as enhancing communication: “I would prefer one-on-one…it makes it a little easier…to communicate back and forth. If you’ve got six people…and they’re all asking different questions, it’s a little hard” (Participant 7). Another facilitator was readiness to engage in exercise training, with several participants reported being “reasonably ready” to “very ready,” particularly among those with little to no significant health issues posttreatment (Participants 2, 3, 7, 8, 9). A few were open to group-based telerehabilitation with therapist interaction: “Live interaction, that would be great. Either one-on-one or in a group [is fine]) (Participant 17).

4a) Somewhat poorly formulated and no predominant health goal within 1-6 months following curative intent therapy, with common questions or concerns about lung cancer status (Table 5A).

When asked about their health goals in the next few months and beyond, most participants had trouble verbalizing their explicit health goals, with some simply stating to “stay healthy” (Participants 4, 17) or “alive” (Participants 15, 19), and others reporting that health goals were “not something [they]…[thought] about” (Participant 5), or that they “[had] none (health goals)” (Participant 6). A common concern participants voiced was uncertainty about their lung cancer status. Many reported being in a state of waiting for the next computed tomography (CT) scan to determine if their lung cancer were in remission: “I guess they kind of left me hanging. I don’t know if I still have [lung cancer] or if [the treatment] worked…I won’t get another CT scan until

October, so I really don't know what my situation is" (Participant 9). Some expressed fear about treatment failure:

> 'They're [going to] do a CT scan on me on the first [of the month], and we'll be able to determine then whether or not they've got it – the cancer beat or not. Personally, it makes me wonder if the radiation…has done any good…if I'm [going to] be terminal or are they [going to] cure this thing [...]. You're kind of out here in no man's land, and until we get the CT scan back…we just don't know for sure' (Participant 13).

4b-i) Physical and psychosocial functioning, and comorbid conditions: While most participants lacked explicit health goals, some expressed wanting control of symptoms and functional challenges: "I would like to be able to walk better, have more energy, and breathe better" (Participant 3). Another participant reported wanting to have "more control over [his] breathing," to "get rid of the swelling in the feet," get back to "[doing] the things [he] enjoyed doing," and have "better [physical] stability at work" (Participant 2). Some also reported wanting to address specific conditions beyond lung cancer: "[My health goals are to] basically start working on the other things that are wrong with me, like managing the COPD (chronic obstructive pulmonary disease) better" (Participant 18). One participant reported sequential goals: "I'd like to get a clean bill of health on my cancer for one…and then get my knee taken care of (replaced), and [then] I can get out and exercise" (Participant 16) (Table 5B-i).

(4b-ii) Health promotion and disease prevention: Some participants spoke about maintaining an active lifestyle: "Three days a week…I go over to the YMCA and play pickleball […]. I think it's important…to keep exercising" (Participant 1). Others spoke about positive changes: "I'd like to be able to quit smoking. I'd like to be more [physically] active than I am" (Participant 9); or "see if I can [quit smoking] and lose some weight" (Participant 15). Some also reported having survived lung cancer as a reason for change: "Because I had lung cancer…I feel like I need to exercise more" (Participant 13), and with another participant, to return to previous behavior: "this

[lung cancer]…has kind of forced me to go back to using the bicycle four or five times a week" (Participant 11). One participant wanted to reduce substance use: "I'm trying to cut down on the alcohol use" (Participant 7); and another, improve sleep: "I need to work on my sleep habits […]. I get up [in the morning] and I go back to sleep" (Participant 8) (Table 5B-ii).

DISCUSSION

In this study, we found that lung cancer survivors perceived telemedicine as convenient, however impersonal and technologically challenging, with most reporting low self-efficacy in their ability to use technology to access health care. Almost all had little to no knowledge of the potential benefits of specific exercise training regimens to reduce dyspnea, fatigue, or falls. If they were able to design their own telerehabilitation program, participants strongly preferred live and one-on-one interaction with a therapist to enhance therapeutic relationship and ensure correct learning of the exercise training regimens. Participants were often unable to formulate health goals, with many having questions or concerns about their lung cancer status. These findings have important implications in the design of telerehabilitation interventions to improve the physical and psychological function of lung cancer survivors following curative intent therapy.

The contrasting views on telemedicine we identified are similar to a previous meta-synthesis of qualitative studies, in which adult cancer survivors identified the convenience and burden of telemedicine interventions.[39] Similar to our findings, a meta-synthesis reported that while telemedicine enabled survivors to feel more connected with clinicians, many also perceived it as impersonal.[39] These contrasting views have been described in systematic reviews involving patients with COPD,[40] cardiovascular disease,[41] and care across different healthcare settings,[42] and may reflect subgroup or individual perspectives, or differences in

context (e.g., telemedicine modality, purpose). The possibility of "trade-offs" between convenience and impersonality of telemedicine were not explored.

There is paucity of knowledge on lung cancer survivors' views on telemedicine to deliver rehabilitation services (i.e., telerehabilitation) following curative intent therapy. One study with lung cancer survivors within two years of surgical resection found that approximately half were willing to use a prototype, web-based exercise program, with higher perceived acceptance of a mobile-based symptom and activity monitoring system.[43] Another study of stage I-IIIA lung cancer survivors' perspectives on a prototype mindfulness-based mobile application identified convenience and potential health benefits as attractive features, with concerns also raised about technological challenges and absence of live therapist interaction.[44] The predominant preference for live and one-on-one telerehabilitation we identified contrasts with previous studies reporting varied preferences on physical activity programming,[45-48] possibly due to the telerehabilitation context, shorter time since treatment completion, patient cultural, and/or organizational characteristics. The importance of supervision by an exercise or physiotherapy professional for training has been reported, albeit not in the telerehabilitation context[45,46,49] or exclusively involving lung cancer survivors.[50]

Lung cancer survivors in our study also had limited knowledge regarding the role of exercise training regimens to address specific symptom or functional challenges, including shortness of breath, fatigue, or falls, all of which are highly-prevalent and important to stage I-III survivors.[51] Moreover, most patients equated rehabilitation as a strategy to improve physical, not psychological function. This view is in contrast with the definition and intention of "pulmonary rehabilitation" – "a comprehensive intervention…designed to improve the physical and psychological condition of people with chronic lung disease…"[52] – and could reflect low accessibility or utilization of pulmonary rehabilitation services. In addition, patients in our study had no concern about the terms "rehabilitation" or "rehab" being negative or stigmatizing. These

positive-to-neutral views are in contrast to a prior editorial[31] reporting that patients with COPD voiced concerns about "rehab," due to common media stories of popular television personalities undergoing treatment for substance use disorders. These findings have important implications on the messaging related to rehabilitation services.

Many survivors in our study had questions or concerns about their lung cancer status, with some understandably fearing treatment failure. Fear of cancer recurrence – common among cancer survivors[53] including among those without comorbid psychiatric disorders[54] – has been associated with lower engagement in healthful behaviors,[55] higher physical and psychological impairment,[56] and increased healthcare utilization.[57] These feelings, generally not addressed in lung cancer, may also hinder patients from planning for the future or formulate health goals. Our findings suggest that, following curative intent therapy and prior to the guideline-recommended, six-month interval, surveillant chest CT,[20] strategies to manage worry or fear of treatment failure or cancer recurrence[58] may also be needed. Psychological support could enhance awareness of emotions about cancer, reduce the influence of rigid or distressing thoughts, clarify personal values, and commit to meaningful life activities,[59] may reduce fear and facilitate the formulation of health goals. Such strategy could be delivered concurrently or sequentially,[60] depending on patient physical and/or psychological needs,[61] to arrive at multi-targeted rehabilitation.[62]

The perceived low self-efficacy towards telemedicine suggests that hybrid strategies of remotely-delivered and in-person rehabilitation may be needed to enhance therapeutic relationships and ensure delivery of essential components (i.e., exercise training, education, and behavioral support).[23,52] Education could enhance knowledge or learning about the potential benefits of exercise training regimens on impairments (e.g., inspiratory muscle training to alleviate dyspnea)[63] and self-management skills (e.g., of comorbid cardiopulmonary disease).[64]

Behavior change support may incorporate techniques that align with the SCT (e.g., formulate goals).[30] Psychological interventions to reduce worry or fear may also be beneficial.

Strengths and limitations

Strengths of our study include trustworthiness: we developed codes *a priori* and used multiple interviewers and coders (enhancing dependability); provided in-depth illustrations of participants' views, with almost all of participants having had experience with telemedicine (credibility); and adapted the SCT to guide study design, analysis, and interpretation (transferability). Additional strengths include a real-world and contemporary sample of lung cancer survivors within six months of curative intent therapy, providing valuable insights into this unique patient population at an often-overlooked period, with implications to improve downstream survivorship outcomes.

Our study is limited by the absence of subgroup comparisons (e.g., by age, sex, upstream time from possible to diagnosed lung cancer, prior life-threatening diagnoses including another cancer), with limited time elapsed posttreatment, precluding definitive conclusions on worry or fear. In addition, we did not use other theoretical frameworks, inquire about specific socio-environmental factors, nor conduct longitudinal interviews, which may be important to inform intervention design. Further, we included participants from a single U.S. Veterans Affairs Medical Center, most of whom were male, with significant cigarette smoking, and comorbid COPD, limiting transferability. Women's perspectives could reveal important health-related attitudes, knowledge, or behaviors not captured in our study. Last, we do not know the feasibility or acceptability of a telerehabilitation intervention in this population.

CONCLUSION

Features of telerehabilitation interventions for lung cancer survivors following curative intent therapy may need to include strategies to improve self-efficacy and skills in telemedicine. Education to improve knowledge of potential benefits of rehabilitation and exercise training may increase uptake. Exercise training with live therapist interaction, to target specific symptoms, physical and psychological impairments, and/or facilitate comorbidity control, with alignment to patient formulated goals, may enhance learning, adherence, and completion. Future work should determine how to incorporate these features into telerehabilitation programs.

Author Contributions

DMH, MAN, RPK, and LMH contributed substantially to the study design, data analysis and interpretation, writing, and/or final approval of the manuscript. DBB, MLN, SKR, JES-L, JLS, AVP, and RLK contributed substantially to the study design, interpretation, writing, and/or final approval of the manuscript.

Competing interest

All authors declare that no competing interest exists.

Funding

This work was supported by the Career Development Award (1IK2RX003661, PI Ha) from the United States (U.S.) Department of Veterans Affairs, Rehabilitation Research and Development Service.

Acknowledgement

The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the U.S. government. The following authors were employed (job title) at the Rocky Mountain Regional Veterans Affairs Medical Center, Aurora, Colorado: DMH, DBB, MLN, SKR (Staff Physician/Surgeon); RLK (Associate Chief of Staff, Research Service); MAN and RPK (Health Sciences Specialist); LMH (Health Research Scientist); and JES-L (GRECC Researcher). DMH, LMH, DBB, MLN, SKR, JSL, JES-L, AVP, and RLK also hold academic appointments at the University of Colorado School of

Medicine. Dr Ha is also supported by the American Lung Association Lung Cancer Discovery Award (820773). The American Lung Association had no role in the study design, data collection, analysis, or interpretation, writing, or decision to submit the article for publication.

Ethics Approval

This study involved human participants and was approved by the Colorado Multiple Institutional Review Board (21-4701). All participants gave informed consent to participate in the study before taking part.

Data Availability Statement

Not applicable – this study is not a clinical trial and does not meet requirements for data sharing per *Tier 2* journal policy.

Abbreviations

COPD = chronic obstructive pulmonary disease; CT = computed tomography; FEV_1 = forced expiratory volume in one second; FVC = forced vital capacity; OSA = obstructive sleep apnea; SBRT = stereotactic body radiotherapy; RMR VAMC = Rocky Mountain Regional Veterans Affairs Medical Center; SCT = Social Cognitive Theory; SD = standard deviation

Tables

Table 1: Participant Characteristics

Characteristic (N=20)	Value
Age, *years*, mean ± SD	71.2 ± 5.5
Age ≥ 65 years, *%*	80
Male, *%*	90
White, non-Hispanic, *%*	95
Married, *%*	65
College education or higher, *%*	65
Employed, *%*	10
Marginal or limited health literacy (BRIEF scale), *%*	40
Frail (FRAIL scale), *%*	40
Home access to internet, *%*	85
Rural living environment*, *%*	25
Prior experience with telemedicine†, *%*	85
Smoking status**, *%*	
Current	45
Former	55
Comorbidities, *%*	
COPD‡	90
Oxygen therapy (1-6 liters/minute)	40
OSA	25
Psychiatric illness§	40
Lung cancer characteristics, *%*	
Screen-detected	35
Adenocarcinoma‖/squamous/small-cell/presumed	60/25/5/10
Collaborative stage IA/IIA/IIIA	75/10/15
Curative intent therapy modality, *%*	
Surgical resection¶	40
SBRT	40
Chemoradiation	20
Time since primary treatment completion, months, median (range)	2 (1-6)

**Defined by the Veterans Health Administration Office of Rural Health (i.e., areas with < 30% of the population residing in an urbanized area) using zip code of residence.*
***As documented clinically in participants' electronic health records.*
†Via telephone or video visits.
‡Defined as post-bronchodilator FEV_1/FVC < 70%.
§Defined as clinically diagnosed depression, anxiety, post-traumatic stress disorder, bipolar, or schizophrenia.
‖Including 1 case of adeno-squamous carcinoma.
¶Of which 6 were lobectomies and 2 sub-lobar (1 segmentectomy; 1 wedge) resections.

COPD = chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in one second; FVC = forced vital capacity; OSA = obstructive sleep apnea; SBRT = stereotactic body radiotherapy; SD = standard deviation

Table 2: Attitudes and Perceived Self-Efficacy Towards Telemedicine

Illustrative Quotes	Participant ID
(A) Telemedicine is convenient	
"It's nice to have a [telemedicine visit], talk about things and not have to worry about showing up somewhere…100-and-some miles away. I think [telemedicine is very] darn convenient."	Participant 7
"I think [telemedicine] is a good idea. Some people…come in-person to see an actual physician, but if they can see [the physician] on the phone, talk to [him or her remotely], I think it works out great."	Participant 2
"Some appointments…have to be physical, but unless [the doctor's] physical presence is required, I'm going to, as much as possible, work on video appointments."	Participant 12
"I think [telemedicine] is a great idea…it keeps everybody safer [because] people aren't driving to the hospital sick…to go in for a meeting [with a clinician]."	Participant 18
"I think [telemedicine] would be a lot more convenient, rather than having to go to a building [for in-person visits]."	Participant 13
(B) Telemedicine is impersonal	
"Depending on the [health] issues…you have to [be in person] to see what's going on. You can't listen to breathing over [the] internet [or] phone…I'd rather have a one-to-one in-person appointment."	Participant 2
"I like the face-to-face [visits]. When it comes to issues like what I have, I want face-to-face [visits]. I want to feel comfortable with who I'm talking to…[telemedicine] is too cold and sterile."	Participant 17
"[I've had experience with telemedicine (video and telephone)], and I think that the video takes away [the hands-on interaction]. In-person visits [are] better."	Participant 16
"I'd rather go physically [for my appointments] and have them talk to my face."	Participant 20
"I've talked to my heart doctor now and again about changing my medicine [over the phone]. But that's about it [regarding my experience with telemedicine]. Otherwise, I go to the VA [physically for my appointments]. I'm very happy with the VA. I'd rather [have my visits] in-person."	Participant 15
"[I am hesitant to use telemedicine]. I like the one-on-one health experiences."	Participant 10
(C) Telemedicine is technologically challenging	
"[I've had experience with remote care] a couple of times…with video, and as far as the technology, I had a [heck] of a time with it. I had to actually go into the VA and have the nurse show me how to do it because I'm not really [technical]."	Participant 7
"[I've received care remotely], via video…[but at times needed] to use the telephone]. I'm just not computer literate […]. I did get a tablet from the VA [for remote care]…but now I don't know my password. I forgot it."	Participant 3
"[I've not received remote care via video because] I'm not too computer savvy."	Participant 9

“My computer skills are limited…I would have to have hands-on teaching [to have video visits].”	Participant 8
“[I anticipate that with video visits, I would have] my standard problems (with the software) and beat[ing] my head against the wall trying to get it going, but I’ll get it going if I need to.”	Participant 11
“I don’t know how to use the computers. I’m challenged with the computer …[I would be more comfortable with video visits if] somebody [could] walk [me] through it, like over the phone.”	Participant 5
“[I’ve received care remotely], over the phone…I’m probably not as versed as most people [with video visits]. [For video visits,] I [would] get my daughter over here and help me, maybe.”	Participant 10

Table 3: Knowledge of Benefits of Rehabilitation and Exercise Training

Illustrative Quotes	Participant ID
(A) Limited knowledge of benefits of rehabilitation/exercise training	
"You're talking in strange territory there [about the types of exercises or how to do them]. I've had no instructions whatsoever…other than the [incentive] spirometer. About breathing exercises or any of that stuff, I just haven't had any [instructions]."	Participant 1
"I really don't have any [understanding of the types of exercises and how they can or cannot help with my health]."	Participant 9
"The only [type of exercise] I can think of is cardio […]. Rehab [for me has to] have something to exercise the lungs […]. If there were exercises that would help me with my falls, yeah [I'd also be interested to learn]; I've got scars all over my face."	Participant 17
"I really learned to exercise in the Army. I don't use them all, but I exercise once in a while."	Participant 6
(B) Neutral-to-positive views on rehabilitation	
"I think [of rehabilitation as] a physical therapy thing, not getting over being a drunk [or substance use disorder]…for me, [rehabilitation is] to keep my body working the way it's supposed to be working."	Participant 1
"[Rehabilitation or exercise would help] quite a bit [with my health]. I would feel better. Anytime I exercise it helps me feel better."	Participant 3
"Rehabilitation means…to get yourself better, to work yourself through something to make your life better."	Participant 18
"Rehab would be trying to make my lungs better and techniques to be more comfortable, and hopefully I can deal with the issues from lung cancer much better, like breath control…things that I could use if I start getting short of breath."	Participant 2
"My thing with rehabilitation is if you have a problem, you need to get somebody to help you solve your problem. That's rehabilitation. I don't care if drugs or alcohol, eating disorder, or something, all kinds of stuff out there. People need rehab, they need it."	Participant 6
"To me [rehabilitation is] extremely positive."	Participant 12

Table 4: Perceived Facilitators and Preferences Towards Telerehabilitation

Illustrative Quotes	Participant ID
(A) Live therapist interaction as a facilitator	
"[It is] absolutely important [to have live interaction with a therapist […]. By having [live interaction with] a PT (physical therapy) person, [the therapy is] more specifically tailored for me...." "	Participant 12
"[Having live interaction with a therapist is] very important to make sure if I'm doing things the right way, [particularly] if there's some kind of technique or twisting or bending motion."	Participant 2
"[Telerehabilitation] would be fine as long as they could view me while the session was going on…I think it would be very important to [to have live interaction with a therapist]."	Participant 8
"[Having live interaction with a therapist is] the ideal for me."	Participant 6
"If there is not an instructor or something, I probably wouldn't do it."	Participant 3
(B) Predominant preference for one-on-one over group telerehabilitation	
"I prefer one-on-one's. I've always been that way…I'm kind of shy in front of big groups…I don't like being around a lot of people…I feel like everybody is staring at me."	Participant 18
"[My ideal telerehabilitation program] would be face-to-face conference…[one-on-one] if the clinician isn't overworked."	Participant 11
"If you had a bunch of other people [in telerehabilitation together], I'd feel kind of inadequate...I'm not tech savvy."	Participant 13
"I think having one-on-one is probably ideal, but I think you could probably get the same message, especially if it's people that had the same surgery and they're recovering from the same thing, then the group would probably work fine."	Participant 5

Table 5: Health Goals Following Curative Intent Therapy of Lung Cancer

Illustrative Quotes	Participant ID
(A) Common questions or concerns about lung cancer status	
"I'm thinking about [recovering]. I'm [going to] find out…in a couple of weeks whether or not this [radiation treatment] did any good."	Participant 7
"I haven't seen anybody since my treatment. I don't have an appointment… until the 23rd of September…when I go in…to do another CT scan to see if they got all of the cancer […]. Then on the 27th or 29th (of September) [my oncologist] will go ahead and give me the results of the CT scan and let me know, 'hey, it's all gone', or 'hey, there's still something there' or what we're [going to] do next."	Participant 18
"The only concern I have [is about] the lung cancer coming back."	Participant 17
"I'm kind of in a limbo until I know [about my lung cancer status]. And once I know one way or another, what the deal is, I'll remain in limbo. After I find out for sure what's happening [with my lung cancer status], then I can be more [purposeful] as far as what my aspirations are."	Participant 13
"Well, naturally, [my goal is] to improve. Hopefully the radiation…has done its job and taken care of it – the lung cancer that I had, the spot wasn't that big."	Participant 4
"I'm basically doing pretty good right now […]. I just won't know [about my lung cancer status] until July."	Participant 6
(B-i) Physical and psychosocial functioning, comorbidity control	
"I'd like to have better balance [with walking]."	Participant 8
"I'd like to improve my mobility […]. I'm [also] hoping to relieve some pain […]. I walk about 15 minutes and…I'm spent."	Participant 10
"[My goal is to be] able to get around without breathing hard."	Participant 14
"Hopefully the neuropathy will dissipate, and I can go back to doing my needlework (art craft)."	Participant 2
"I'm getting TMS (transcranial magnetic stimulation, an approach to treat anxiety and depression) so I want to finish that."	Participant 3
"I have arthritis; I try to walk one mile every morning."	Participant 15
(B-ii) Health promotion and disease prevention	
"My health goals are to stay healthy […]. I'm 64 years old, and because I've taken care of myself and [have] had plenty of exercise, I'm still pretty healthy."	Participant 17
"I'd like to get out a little bit more […]. I like going to the park but I get a little bit apprehensive to get out and walk too long."	Participant 20
"I'm a smoker, so I'm trying to quit. That's my big goal."	Participant 15
"[My goal is to try] to quit smoking."	Participant 4

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Lung Cancer Survivors' Views on Telerehabilitation Following Curative Intent Therapy: A Formative Qualitative Study

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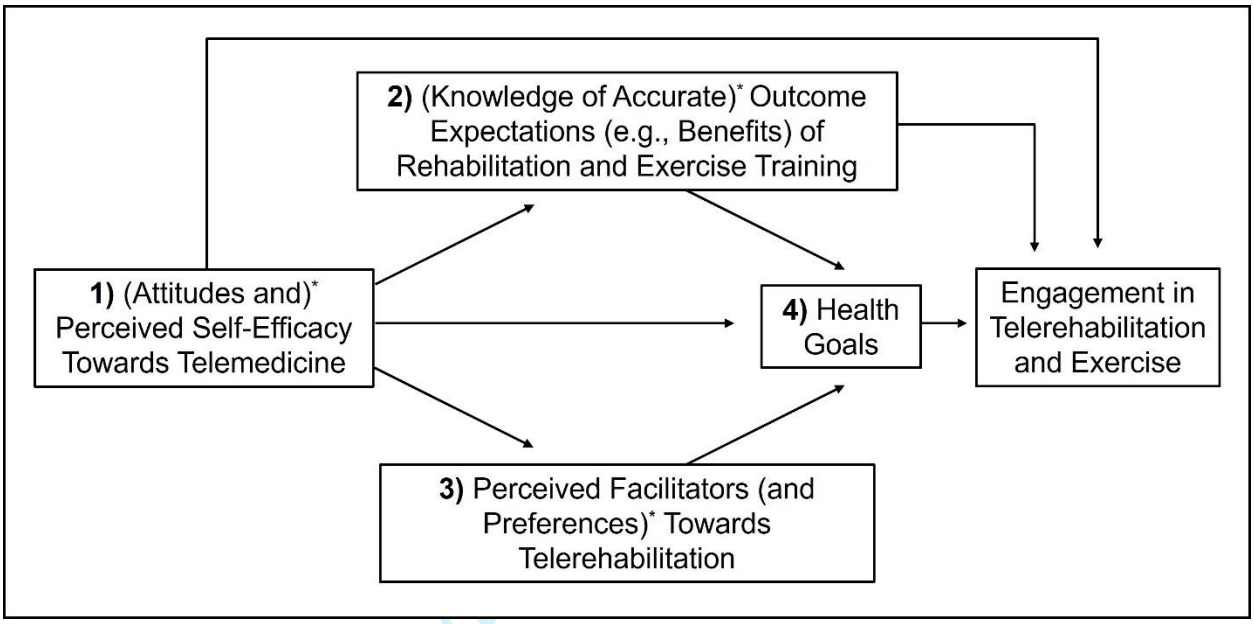
ONLINE SUPPLEMENT

E-Figure 1: Bandura's Social Cognitive Theory[1] Adapted to Inform Telerehabilitation



**Additional constructs or modifications to the SCT that could influence engagement in telerehabilitation and exercise.*

E-Table 1: Semi-structured Interview Questions Guided by the Social Cognitive Theory[1]

Thank you for taking your time to help us with these questions. In this interview, we will ask you about your health goals, knowledge on exercise and rehabilitation, and views on technology. We will also ask you about your level of health literacy, frailty, and basic demographics. These interviews typically take about 30-45 minutes. We will use the results to help design an ideal telerehabilitation program for Veterans who recently completed lung cancer treatment.

(*Opening question*) To begin, we will start with a broad question – When were you diagnosed with lung cancer?

- What treatment did you receive? (surgery, chemo, radiation, etc.)
- When did you complete the treatment? (1-6 months ago)

How has your experience been following lung cancer treatment?

- Have there been any new diagnosis or any new medical issues/concerns following your treatment?

What **heath issues** (new symptoms, new limitations to daily activities/daily life; shortness of breath, poor sleep, or fatigue, neuropathy) have you had to deal with since completing lung cancer treatment? [possible probes: Can you tell me more about…; Can you describe…more?]

- How have symptoms impacted your day-to-day activities, hobbies, or ability to complete tasks?
- Have you had any falls since completing your treatment (related or non-related to treatment)?
- What concerns you most about these health issues that you've had to deal with (since completing lung cancer treatment)?
- What is the most important (health) issue you think we should know about your experience following lung cancer treatment?

Thank you for sharing your experience. Now, we will ask you a few questions about your current and future goals.

What are your **health goals** in the next few months and beyond? [possible probes: Can you describe more about…; Can you explain…more?]

- What are your goals for the next few months to get your life activities to where you would like them to be?
- How are your (health) goals similar or different compared to before your lung cancer treatment? [possible probes: Describe…more for me; Explain…]
- How ready do you feel about taking steps to meet these goals? What are some possible challenges?

What else would you like to add that you think might be important for us to know about your health since you completed lung cancer treatment.

Thank you for sharing with us your health issues and goals. Next, we would like to understand more about your knowledge of exercise and rehabilitation.

What, if any, have you been **told about exercise** after lung cancer treatment? [possible probes: Tell me more about…; Explain…]

> What is your understanding about what types of exercises there are and how they can or cannot help with your health?
>
> What is your understanding about how much exercise can or cannot help with symptoms we previously discussed (e.g., shortness of breath, poor sleep, or fatigue)?
>
> What is your understanding about what types of exercises can reduce falls? How are these important to you, if at all?

When clinicians use the word "rehabilitation", what does that mean to you? [possible probes: Tell me more about…; Explain…]

> How is the **meaning of "rehabilitation"** similar or different compared to some of the health services that you may have received in the past, like physical or occupational therapy, or pulmonary or cardiac rehabilitation?
>
> Sometimes people think that "rehab" or "rehabilitation" is for substance use or abuse; how is the meaning of "rehabilitation" negative, positive, or neutral to you?

How do you **feel rehabilitation and exercise** can help you achieve your health goals, if at all? [possible probes: Can you tell me more about…; Describe…]

> How are your exercise levels different, if at all, after lung cancer treatment?
>
> What are some reasons why you exercise or not?
>
> How ready do you feel to participate in rehabilitation and exercise in the next few months?

Thank you sharing these thoughts. Part of the reason why are doing this is to help design a telerehabilitation program for Veterans who recently completed lung cancer treatment. So the next set of questions will ask you about using **technology for health care**.

Recently, a lot of Veterans have had experience receiving care remotely through telephone or video – where you can see a picture on your phone or computer screen. In the VA, this is called VA Video Connect, or VVC.

> Have you received care remotely in VA? Over telephone or video? If you did not do it over video, why is that?
>
> How comfortable do you feel about using computers and the internet for health care services?
>
> What are some challenges you expect to have with video technology? What would help you feel more comfortable using it?
>
> How do you feel about exercise or rehabilitation services delivered remotely using video technology?

Since our goal is to design a telerehabilitation program for Veterans with lung cancer following treatment,

> If you could design your **ideal telerehabilitation program**, what would that look like?

How important is having live interaction with a therapist (and one-on-one or in group setting)? Why or why not?
How do you feel about self-help videos for exercises? How can they help or not?

The next set of questions are surveys. Unlike the previous questions, these next questions do not need detailed or lengthy answers since we can only check the answer options available on the surveys.

This first survey assesses your level of **health literacy**.[2]

1) How often do you have someone help you read hospital materials?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

2) How often do you have problems learning about your medical condition because of difficulty understanding written information?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

3) How often do you have a problem understanding what is told to you about your medical condition?

___Always (1) ___Often (2) ___Sometimes (3) ___Occasionally (4) ___Never (5)

4) How confident are you filling out medical forms by yourself?

___Not at all confident (1) ___A little bit (2) ___Somewhat (3) ___Quite a bit (4)

___Extremely confident (5)

This next survey assesses your level of **frailty**.[3]

1) How much of the time during the past 4 weeks did you feel tired?

___All of the time ___Most of the time ___Some of the time ___A little of the time ___None of the time

2) By yourself and not using aids, do you have any difficulty walking up 10 steps without resting?

___Yes ___No

3) By yourself and not using aids, do you have any difficulty walking a couple of blocks (e.g., several hundred yards)?

___Yes ___No

4) Did a doctor ever tell you that you have these illnesses? (*check each illness*)
___hypertension, ___diabetes, ___chronic lung disease, ___heart attack, ___congestive heart failure, ___angina, ___asthma, ___arthritis, ___stroke, and ___kidney disease. How many?
[Total number of illnesses, then add 1 for (lung) cancer]: ____

5) How much do you weigh?____

6) One year ago, how much did you weigh?____

7) Have you been admitted to the hospital in the past 3 months? ___Yes ___No

This last set of questions are on your basic **demographics**.

1) Are you

___Married/living with partner; ___Divorced/separated; ___Widowed; or ___Single/Never married?

2) What is your highest level of education?

___Some high school ___Completed high school ____Some college

____Completed college ___Graduate or doctorate degree

3) What is your employment status?

___Employed (part- or full-time) ___Retired ___Disabled ___Unemployed

4) Do you have access to internet at home? ___Yes ___No

This completes our interview today. Thank you again your time. Please let us know if you have any questions for us?

E-Table 2: Post-Interview Debrief Guide

In general, how did the interview process go? (e.g., how engaged was the participant; how candid were the responses; how was your own comfort level?)

What were the main **health issues** and **health goals** that came up?

- Health Issues:
- Health Goals:

What were participants' **knowledge** on exercise and rehabilitation?

- How was their understanding on the types and roles (purpose) of exercise?
- How did they view and define rehabilitation?
- How did they feel about rehabilitation and exercise?

How did participants feel about using **technology** for health care?

- How did they feel about using technology to access health care?
- How did they feel about using technology for rehabilitation services?
- What were key program designs?

Did anything surprise you?

Did anything **new** come up?

Should we change anything about the interview process?

Should we change anything on the interview guide?

Codes to consider:

E-Table 3: Operational Definitions of Terminologies for Data Analysis and Interpretation

Terminology	Definition
Exercise	Physical activity which is usually regular and done with the intention of improving or maintaining physical fitness or health.[4]
Goal	The end (or result or achievement) toward which effort is directed.[5,6]
Rehabilitation	Restoration of human functions to the maximum degree possible in a person or persons suffering from disease or injury.[7]
Self-efficacy	*General:* 1) Participant's belief about his/her ability to perform actions necessary to produce a given effect [8]; and 2) Participant's perception that he/she can exercise control over his/her health habits.[1] *Specific to this study:* Participant's belief about his/her ability to use technology to access health care.
Telemedicine	The delivery of health services via remote telecommunications.[9]
Telerehabilitation	The delivery of therapeutic rehabilitation at a distance or offsite using telecommunication technologies.[10]

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10. National Library of Medicine - Medical Subject Headings (MeSH): "Telerehabilitation" (https://www.ncbi.nlm.nih.gov/mesh/?term=telerehabilitation).

Standards for Reporting Qualitative Research (SRQR) Checklist

No.	Topic	Item
S1	Title	We provided a concise description of the nature and topic of the study identifying the study as qualitative research (Page 1).
S2	Abstract	We provided a summary of key elements of the study using the abstract format of the intended publication (Pages 3-4).
S3	Problem formulation	We provided a description and significant of the problem studied in the Introduction (Page 5).
S4	Purpose and research question	We described the purpose of the study and specific research questions in the Introduction (Page 5-6).
S5	Qualitative approach and research paradigm	We described the qualitative research approach (i.e., informative) and guiding theory (Bandura's Social Cognitive Theory) (Page 7).
S6	Researcher characteristics and reflexivity	We provided a description of the researcher characteristics (Page 6-7).
S7	Context	We described the setting/site and salient contextual factors (Page 6).
S8	Sampling strategy	We provided description of the sampling of research participants (Page 6).
S9	Ethical issues pertaining to human subjects	We provided documentation of the approval of the appropriate ethics review board and participant consent (Page 6).
S10	Data collection methods	We provided description of types of data collection including dates of analysis (Page 7).
S11	Data collection instruments and technologies	We provided description of the interview guide and technology used for recording (Page 7).
S12	Units of study	We provided the number and relevant characteristics of the participants (Page 6).
S13	Data processing	We provided descriptions of methods of processing data prior to analysis including transcription and coding (Pages 7-8).
S14	Data analysis	We described in detail the process by which themes were identified (Pages 7-8).
S15	Techniques to enhance trustworthiness	We provided descriptions of techniques that enhanced the trustworthiness of study findings (Page 17).
S16	Synthesis and interpretation	We described the main findings of salient themes (Pages 9-14).
S17	Units to empirical data	We provided evidence using illustrative quotes to substantiate analytic findings (Pages 9-14).
S18	Integration with prior work, implications, transferability, and contribution to the field	We provided detailed integration of study findings to existing literature, discussed transferability, implications, and contribution to the field (Pages 14-17).
S19	Limitations	We provided descriptions of trustworthiness and limitations of study findings (Page 17).
S20	Conflicts of interest	We provided a statement of conflict of interest (Page 19).
S21	Funding	We provided description of funding (Page 19).