



# Characterization and efficacy of lifestyle behavior change interventions among adult rural cancer survivors: a systematic review

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Received: 1 August 2023 / Accepted: 9 September 2023

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## Abstract

**Purpose** Little is known about the intersection between age and rurality as characteristics that impact lifestyle behavior change for cancer survivors. This review aims to summarize the current literature on lifestyle behavior change interventions conducted among rural survivors of cancer, with an emphasis on older survivors.

**Methods** A systematic search of five databases identified randomized controlled trials and controlled clinical trials that targeted diet, physical activity, alcohol consumption, or tobacco use change in adult cancer survivors living in rural areas of the world.

**Results** Eight studies met the inclusion criteria. Most studies were conducted in either Australia or the USA, included survivors at least 6 weeks post-treatment, and half included only breast cancer survivors, while the other four included a mix of cancer types. All but one had a physical activity component. No articles addressed changes in alcohol or tobacco behavior. Seven (87.5%) had a fully remote or hybrid delivery model. Most of the physical activity interventions showed significant changes in physical activity outcomes, while the dietary interventions showed changes of clinical but not statistical significance.

**Conclusions** Few studies have been conducted to implement and evaluate the effectiveness of lifestyle behavior change interventions among older rural survivors of cancer. Future research should evaluate the acceptability and relevancy of adapted, evidence-based intervention with this population.

**Implications for Cancer Survivors** Effective diet and physical activity interventions exist, albeit limited in terms of effective lifestyle behavior change intervention tailored to older, rural survivors of cancer, particularly in relation to alcohol and tobacco behaviors.

**Keywords** Rural population · Older adults · Lifestyle · Cancer · Survivorship

## Introduction

Over the past decade, the average 5-year relative survival rate for all cancers combined has increased by approximately 20% [1]. This increase, which correlates with improvements in screening and treatment methods, has led to a rise in survivors of cancer

[2]. In the next decade, it is expected that the number of individuals living with and beyond cancer will increase by 30% [3]. Survivors of cancer experience adverse side effects from their treatment that impact their quality of life and lifestyle behaviors, such as pain [4], fatigue [5, 6], and impaired functionality [7, 8]. More than 60% of the cancer survivor population is over 65 years of age, and estimates indicate that about 40% of all cancer survivors have survived for more than 10 years [2, 9]. Older survivors face a greater risk of comorbidity and co-occurring chronic disease than the general population [9].

One area of survivorship that is largely understudied is rural cancer survivorship. It is estimated that 20% of cancer survivors live in rural areas of the USA [10]. Rural populations tend to be older, have a higher prevalence of obesity and other comorbidities, lower cancer screening rates, and reduced access to healthcare services than urban populations [11–15].

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Rural survivors of cancer commonly report their health as fair or poor rather than good or excellent [10] and have been shown to have lower physical functionality than urban survivors of cancer [16, 17]. As rural populations in general tend to be older and over 60% of cancer survivors are over the age of 65 years, it is likely that the intersection of age and rural living contribute to greater survivorship disparities for this population. This is a currently under studied area of cancer survivorship.

Based on a systematic review of the available evidence, the 2022 American Cancer Society Nutrition and Physical Activity Guideline for Cancer Survivorship recommends that cancer survivors follow a healthy eating pattern and engage in regular physical activity [18]. Lifestyle interventions to promote diet and physical activity after cancer have been shown to be effective broadly. Beyond demonstrated evidence that most interventions support positive changes in health behaviors such as diet and physical activity [19–22], systematic reviews have shown that interventions to promote healthy lifestyle behaviors among survivors of cancer, such as increased physical activity and improved dietary pattern, are associated with higher self-reported quality of life and functionality outcomes [20, 23–26]. Adherence to health-promoting behaviors has been reported to be low, especially among rural and older survivors [27–29]. Furthermore, delivering behavior change interventions for this population can be difficult due to barriers such as transportation distance, scarcity of health providers in the area, and lack of resource access [30, 31]. These are two populations of cancer survivors which have known disparities in health outcomes, yet little has been examined on the intersection of these identities and how adherence to health-promoting behaviors can be improved. The shifting population dynamics in cancer survivorship regarding both aging and rurality indicate that it is crucial to understand the health needs of this older, more vulnerable population if effective lifestyle interventions are to be developed and implemented.

To effectively intervene and promote health among rural cancer survivors, gaps in current evidence need to be systematically identified and evaluated. Recent reviews have highlighted the unique needs of rural breast cancer survivors [32] and behavioral interventions conducted with rural survivors of breast cancer [33]. However, these reviews fail to comprehensively examine the interventions conducted with rural survivors of any other cancer type. In addition, no review has specifically addressed the cross-section of rurality and older age of cancer diagnosis as common and novel characteristics that inform on intervention needs. The present systematic review was conducted to fill the gaps in each of these areas. While the eligibility criteria for included articles were intended to gather information for lifestyle behavior change interventions which have been conducted with rural cancer survivors, another unique aspect of this review is the opportunity to explore interventions relative to “older”—over age 65 years—cancer survivors and the

intersection of rurality and older age given this is a priority research area for the National Cancer Institute [34]. We anticipate that this work will inform the future development of randomized controlled trials and controlled clinical trials that are evidence-based and effective in promoting healthy lifestyle behavior change for older, rural cancer survivors.

## Aims

This review aims to summarize the current literature on lifestyle behavior change interventions (i.e., diet, physical activity, alcohol consumption, tobacco use) conducted among rural survivors of cancer, with an additional emphasis on older survivors. The goal is to assess the effectiveness of behavior change interventions and describe the demographic characteristics, intervention components, delivery methods, and measures used in lifestyle interventions for rural cancer survivors as well as to identify gaps in current evidence that will need to be addressed.

## Methods

The conduct and reporting of this review adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [35]. The protocol was registered with PROSPERO International Prospective Register of Systematic Reviews (CRD42021282313).

## Search strategy

The following five electronic databases were searched in May of 2023 for relevant articles of all publications years: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Controlled Trials (CENTRAL), Education Source, Excerpta Medica Database (EMBASE), and PsycINFO. The search strategy included Medical Subject Heading terms and keywords comprising (1) lifestyle behavior—diet, physical activity, smoking cessation, or alcohol consumption, (2) cancer survivors, (3) rural location, and (4) randomized controlled trials and controlled clinical trials. Filters applied to the search included randomized controlled trials, controlled clinical trials, adults, and humans, with no language restrictions. The search string (Supplementary Fig. 1) was developed in PubMed and translated to the other four databases.

## Eligibility criteria

This systematic review includes randomized controlled trials and controlled clinical trials which examine the effect of lifestyle intervention on behavior change in four areas: diet,

physical activity, tobacco use, or alcohol consumption. Supplementary Table 1 summarizes the eligibility criteria. Interventions were excluded unless they targeted at least one of these four health behaviors. Eligible studies included adult (18 years or older) survivors of cancer, defined as an individual from the point of diagnosis onward, of any cancer type living in a rural area of the world. Interventions that did not have a rural delivery focus or express the delivery of the intervention for participants living in rural areas were excluded. Rurality was determined via self-statement by the author, Rural–Urban Continuum Codes (RUCC), or Rural–Urban Commuting Area (RUCA) codes. The primary outcome measure of interest for this review was lifestyle behavior change. To be included in the primary analysis, studies must have reported at least two measurement timepoints of behavior, one pre- and one post-intervention. To provide further information about the delivery and acceptability of the intervention, details on behavior change goals, intervention delivery modes, intervention provider, sessions and duration, eligibility rate, recruitment rate, retention rate, and self-reported satisfaction or participant perspectives were gathered. Papers meeting the primary inclusion criteria were secondarily evaluated for age stratification or minimum age inclusion of 65 years or greater. Data specifically related to older adults were extracted, as available.

### Study selection and data extraction

The authors, content experts with experience in systematic reviews and meta-analysis, developed a search strategy. A single individual (SW) performed the database search, and all citations were exported to EndNote X9 for data management. Duplicate citations were removed following the process described by Bramer et al. [36]. Two reviewers (SW, RR-M) then independently dual screened the titles and abstracts of all publications based on the eligibility criteria to select articles for full-text review. Articles that did not meet the inclusion criteria were excluded, and any articles for which there was a discrepancy between reviewers moved on to full-text screening for further review. The full text of the remaining articles was reviewed independently by two reviewers (SW, RR-M) to assess eligibility. Articles that did not meet eligibility criteria were excluded, and conflicting votes were adjudicated by a third reviewer (CT).

### Outcomes

To describe the nature of the lifestyle studies among rural-dwelling adults who have survived cancer, we collected detailed information on intervention content, delivery, and outcomes. Data were extracted independently by SW and RR-M using an a priori designed data extraction form. Data collected from each trial included the following: (1) general

study information (i.e., first author, year of publication, and location), (2) study design and behavior changes targeted, (3) eligibility criteria, (4) participant characteristics (i.e., sample size, age, sex, race), (5) intervention information (i.e., intervention delivery mode, intervention provider, sessions, and duration), (6) recruitment and retention details, and (7) details on behavior change goals (i.e., behavior change assessments and measures of effect). The effect size for the primary behavior change outcome, when reported, was described for each trial as it was reported by the authors.

### Data quality

Two reviewers (SW, RR-M) independently assessed the quality of all included studies using the Cochrane Collaborations' tool to assess risk of bias [37]. This tool includes five domains to assess the risk of bias and then rates the risk of each as low, high, or some concerns for each category. The five biases assessed were (1) selection bias (randomization and allocation concealment), (2) performance bias (blinding of participants and study staff), (3) detection bias (blinding of the outcome), (4) attrition bias (missing outcome data), and (5) reporting bias (selective outcome reporting). Each reviewer completed a risk of bias chart with these domains for each study, and any discrepancies were discussed and adjudicated by a third reviewer (CT).

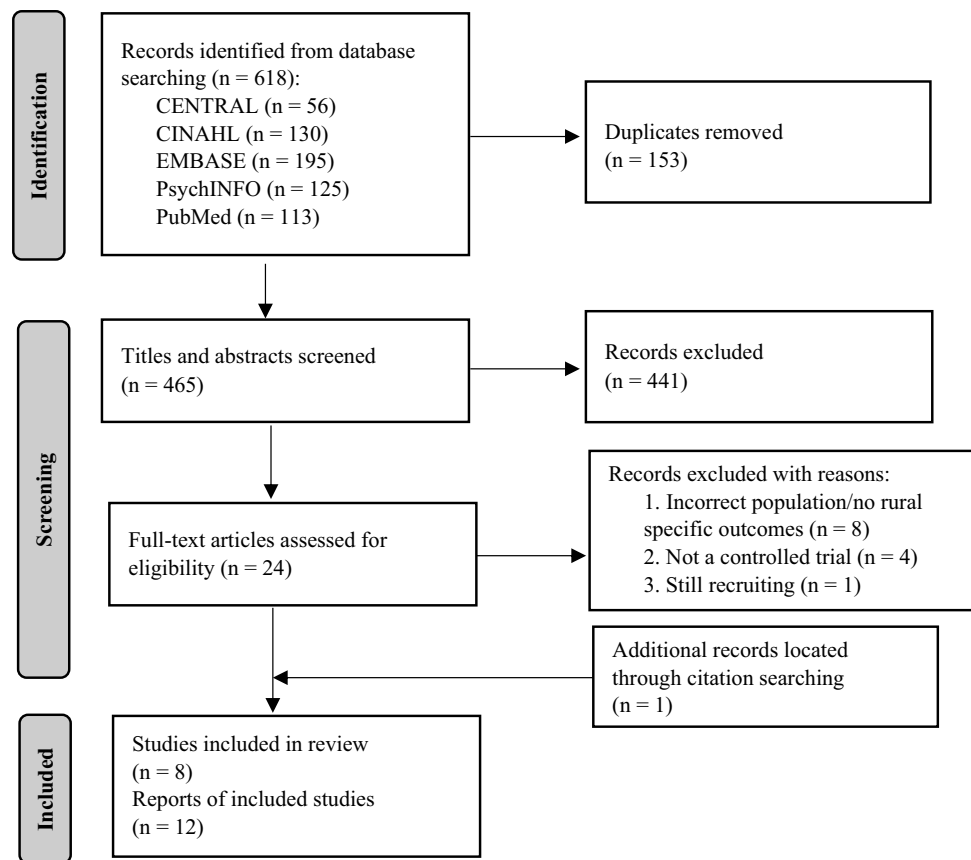
## Results

A total of 618 records were identified with 465 remaining after de-duplication. After title and abstract screening, 24 articles were identified for full-text review. Of these articles, 12 were deemed eligible based on the a priori criteria and were included in data extraction. An additional record was located through citation searching. The study selection process can be seen in detail in Fig. 1.

### Study characteristics

This review included a total of eight studies [30, 38–44]. Four additional manuscripts, such as protocols, were reviewed for information about intervention details that were not reported in the included peer-reviewed manuscript [45–48]. While all studies were randomized controlled trials, four were described as two-arm randomized controlled trials [30, 38, 42, 43], three were described as quasi-randomized controlled trials [39, 40, 44], and one was described as a three stream-controlled trial [41]. Three were described as pilot or feasibility trials [38–40], and the other five were efficacy trials [30, 41–44]. Four studies took place in Australia [40–42, 44], one in Spain [39], and three in the USA [30, 38, 43]. Four studies recruited only breast cancer patients

**Fig. 1** PRISMA flow diagram. Modified from: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. <https://doi.org/10.1136/bmj.n71>



and survivors [30, 38, 39, 42], while the other four recruited a mix of cancer types, including colorectal, lung, prostate, gynecologic, head and neck, and lymphoma [40, 41, 43, 44]. Participants in three trials were still in active treatment [38, 40, 41], while participants in the other trials were at least 6 weeks post-treatment [30, 39, 42–44]. Two trials included both rural and urban or metropolitan survivors of cancer in the intervention [43, 44], while the other six only included rural participants. Overall trial enrollment ranged from 18 to 641 participants; four enrolled only females and the remaining enrolled 50% or more females. The age distribution across all studies ranged from 29 to 90 years, with three studies reporting an average age above 65 years [41, 43, 44]. Only four studies reported participant race and ethnicity. In all four studies, participants predominately identified as White (range: 86.9–100% White). Detailed characteristics from each included study can be found in Table 1. Specific diet and physical activity intervention characteristics and outcomes can be found in Table 2.

### Intervention characteristics

While this systematic review aimed to examine lifestyle interventions that have been conducted concerning four different health behaviors (diet, physical activity, tobacco use,

and alcohol consumption), no studies were identified that have targeted smoking or alcohol consumption in rural cancer survivor populations. Of the eight studies identified for this review, three targeted both physical activity and diet [30, 41, 43], four targeted only physical activity change [38, 39, 42, 44], and one targeted only dietary change [40].

Five trial designs and methods were guided by theories or frameworks [30, 38, 42–44]. Four studies used the Social Cognitive Theory (SCT) [49] to guide their intervention [30, 42–44]. These studies focused on individual goal setting, self-efficacy, self-monitoring, and social support. The Steps Toward Improving Diet and Exercise (STRIDE) study incorporated the Self-determination Theory (SDT) [50] to support autonomy and allow the participants to choose which goal to work on [44] and the Reach-out to ENhance Wellness (RENEW) trial [43] drew on the Transtheoretical Model [51]. The Living Well trial incorporated the Person, Environment, Occupation (PEO) Model of occupational therapy [52], meant to support the incorporation of activity that is meaningful and valuable to the participant, support identity, and reflect culture. A large focus of the trial was an adaptation to activity that reinforced these goals [38].

Given the challenges to delivering evidence-based interventions to populations living in rural areas, such as transportation and facility access [31], seven of the eight

**Table 1** Summary of Eligible Rural Lifestyle Behavior Change Intervention Studies ( $n = 8$ )

Study title (author, year) location	Study design, behavior changes targeted	Cancer type(s), eligibility	Sample size, mean age (SD), sex (%), race	Mode of delivery, intervention provider, # of sessions, duration	Recruitment details, recruitment methods/sources	Retention rate, retention methods
<i>The Rural Women Connecting for Better Health Trial</i> (Befort, 2014 & 2016, Fazzino 2017) Kansas, Nebraska, Iowa, USA [30, 45, 46]	Two-arm RCT Diet and physical activity	1) Treated for Stage 0-IIIc breast cancer within the past 10 years 2) Have completed all local and systemic therapy (including Herceptin) at least 3 months prior to entry 3) Residing in a rural area (RUCA codes, Urban influence codes, amount of agricultural income, and/or individual commuting patterns) 4) BMI of 27 to 45 kg/m <sup>2</sup> 5) Postmenopausal 6) $\leq 75$ years of age	$n = 210$ in phase 1, $n = 172$ randomized to phase 2; $n = 87$ assigned to phone counseling, $n = 85$ assigned to newsletter comparison 58.0 (8.1) years Female (100%) Race: 97.1% ( $n = 204$ ) white	Delivery mode: Telephone group counseling vs. mailed newsletter, included 2 meal replacement shakes per day for the first 6 months and a home-based physical activity program Provider: Trained dietitian (registered dietitian or psychologist) Phase 1: 25 weekly 60-min group conference calls; Phase 2: 26 bi-weekly conference calls or 26 bi-weekly mailed newsletters	721 screened, 95% (688) responded to the mailed brochure, 257 were eligible, 216 attended orientation visit, 210 enrolled in phase 1, 172 randomized in phase 2 11 cancer centers, hospitals, or clinics provided information for patients treated for breast cancer in the previous 10 years, brochures mailed to rural zip codes only, community presentations, physician referral, local and statewide media coverage, and a mailing of the brochure by Mid-Kansas Susan G. Komen Foundation $n = 42$ eligible, $n = 24$ enrolled, $n = 18$ randomized	$n = 154$ retained at 18 months (89.5%), $n = 76$ in phone counseling and $n = 78$ in newsletter Group leaders contacted participants within 1 day of unexplained absence or 2 weeks of failing to report data. Standardized letters were sent by the program director for extended absences. Participants were also sent holiday cards and received a \$30 gift card at baseline, 6 months, and 12 months, a \$75 gift card at 18 and 24 months, and mileage reimbursement for all visits Not specified Not specified
<i>A best practice dietetic service for rural patients with cancer undergoing chemotherapy: a pilot pseudo-randomized controlled trial</i> (Brown, 2008) Australia [40]	Quasi-RCT Diet	1) Breast, colorectal, lung, lymphoma, and unspecified 2) Currently undergoing chemotherapy	$n = 18$ total; $n = 8$ intervention, $n = 10$ usual care 60 range: 41–74 years Male ( $n = 9$ , 50%) and female ( $n = 9$ , 50%) Race: not specified	Delivery mode: Face-to-face, telephone, and mail Provider: Dietician Duration: 8 weeks; weekly or fortnightly 15–30 min consultations for the intervention and monthly or once only 45–60 min consultation for usual care group	Clinical staff invitation at the first chemotherapy visit	Not specified

Table 1 (continued)

Study title (author, year) location	Study design, behavior changes targeted	Cancer type(s), eligibility	Sample size, mean age (SD), sex (%), race	Mode of delivery, intervention provider, # of sessions, duration	Recruitment details, recruitment methods/sources	Retention rate, retention methods
<i>Exercise for Health</i> (Eakin, 2012) Australia [42]	Two-arm RCT Physical activity	1) First diagnosis of invasive breast cancer 2) 6 weeks post-surgery 3) 20–69 years of age 4) Residing in a rural area (Australian Standard Geographical Classification)	$n = 143$ total; $n = 73$ telephone, $n = 70$ usual care Telephone: 51.7 (9.0) years, Usual care: 54.1 (8.7) years Female (100%) Race: not specified	Delivery mode: Telephone delivered, provided workbook and exercise tracker Provider: Exercise physiologists Duration: 8 months; 16 calls total of 15–30 min duration—once/week for 2 months, once/fortnight for 2 months, and once/month for 4 months	$n = 383$ approached, $n = 234$ eligible, $n = 143$ gave consent (61%) Breast care nurses at the hospitals approached all women receiving surgery for breast cancer. Research staff then called potential participants 3–4 weeks post-surgery to explain the trial and screen for eligibility	97% at 6 months and 96% at 12 months Multiple call-back attempts were made when a participant was not reached for a call
<i>Steps Toward Improving Diet and Exercise (STRIDE) Study</i> (Frensham, 2014, 2018, and 2018) Australia [44, 47, 48]	Quasi-RCT Physical activity	1) Breast, colorectal, lung, prostate, gynecologic, head and neck, and unspecified 2) Not undergoing active treatment (excluding hormone therapy) 3) Insufficiently active according to the Active Australia Survey	$n = 102$ total; $n = 51$ intervention, $n = 51$ control Intervention: 65.2 (9.3) 29–78 years; Control 66.1 (9.4) 44–86 years Male ( $n = 44$ , 48.4%) and female ( $n = 47$ , 51.6%) Race: 95.6% ( $n = 87$ ) white	Delivery mode: Intervention group uses a website (including space for community providers to advertise events and activities for social support) and are emailed weekly step goals based on their logged steps from the previous week. Two baseline sessions occur in-person, and the rest is remote Provider: Research staff Duration: two 90-min workshops and weekly emailed step goals for 12 weeks	$n = 169$ screened, $n = 102$ randomized Participants were recruited via cancer support groups, newspaper advertisements, hospitals, flyers, government departments, and allied health personnel contacts in both rural and metropolitan areas	$n = 91$ total; $n = 46$ intervention, $n = 45$ control $n = 43$ rural survivors retained None specified



Table 1 (continued)

Study title (author, year) location	Study design, behavior changes targeted	Cancer type(s), eligibility	Sample size, mean age (SD), sex (%), race	Mode of delivery, intervention provider, # of sessions, duration	Recruitment details, recruitment methods/sources	Retention rate, retention methods
<i>The Reach-out to Enhance Wellness (RENEW) Trial</i> (Gray, 2019) North Carolina, USA [43]	Two-arm RCT Diet and physical activity	1) $\geq 5$ years post-diagnosis of a loco-regionally staged breast, colorectal, or prostate cancer 2) $\geq 65$ years of age 3) BMI: 25–40 kg/m <sup>2</sup> 4) < 150 min of weekly MVPA	$n = 641$ total urban and rural participants; $n = 319$ intervention, $n = 322$ delayed intervention, $n = 160$ rural participants 73 (5) years Male ( $n = 69$ , 43.1%) and female ( $n = 91$ , 56.9%) Race: 86.9% ( $n = 139$ ) white	Delivery mode: Mailed print materials and weekly tapered to monthly telephone counseling Provider: Assigned counselor Duration: Telephone counseling weekly the first 3 weeks followed by every other week for 1 month and monthly up to 12 months. Mailed progress report every 12 weeks	$n = 20,015$ mailed study invitation letter, $n = 2156$ responded and mailed screener and consent, $n = 1208$ returned signed consent and completed screener, $n = 753$ completed baseline surveys, $n = 641$ urban and rural survivors deemed eligible, $n = 160$ rural residents included for analysis Cancer registries: the North Carolina Central Cancer Registry (NCCCR) and Duke Cancer Registry, and self-referrals from flyers posted to websites, physicians' offices, national meetings and NexCura, Inc (Thompson Company, Seattle, WA) an electronic mail posting to cancer registrants	$n = 488$ total; $n = 243$ intervention, $n = 245$ control, 24% attrition overall $n = 160$ rural participants retained Not specified

Table 1 (continued)

Study title (author, year) location	Study design, behavior changes targeted	Cancer type(s), eligibility	Sample size, mean age (SD), sex (%), race	Mode of delivery, intervention provider, # of sessions, duration	Recruitment details, recruitment methods/sources	Retention rate, retention methods
<i>The Living Well Trial</i> (Hegel, 2011) New Hampshire, USA [38]	Two-arm RCT Physical activity	1) Diagnosed with Stage 1–3 breast cancer 2) Beginning second cycle of chemotherapy	$n = 31$ total; $n = 15$ intervention, $n = 16$ usual care 52.6 (9.4) years Female (100%) Race: 100% ( $n = 31$ ) white	Delivery mode: PST-OT (problem-solving and occupational therapy) delivered via telephone Provider: Occupational therapist Duration: Weekly meetings for 6 weeks	$n = 46$ referred and screened, $n = 31$ enrolled Oncology nurse practitioner described the study to patients arriving consecutively for their initial chemotherapy consultation visit and provided their name to the study research assistant. The research assistant then completed the eligibility determination	$n = 29$ total; $n = 14$ intervention, $n = 15$ usual care Not specified
<i>I.CAN</i> (Ristevsk, 2020) Australia [41]	Three stream-controlled trial Diet and physical activity	1) Breast, colorectal, lymphoma, and unspecified 2) New and existing cancer patients admitted to the chemotherapy day unit 3) Currently undergoing chemotherapy	$n = 35$ total; Arm A: one-on-one support: $n = 18$ , Arm B: combination of one-on-one support and group sessions: $n = 10$ , Arm C: group sessions (2 h/fortnightly): $n = 7$ 65.9 (2) 44–90 years Male ( $n = 10$ , 29%) and female ( $n = 25$ , 71%) Race: not specified	Delivery mode: in-person initial consultation for personalized nutrition and physical activity plan, in-person group sessions Provider: Dietitian and exercise physiologist Duration: Group sessions 2 h each week for 6 weeks and 30 min one-on-one support	Not specified A collaboration of community organizations (leisure centers, community recreational groups), allied health (dietitians, exercise physiologists) and oncology specialists (nurses, medical oncology)	Not specified
<i>Effect of a short duration exercise program on physical fitness and quality of life in rural breast cancer survivors</i> (Santos-Olmo, 2019) Spain [39]	Quasi-RCT Physical activity	1) Diagnosed with Stage 1–IIIa breast cancer 2) $\geq 12$ weeks to $\leq 3$ years post-treatment 3) 18 to 70 years of age	$n = 30$ total; $n = 15$ per arm Intervention: 50.63 (8.56) years; Control: 52.62 (8.33) years Female (100%) Race: not specified	Delivery mode: in-person exercise sessions Provider: Research staff with degrees in Sports and Physical Activity Duration: 5 weeks; 3 exercise sessions per week—two supervised (75 min) and 1 aerobic on their own (60 min walks)	$n = 114$ referred and screened, $n = 35$ eligible, $n = 30$ enrolled and randomized Referrals from doctors and associations against cancer	$n = 21$ total; $n = 13$ control, $n = 8$ intervention Not specified

Abbreviations: USA, United States of America; RUCA, Rural-Urban Commuting Area; BMI, body mass index; RCT, randomized controlled trial



**Table 2** Summary of eligible intervention behavior change goals, measures, and measures of effect ( $n = 8$ )

Study title (author, year) location	Sample size, mean age (SD), sex	Diet		Physical activity		Measures of effect
		Intervention dietary change goals	Dietary change assessments	Intervention physical activity goals	Physical activity assessments	
<i>The Rural Women Connecting for Better Health Trial</i> (Befort, 2014 & 2016, Fazzino 2017) Kansas, Nebraska, Iowa, USA [30, 45, 46]	$n = 210$ in phase 1, $n = 172$ randomized to phase 2; $n = 87$ assigned to group phone counseling, $n = 85$ assigned to newsletter comparison Age: 58.0 (8.1) years Female (100%)	Diet reduced to 1200–1500 kcal/day and include greater than or equal to 5 FV servings/day, less than 25% kcal from fat, and 20–30 g of fiber. In phase 2, participants are given a new calorie goal calculated from the Harris–Benedict equation to sustain reduced body weight	At baseline, 6-, 12-, and 18-month visits, trained dietitians collect two 24-h dietary recalls on 2 non-consecutive days of the week including 1 weekend day using the United States Department of Agriculture multiple-pass approach. Participants also have self-reported food logs	MVPA increase from 15 min/day, 3 days/week to 225 min/week by week 12	At baseline, 6-, and 18-months, the Paffenbarger Physical Activity Questionnaire was collected. Participants also wore GT3X + Actigraph Accelerometers for 7 consecutive days	Median MVPA min/week (interquartile range) Accelerometer: Baseline: 18.4 (62.1), 6-months: 65.3 (166.3), 12-months: 40.3 (131.5), 18-months: 38.1 (119.3) ( $p = 0.01$ ) Paffenbarger self-report: Baseline: 0 (120.0), 6-months: 227.5(183.7), 12-months: 142.5 (220.0), 18-months: 150 (227.7) ( $p = 0.001$ ) N/A
<i>A best practice dietetic service for rural patients with cancer undergoing chemotherapy: a pilot pseudo-randomized controlled trial</i> (Brown, 2008) Australia [40]	$n = 18$ total; $n = 8$ intervention, $n = 10$ usual care 60 range: 41–74 years Male ( $n = 9$ , 50%) and female ( $n = 9$ , 50%)	Dietetic service outcomes/nutritional status improvements	Nutritional status measured by PG-SGA	N/A	N/A	Intervention: Baseline (SGA-A 75%, SGA-B 12.5%, SGA-C 12.5%) 8 weeks (SGA-A 87.5%, SGA-B 12.5%, SGA-C 0%) Control: Baseline (SGA-A 87.5%, SGA-B 12.5%, SGA-C 10%) 8 weeks (SGA-A 60%, SGA-B 40%, SGA-C 0%)

Table 2 (continued)

Study title (author, year) location	Sample size, mean age (SD), sex	Diet		Physical activity		Measures of effect
		Intervention dietary change goals	Dietary change assessments	Intervention physical activity goals	Physical activity assessments	
<i>Exercise for Health</i> (Eakin, 2012) Australia [42]	$n = 143$ total; $n = 73$ telephone, $n = 70$ usual care Telephone: 51.7 (9.0) years, Usual care: 54.1 (8.7) years Female (100%)	N/A	N/A	Exercise 4 days/week for at least 45 min with strength-based exercise at least twice/week	Active Australia Survey, Strength training was assessed via CHAMPS	Odds (OR, 95% CI) of meeting intervention targets favored the intervention group for resistance training (OR 3.2; 1.2, 8.9) and aerobic (OR 2.1; 0.8, 5.5) activity
<i>Steps Toward Improving Diet and Exercise (STRIDE) Study</i> (Frensham, 2014, 2018, and 2018) Australia [44, 47, 48]	$n = 102$ total; $n = 51$ intervention, $n = 51$ control Intervention: 65.2 (9.3) 29–78 years; Control 66.1 (9.4) 44–86 years Male ( $n = 44$ , 48.4%) and female ( $n = 47$ , 51.6%)	N/A	N/A	Personalized step targets using rate of perceived exertion and affect. The first week served as baseline data from which the first goals were set—with 0%, 5%, and 10% used as a guide for progression across the 12 weeks of the intervention on “bad,” “neutral,” and “good” days, respectively	Steps/day, measured using pedometer	Mean steps/day (SD) Baseline: Intervention: 7055 (2633), Control: 6667 (2993) ( $p = 0.56$ ) Week 12: Intervention: 9274 (3579), Control: 7499 (3320) ( $p = 0.04$ ) 3 months: Intervention: 8437 (3487), Control: 7333 (4044) ( $p = 0.55$ )
<i>The Reach-out to ENhance Wellness (RENEW) Trial</i> (Gray, 2019) North Carolina, USA [43]	$n = 641$ total; $n = 319$ intervention, $n = 322$ delayed intervention 73 (5) years Male ( $n = 69$ , 43.1%) and female ( $n = 91$ , 56.9%)	7–9 servings of FV daily, less than 10% of calories from saturated fat	Dietary intake data were averaged from 2 unannounced 24-h recalls at baseline and at 12 months	Greater than or equal to 30 min MVPA/day, 15 min strength training every other day	CHAMPS—frequency per week of all physical activities and minutes of all PA per week	The mean (SE) duration of strength training exercise increased in rural participants by 22.71 (3.94) min per week and the mean (SE) duration of endurance exercise minutes by 27.12 (7.98) min per week

Table 2 (continued)

Study title (author, year) location	Sample size, mean age (SD), sex	Diet		Physical activity		Measures of effect
		Intervention dietary change goals	Dietary change assessments	Intervention physical activity goals	Physical activity assessments	
<i>The Living Well Trial</i> (Hegel, 2011) New Hampshire, USA [38]	$n = 31$ total; $n = 15$ intervention, $n = 16$ usual care 52.6 (9.4) years Female (100%)	N/A	N/A	N/A	N/A	N/A
<i>I.CAN</i> (Ristevsk, 2020) Australia [41]	$n = 35$ total; Arm A: $n = 18$ , Arm B: $n = 10$ , Arm C: $n = 7$ 65.9 (2) 44–90 years Male ( $n = 10$ , 29%) and female ( $n = 25$ , 71%)	Individualized goals, not specified	Food Frequency Questionnaire	Individualized goals, not specified	Godin Leisure Time Exercise Questionnaire	Increase in positive food choices from 62% at baseline to 66% at 3 months, though not statistically significant
<i>Effect of a short duration exercise program on physical fitness and quality of life in rural breast cancer survivors</i> (Santos-Olmo, 2019) Spain [39]	$n = 30$ total; $n = 15$ per arm Intervention: 50.63 (8.56) years; Control: 52.62 (8.33) years Female (100%)	N/A	N/A	Increased physical fitness	Aerobic Capacity ( $VO_2$ max, Fitness Index, UKK Pulse, UKK recovery pulse), Muscular resistance (functional arms test, chair stand test)	N/A

Abbreviations: USA, United States of America; SD, standard deviation; SE, standard error; OR, odds ratio; MVPA, moderate to vigorous physical activity; FV, fruits and vegetables; PG-SGA, patient-generated subjective global assessment; CHAMPS, Community Health Activity Model Program for Seniors questionnaire; UKK, Urho Kaleva Kekkonen Institute for Health Promotion Research;  $VO_2$  max, maximal oxygen consumption

interventions utilized a home-based [30, 38, 42, 43] or hybrid delivery method [40, 44]. These interventions primarily utilized individual [38, 40, 42, 43] and group [30] telephone counseling as a way to provide greatest reach to rural areas and to support peer interaction for rural survivors. Interventions commonly incorporated mailed print materials [30, 38, 40, 42, 43], such as newsletters or workbooks, meal replacement shakes [30], and activity trackers as supplemental behavior change and study engagement strategies [42, 44]. The STRIDE trial was unique in the use of a website and emails to participants with weekly goals. The interactive website was used as a place for participants to record their steps taken and as a place for participants to interact with their peers in an online forum [44]. The I.CAN program was delivered in-person in the chemotherapy day unit where cancer patients were already traveling to receive care, thus not increasing the travel burden above their routine cancer care [41]. The physical activity intervention conducted by Santos-Olmo et al. in Spain included two supervised, in-person sessions and one unsupervised session [39]. Santos-Olmo et al. intended to minimize burden while maximizing potential impact by keeping the intervention under 5 weeks and creating a hybrid delivery model. In-person sessions incorporated exercise machines that participants could not access in a remotely delivered intervention. Importantly, the authors noted that while supervised sessions tend to show greater effect, unsupervised, home-based exercises are ideal as a tool for rural survivors to participate in long-term exercise programming.

Intervention duration ranged in time from 5 weeks [39], 8 weeks [40], 12 weeks [38, 41, 44], 8 months [42], 12 months [43], and 2 years [30]. The interventions were delivered primarily by health care professionals, including registered dietitians [30, 40, 41], psychologists [30], exercise physiologists [39, 41, 42], and occupational therapists [38]. The STRIDE study and the RENEW trial did not specify the qualifications of the intervention providers [43, 44].

### Diet intervention and behavior change

Four studies targeted dietary change [30, 40, 41, 43]. Dietary change goals included change in energy consumption [30], increase in fruit and vegetable servings daily [30, 43], decrease in calories consumed from fat [30, 43], increase in the grams of fiber consumed [30], and change in nutritional status [40]. To measure these outcomes, studies utilized food frequency questionnaires (FFQ) [41], 24-h dietary recalls [30, 43], self-report food logs [30], and the patient-generated subjective global assessment (PG-SGA) [40, 53]. All four studies showed improvements in a priori outcomes in the direction of clinical interest after intervention, though these changes were not found to be significant. The Rural Women Connecting for Better

Health trial showed significant weight loss among intervention participants, without significant change in self-reported dietary behaviors reported [30]. The I.CAN study reported an increase in positive food choices from 62% at baseline to 66% at 3 months [41]. The RENEW trial showed a 1.47 mean increase in fruit and vegetable servings and a 3.33 g per day mean decrease in saturated fat consumption for rural participants [43]. Finally, Brown et al. showed improvement in reported nutritional status after intervention [40].

### Physical activity intervention and behavior change

Seven trials targeted physical activity [30, 38, 39, 41–44]. Goals for physical activity change included increase in moderate to vigorous aerobic physical activity (MVPA) minutes per week [30, 43], increase in step count [44], and increase in frequency of strength training [39, 42, 43] and aerobic exercise sessions [38, 39, 42]. These were analyzed using subjective measures such as the Paffenbarger Physical Activity Questionnaire [30, 54], the Godin Leisure Time Exercise Questionnaire [41, 55], the Community Health Activity Model Program for Seniors Questionnaire (CHAMPS) [42, 43, 56], and the Active Australia Survey [42, 57]. Objective measures utilized include actigraphy [30], the Urho Kaleva Kekkonen Institute for Health Promotion research (UKK) test, which includes heart rate, Fitness Index, and VO<sub>2</sub> max [39, 58], and a dumbbell and squat test to measure change in muscle resistance [39, 59, 60]. Four of the efficacy trials showed significant changes in physical activity or fitness outcomes post-intervention [30, 41, 42, 44]. The Rural Women Connecting for Better Health trial showed a significant increase in accelerometer-measured MVPA from baseline to 18 months (+19.7 min) [61]. The I.CAN trial found a statistically significant increase in exercise activity from 51% at baseline to 86% at 3 months ( $p < 0.001$ ) [41]. The STRIDE trial showed a significant increase in mean steps per day for intervention participants from baseline to 12 weeks (+2219 steps) [44]. The Exercise for Health trial found odds of meeting intervention targets favored the intervention group for resistance training (OR 3.2) and aerobic (OR 2.1) activity [42].

### Interface of age and rurality

Three studies reported participant mean age greater than 65 years [41, 43, 44]. Among these studies, only the RENEW trial included an a priori focus on older cancer survivors [43]. However, while this study did recruit and report outcomes for rural participants, rurality was not an inclusion criterion. The study included both urban and rural

participants and did not tailor the intervention for rural delivery. Similarly, the STRIDE trial included both urban and rural participants, but did not tailor the intervention for either older or rural cancer survivors [44]. While the I.CAN trial was tailored for rural delivery, it was not tailored for older age [41]. The RENEW trial found that older and rural cancer survivors reported significantly more favorable mean changes in physical functioning ( $p=0.015$ ) and physical health ( $p=0.044$ ) than older and urban participants [43]. Lower percentages of rural participants met study goals related to fruit and vegetable consumption and saturated fat than urban survivors.

**Risk of bias**

Full risk of bias assessment can be seen in Fig. 2. Based on assessment from two independent reviewers (SW, RR-M), all included studies had at least some risk for concern or high risk of bias. For the randomization process, three studies were low risk of bias [42–44], one had unclear risk [30], and four had high risk of bias [38–41]. Allocation concealment was not well described in any trial; four studies had unclear risk [30, 42–44]; and four had high risk of bias [38–41] due to the ambiguity. Given the nature of behavioral interventions, blinding of participants and study staff was difficult, resulting in all studies having a high risk of bias. For blinding of outcome assessment, two trials had low risk of bias

[42, 43], two had unclear risk [41, 44], and four had high risk of bias [30, 38–40]. Most studies had low risk of bias for incomplete outcome data and selective reporting. Only three had unclear risk of bias in these areas [40, 41, 44].

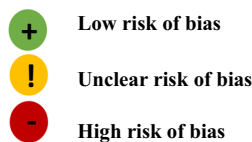
**Discussion**

This review highlights the current literature regarding physical activity and dietary interventions conducted with rural survivors of cancer. A key finding from this review is that the number of studies published on this topic is limited, and no studies addressing alcohol or tobacco use were identified. The trials reported suggested that the interventions were effective in promoting diet and physical activity change. Most interventions utilized a remote or hybrid delivery approach to reach rural participants. The majority of trials incorporated behavioral theory with most focusing on personalized goal setting and individual motivation for promotion of behavior change.

No lifestyle behavior change interventions were identified which set an a priori focus on the intersectionality of age and rurality in cancer survivorship. Only six studies tailored or designed the intervention for rural delivery, regardless of age. Given the known health inequities for older, rural cancer survivors, such as lack of access to

**Fig. 2** Risk of bias summary diagram

	Random sequence generation	Allocation concealment	Blinding of participants and study staff	Blinding of outcome assessment	Incomplete outcome data	Selective reporting
The Rural Women Connecting for Better Health Trial (Befort, 2014 & 2016, Fazzino 2017)	!	!	-	-	+	+
Steps Toward Improving Diet and Exercise (STRIDE) Study (Frensham, 2014, 2018, and 2018)	+	!	-	!	+	!
I.CAN (Ristevsk, 2020)	-	-	-	!	!	+
Effect of a short duration exercise program on physical fitness and quality of life in rural breast cancer survivors: A pilot study (Santos-Olmo, 2019)	-	-	-	-	+	+
The Living Well Trial (Hegel, 2011)	-	-	-	-	+	+
The Reach-out to ENhance Wellness (RENEW) Trial (Gray, 2019)	+	!	-	+	+	+
A best practice dietetic service for rural patients with cancer undergoing chemotherapy: a pilot pseudo-randomized controlled trial (Brown, 2008)	-	-	-	-	!	+
Exercise for Health (Eakin, 2012)	+	!	-	+	+	+



healthy food, transportation barriers, lack of public infrastructure, and scarcity of health professionals [31, 62, 63], this gap in the literature must be addressed. The RENEW trial that enrolled older and rural (as well as urban) cancer survivors showed a significant improvement in physical functioning, as measured by the Medical Outcomes Study Short-Form 36. It also demonstrated lower adherence to dietary change goals for rural versus urban participants [43]. This suggests that interventions which are shown to be effective for urban cancer survivors may not be as acceptable and/or effective for rural cancer survivors. Evidence-based interventions should be tailored and adapted for the needs of rural populations.

While there has been an overall increase in the use of telehealth methods for health promotion in the last decade [22], such as mobile app or internet-based interventions, access to broadband in rural areas is limited, and older survivors are less likely to use the internet [64, 65]. Though telehealth methods would appear to be ideal to overcome some barriers to rural intervention implementation, increased use of online platforms to promote behavior change interventions may leave older, rural cancer survivors behind, magnifying the health disparities faced by this population. This review highlights five interventions which utilized both individual and group telephone-based counseling [30, 38, 40, 42, 43], while only one, the STRIDE study, utilized an internet-based intervention [44]. The STRIDE study was conducted with both rural and urban participants and found that rural participants had lower engagement with the website than urban participants [44], possibly an indication of the need for specified technical support for rural participants. Telephone counseling appears to be feasible for rural intervention delivery. However, there is not enough research completed with mobile app or internet-based interventions to determine feasibility for older, rural cancer survivor populations. Preliminary research, though sparse, suggests that older and rural survivors of cancer are interested in adopting the use of mHealth tools to support self-monitoring of health and encourage health behavior change [66, 67]. For example, Ginossar et al. conducted interviews and focus groups with older, rural cancer survivors in New Mexico to explore perception of mHealth technology as a tool for health promotion. Participants identified that mHealth technology is compatible with behavior change goals, that the use of mHealth tools is advantageous over current methods for tracking health, and that the use of mHealth technology would increase motivation to change behaviors [67].

There is significant heterogeneity across the included studies that warrant further consideration. First, studies were conducted across the globe. This resulted in a wide variety of included measures for diet and physical activity that are difficult to compare without additional analysis. Considerations for cultural adaptation and resource availability will also

vary based on geographic location. Second, studies recruited across the survivorship continuum, a dynamic period which includes both active treatment with curative intent as well as post-treatment care and follow-up. Survivors actively undergoing treatment may have different response to and acceptability of lifestyle behavior intervention compared to participants who are finished with active treatments. For example, survivors in the first-year post-treatment frequently report greater symptom burden than during treatment [68], a factor that may impact behavior change goal acquisition. As three of the included studies enrolled participants undergoing active treatment while the other five enrolled participants at least 6 weeks post-treatment, this difference in enrollment criteria may have implications for recruitment feasibility, retention, participant adherence to the intervention activities, and dietary and physical activity-related outcomes. Finally, half of the studies recruited only breast cancer survivors while the other four recruited across cancer types. This is not surprising as breast cancer is the most frequently diagnosed cancer in women [1]. This review has indicated that there is a lack of evidence-based lifestyle behavior change programming for rural survivors diagnosed with non-breast malignancies and additional efforts are warranted.

Our initial search terms were selected to evaluate and describe literature about smoking and alcohol consumption in addition to diet and activity interventions; however, no interventions targeting these health behaviors were identified. For survivors of cancer, research shows that the risk of subsequent primary cancer is lower if the survivor quits smoking, even if they do not quit until after their first diagnosis [69]. Smoking and alcohol consumption also impact quality of life and cancer-related fatigue after cancer treatment [70, 71]. This lack of smoking and alcohol cessation programming adapted for rural survivors of cancer highlights a gap that should be addressed by future evidence-based interventions, especially due to the tobacco- and alcohol-related health disparities that are known to contribute to morbidity and mortality in rural areas [72–75].

The strengths of this review are that the inclusion criteria were not limited by language or publication year, allowing for the inclusion of one article published in Spanish [39] and a comprehensive search for any intervention conducted with rural survivors of cancer. While describing the effectiveness of these trials, this review also highlights key intervention characteristics used for dissemination and implementation and includes a novel focus on the intersection of age and rurality. As with any systematic review, one limitation is that there is a chance that some studies may have been missed using our search strategy. While the authors have experience in developing search strategies for systematic reviews and have been trained by research librarians, additional consultation with a research librarian may have further enhanced the thoroughness of the search. The limited number of studies identified and



the diversity in the study methods, population, and settings limit the generalizability of the findings. As three of the studies were pilot or feasibility trials, they were likely not sufficiently powered to assess efficacy of the intervention and thus overall efficacy for lifestyle behavior change in rural cancer survivors is unclear. Additionally, many studies had a high risk of bias. It is difficult to conceal or blind study assignment when asking participants to change a behavior. This may have resulted in a Hawthorne effect or social-desirability bias as participants may have changed how they would otherwise behave because they were being observed. Another risk for the I.CAN trial was self-selection bias as participants were able to select which of the three arms of the trial that they would like to participate in. Interpretation of study findings should consider the generalizability of the data and real-world application.

## Conclusion

In summary, this review identified that sparse research has been conducted to implement and evaluate the effectiveness of lifestyle behavior change interventions among older, rural cancer survivors, even though nearly 20% of cancer survivors live in rural areas of the country [10], 60% of survivors are over 65 years of age [2, 9], and there are known health disparities faced by these populations [27–29]. Future research should focus on the intersection of rurality and aging in cancer survivorship and determine the acceptability and feasibility of delivery methods and implementation strategies. Utilizing telehealth methods with rural cancer survivor populations, particularly older cancer survivors, to overcome barriers for implementing interventions in remote areas holds promise to improve the current state of wellness interventions and care in this underserved group of survivors. Given the limited availability of published work in this area, further qualitative and quantitative research to robustly describe the acceptability and feasibility of lifestyle behavior change interventions in this population are warranted. Future research should identify key considerations for adapting evidence-based interventions for delivery in rural areas and assess the fidelity of these adapted interventions.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s11764-023-01464-4>.

**Acknowledgements** The authors would like to thank Dr. Amanda Sokan and Dr. Zhao Chen for their topic expertise and feedback on early drafts of this manuscript.

**Author contribution** Study conception and design was completed by SJW with guidance from CAT and RR-M. Material preparation, data collection and analysis were performed by SJW and RR-M. The first draft of the manuscript was written by SJW and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

**Funding** This research was supported by the University of Arizona Cancer Center Support Grant (P30 CA023074).

## Declarations

**Competing interests** The authors have no relevant financial or non-financial interests to disclose.

**Conflict of interest** None

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