



City Research Online

City St George's, University of London

Citation: Smith, S., Lally, P., Steptoe, A., Chavez-Ugalde, Y., Beeken, R. J. & Fisher, A. (2024). Prevalence of loneliness and associations with health behaviours and body mass index in 5835 people living with and beyond cancer: a cross-sectional study. *BMC Public Health*, 24(1), 635. doi: 10.1186/s12889-024-17797-3

This is the published version of the paper.

This version of the publication may differ from the final published version. To cite this item please consult the publisher's version.

Permanent repository link: <https://openaccess.city.ac.uk/id/eprint/33646/>

Link to published version: <https://doi.org/10.1186/s12889-024-17797-3>

Copyright and Reuse: Copyright and Moral Rights remain with the author(s) and/or copyright holders. Copies of full items can be used for personal research or study, educational, or not-for-profit purposes without prior permission or charge, unless otherwise indicated, provided that the authors, title and full bibliographic details are credited, a hyperlink and/or URL is given for the original metadata page and the content is not changed in any way. For full details of reuse please refer to [City Research Online policy](#).

RESEARCH

Open Access



Prevalence of loneliness and associations with health behaviours and body mass index in 5835 people living with and beyond cancer: a cross-sectional study

Susan Smith¹, Phillippa Lally², Andrew Steptoe¹, Yanaina Chavez-Ugalde³, Rebecca J Beeken^{4†} and Abi Fisher^{1*†}

Abstract

Background A cancer diagnosis and its treatment may be an especially isolating experience. Despite evidence that positive health behaviours can improve outcomes for people living with and beyond cancer (LWBC), no studies have examined associations between loneliness and different health behaviours in this population. This study aimed to describe the prevalence of loneliness in a large sample of UK adults LWBC and to explore whether loneliness was associated with multiple health behaviours.

Methods Participants were adults (aged ≥ 18 years) diagnosed with breast, prostate or colorectal cancer who completed the Health and Lifestyle After Cancer Survey. Loneliness was reported using the UCLA loneliness score, dichotomised into higher (≥ 6) versus lower (< 6) loneliness. Engagement in moderate-to-vigorous physical activity, dietary intake, smoking status, alcohol use, and self-reported height and weight were recorded. Behaviours were coded to reflect meeting or not meeting the World Cancer Research Fund recommendations for people LWBC. Logistic regression analyses explored associations between loneliness and health behaviours. Covariates were age, sex, ethnicity, education, marital status, living situation, cancer type, spread and treatment, time since treatment, time since diagnosis and number of comorbid conditions. Multiple imputation was used to account for missing data.

Results 5835 participants, mean age 67.4 (standard deviation = 11.8) years, completed the survey. 56% were female ($n = 3266$) and 44% ($n = 2553$) male, and 48% ($n = 2786$) were living with or beyond breast cancer, 32% ($n = 1839$) prostate, and 21% ($n = 1210$) colorectal. Of 5485 who completed the loneliness scale, 81% ($n = 4423$) of participants reported lower and 19% ($n = 1035$) higher loneliness. After adjustment for confounders, those reporting higher levels of loneliness had lower odds of meeting the WCRF recommendations for moderate-to-vigorous physical activity (Odds Ratio [OR] 0.78, 95% Confidence Interval [CI], 0.67, 0.97, $p = .028$), fruit and vegetable intake (OR 0.81, CI 0.67, 1.00, $p = .046$), and smoking (OR 0.62, 0.46, 0.84, $p = .003$). No association was observed between loneliness and the other dietary behaviours, alcohol, or body mass index.

[†]Rebecca J Beeken and Abi Fisher are joint senior authors.

*Correspondence:

Abi Fisher
abigail.fisher@ucl.ac.uk

Full list of author information is available at the end of the article



© The Author(s) 2024. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Conclusions Loneliness is relatively common in people LWBC and may represent an unmet need. People LWBC who experience higher levels of loneliness may need additional support to improve their health behaviours.

Keywords Loneliness, Cancer survivors, Smoking, Exercise, Diet

Background

There are over 3 million people living with and beyond a cancer diagnosis (LWBC) in the United Kingdom (UK) [1]. Assuming trends continue, this will increase by 1 million per decade to 2040 [2]. Similar increases have been observed in other developed countries [3]. As cancer survival rates continue to improve, it is crucial to ensure that people LWBC are supported to achieve the best quality of life, a key aim of cancer strategies [4, 5]. Loneliness (the subjective negative experience of social isolation [6, 7]) is an established risk factor for poorer health and higher mortality in the general population [8–11], and there is some indication that loneliness may result in worse outcomes after a cancer diagnosis [12].

In a meta-analysis of 87 prospective cohorts of cancer patients, factors associated with lower loneliness, such as greater social network size, higher perceived social support, and being married, were associated with 12–25% lower mortality, although a measure of loneliness itself was not included [13]. Furthermore, a synthesis of 20 qualitative studies identified sources of loneliness specifically related to a cancer diagnosis and treatments, including feeling alone in the experience, others' avoidance of discussion about cancer, lack of understanding/misperceptions of cancer, lack of recognition of the impact of the side effects of treatment, and unmet needs in the healthcare system [14]. For instance, Rosedale described how women diagnosed with breast cancer reported that their healthy peers had difficulty grasping the magnitude of the challenges they faced. They described feeling left behind as others continued with their lives, resulting in feelings of loneliness, disconnectedness, and distress [15]. A meta-analysis of 15 observational studies describing the prevalence of loneliness after a cancer diagnosis found moderate prevalence and associations with a number of demographic and clinical factors [16]. However, the samples within the included studies were small (13/15 included ≤ 200 participants), and larger studies exploring loneliness after acute cancer treatment phases are needed.

Loneliness may impact health outcomes via both direct biological mechanisms and behavioural mechanisms [17, 18]. For example, loneliness may have a negative impact on health behaviours in people LWBC and an ever-growing body of evidence suggests that healthier behaviours lead to better outcomes after a cancer diagnosis [19–22]. This has led a number of governing bodies, such as the World Cancer Research Fund and American Institute for Cancer Research (WCRF/AICR), to issue health

behaviour guidance for those LWBC [23, 24]. There is already evidence to suggest that some health behaviours worsen following a diagnosis of cancer and its treatments (e.g., decline in physical activity [25, 26]), so negative effects could be exacerbated in lonelier people. However, data exploring associations between loneliness and health behaviours are mainly from the general population. A systematic review of 37 studies exploring the association between loneliness and physical activity, including healthy older adults and adolescents, found negative associations between physical activity and loneliness in 12 cross-sectional studies and one longitudinal study [27]. Although relationships are likely to be bidirectional, four prospective studies have found that people with higher levels of loneliness at baseline were less likely to be physically active at follow-up [28–31]. While Newall and colleagues reported that loneliness predicted perceived engagement in physical activity in a sample of 228 older adults, they also found that this relationship was moderated by happiness, suggesting that happiness may buffer against the negative effect of loneliness in this age group [29]. In a study of older adults taking part in the English Longitudinal Study of Ageing (ELSA), Kobayashi and Steptoe investigated the associations between social isolation and loneliness at baseline and engagement in health behaviours over 10 years [32]. After dichotomisation of health behaviours into meeting or failing to meet the public health recommendations, they observed that higher loneliness was associated with lower odds of meeting the recommendations for physical activity, smoking and body mass index (BMI), although the association between loneliness and health behaviours was lost after adjustment for sociodemographic variables [32, 33]. Similarly, where Schrempf and colleagues examined how objective physical activity differs according to levels of social isolation and loneliness in ELSA, a negative association was observed between total physical activity counts and loneliness, although this was attenuated after adjusting for covariates [33]. Data exploring associations between loneliness and physical activity in people LWBC are lacking. In older breast cancer survivors, one prospective study found an inverse association between loneliness and physical activity over a five-year follow-up period [34], while another cross-sectional study found that lower social support and living alone was associated with lower levels of physical activity [35].

In addition to physical activity, there is also some evidence that loneliness can also impact health via smoking and poor dietary intake. A systematic review of studies on

loneliness and smoking reported that over half of the 23 included studies observed an association between smoking and loneliness, and their results consistently demonstrated that lonely people were more likely to be smokers [36]. This association is likely to be bidirectional whereby smokers are also more likely to be lonely [37]. Despite qualitative data suggesting that experiencing loneliness may negatively impact eating habits in older adults [38, 39], quantitative data exploring associations between loneliness and intake of different dietary components are lacking. Lastly, loneliness may impact body mass index (BMI) in people LWBC, as evidence from the general population suggests a complex association between loneliness and obesity due to factors such as weight-related stigma [40, 41]. While there is conflicting evidence suggesting a BMI in the overweight range (25–29.9) may be associated with improved survival across some cancer types, explanations for this paradox have still yet to be established [42, 43]. Acknowledging that this evidence is still inadequate to make specific recommendations with confidence, the WCRF recommends that people LWBC follow the guidelines published for healthy populations in maintaining a BMI in the healthy range (18.5–24.9), recognising that this is unlikely to be harmful to people LWBC who have completed treatment [42].

While the link between loneliness and health behaviours in this population remains underexplored, behaviour change theories such as social cognitive theory (SCT [44]) and the capability, opportunity, and motivation model of behaviour (COM-B [45]) can complement each other in providing us with possible explanations for this relationship. In line with SCT, it is plausible that individuals with LWBC experiencing loneliness may experience low self-efficacy attributed to feeling a loss of control over their health and how others react [14], and this lack of confidence can hinder their ability to engage in behaviours such as physical activity [46]. This is also emphasised by the COM-B model where reduced capability can erode the individual's confidence and belief in their ability to perform positive health behaviours. Furthermore, the opportunity component of the COM-B model asserts that the environment must make the execution of the behaviour possible [45]. As lonelier people LWBC may have fewer supportive networks to encourage and facilitate participation in health-promoting behaviours, their opportunity to perform these behaviours can be limited [15].

The aims of the current study were to (i) describe the prevalence of loneliness in a large sample of LWBC in the UK and (ii) explore associations between loneliness and health behaviours while adjusting for sociodemographic and clinical factors.

Methods

Design and participants

The 'Health and Lifestyle after Cancer' survey was mailed to patients who had received a diagnosis of breast, prostate, or colorectal cancer between 2012 and 2015 at 10 participating National Health Service (NHS) hospital sites in London and Essex (United Kingdom). Dates of diagnosis for survey administration were chosen because the survey was also used to identify initial interest in the Advancing Survival after Cancer Outcomes Trial (ASCOT) (which included only patients who had completely primary curative treatment) [47]. Patients were identified by hospital staff and although primarily included patients diagnosed between 2012 and 2015, the final sample for the analysis included patients diagnosed with breast, prostate, or colorectal cancer outside of these dates (range: 1994–2017). As some participants had received a subsequent cancer diagnosis, the date of their most recent breast, prostate, or colorectal cancer diagnosis was reported and used in the analysis. This ranged between 2001 and 2017 in the final sample (mean time in months=35.5, standard deviation (SD)=13.6). Survey packs were sent between February 2015 and November 2017 and included a letter of invitation signed by the hospital consultant, a paper version of the survey, and a link to an online version. Participants completed the survey via their preferred method and returned it directly to the research team. Returned questionnaires were accepted until 4th January 2018. No data were collected on non-responders.

Inclusion and exclusion

Inclusion criteria were adults (≥ 18 years) who had received a diagnosis of breast, prostate, or colorectal cancer in one of the participating hospitals. Survey exclusion criteria were intentionally minimal to make administration at hospital sites as low-burden as possible. Patients were only excluded if it was identified that they were deceased or if hospital staff deemed it inappropriate to send the patient a questionnaire for any other reason (e.g., they had previously requested not to be approached about participation in research).

Ethical approval

This study received ethical approval from the NHS National Research Ethics Committee—South Central Oxford B (reference 14/SC/1369). The initial page of the survey stated that completion and return of the questionnaire meant giving consent for the anonymous collected data to be used in research on lifestyle in people diagnosed with cancer.

Demographic and clinical characteristics

Age was recorded as a continuous variable (in years). Sex (male/female), highest level of education (no formal qualifications/General Certificate of Secondary Education/Vocational or equivalent/A-level or equivalent/Bachelor's Degree and above), marital status (married/divorced or separated or widowed or single), and living arrangements (alone/with others) were recorded. Ethnicity information was collected by 15 possible responses to the question "Which of these best describes your ethnic group?". For cancer-related questions, participants were asked to answer in relation to their most recent cancer diagnosis, given the questionnaire was sent based on their diagnosis of breast, prostate, or colorectal cancer in 2012 or 2013. Participants were asked to report their cancer stage (1/2/3/4/don't know), but because a high proportion (43%) didn't know, 'has your cancer spread' (yes/no) was used as a proxy (after confirmation from an oncologist that this was acceptable). Cancer treatments (no treatment or active surveillance/surgery/surgery plus one other/other combination of treatment) and time since main treatment completed (<1 year/1–5 years/on active surveillance) were reported. Time since diagnosis was calculated as the time between their most recent cancer diagnosis date and the date when the questionnaire was received back by the research team (in months). Participants self-reported their comorbidities from a pre-defined list including 15 conditions (osteoporosis/diabetes/asthma/emotional or psychiatric illness/stroke/Parkinsons disease/Alzheimer's disease or dementia/lung disease/arthritis/angina/heart attack/heart murmur/irregular heart rhythm/any other heart trouble/another cancer) and could report any 'other' comorbidities that were not present on the list. Total comorbidities were calculated by adding these together and where participants did not report having any of these conditions, this was interpreted as having no comorbidities. Self-reporting of comorbid conditions has shown a high level of accuracy when compared with medical records in people LWBC [48, 49].

Exposure: loneliness

Loneliness was assessed using the 3-item short form of the Revised UCLA Loneliness Scale [50]. The UCLA scale has been the most commonly used to assess loneliness after cancer [16], and items in the short form are 'How often do you feel you lack companionship?', 'How often do you feel left out?' and 'How often do you feel isolated from others?' with response options: '1=Hardly ever or never', '2=Some of the time', and '3=Often'. Scores for each item are summed to create a total loneliness score that can range from 3 to 9. Total scores were not normally distributed, so they were dichotomised to represent higher (≥ 6) and lower loneliness (< 6). This approach was

taken in previous research in the English Longitudinal Study of Ageing [32], allowing for descriptive comparison of the prevalence of loneliness with a representative sample of older adults in the general population.

Outcomes: health behaviours and BMI

The guidelines for each behaviour for people LWBC were taken from the WCRF/AICR [4] and national UK guidelines, and these were coded as meeting vs. not meeting guidelines.

Physical activity

Weekly minutes of moderate to vigorous physical activity (MVPA) were assessed using the Godin Leisure Time Exercise Questionnaire (GLTEQ). The GLTEQ is the most commonly used self-report measure of activity in oncology and compares favourably to objective measures [51–53]. The questionnaire was modified to include a question about duration of activity to allow calculation of minutes of MVPA, which is a very common approach in oncology research [52]. MVPA was dichotomised as meeting (≥ 150 min/week) or not meeting (< 150 min/week) recommendations.

Diet

The validated Dietary Instrument for Nutrition Education Food Frequency Questionnaire (DINE FFQ) [54] was used to assess dietary intake including fibre and fat intake, with some food items updated to reflect those currently available and items amended to include red and processed meat estimation [47]. This measure has been previously validated in the general population [54] and was chosen after a review of validated food frequency questionnaires and a review of how diet has previously been assessed in people LWBC [47]. To estimate free sugar, the survey asked about consumption of sugary drinks and fruit juices [55] and included a custom-made question asking participants to write their total number of teaspoons of added sugar per day. Two items were included to measure the number of daily portions of fruit and vegetables [56]. This measure has demonstrated sufficient validity when compared against blood chemistry [56, 57]. The cut-off scores for meeting the WCRF recommendations were as follows: fruit and vegetables (≥ 5 portions/day), fibre (≥ 30 g Association of Official Analytical Collaboration fibre [58]/day), free sugar ($< 5\%$ calories from free sugars/day), fat ($< 33\%$ total energy), red meat (< 500 g/week), and processed meat (none). The scoring system implemented for operationalising meeting or not meeting the recommendations has been described previously [59].

Alcohol & smoking

Smoking status was collected with a single item from the Health Survey for England to categorise participants as current smokers (not meeting) or non-smokers (meeting) [60]. Alcohol consumption was self-reported with two items (How often do you have a drink containing alcohol?; How many units of alcohol do you drink on a typical day when you are drinking?), adapted from The Alcohol Use Disorders Identification Test consumption questions (AUDIT-C [61]) which were calculated into an estimate of the average number of units consumed per week. The use of the AUDIT in its original and reduced form has been validated across different contexts and cultures [62]. Meeting or not meeting this recommendation was operationalised based on the national UK guidelines for alcohol consumption of not exceeding more than 14 units of alcohol per week [63].

Body mass index

BMI was calculated from participants' self-reported height and weight. Participants were classified into the following categories: underweight, healthy, overweight, or obese [64]. Meeting the WCRF recommendation for BMI was operationalised as being classified into the healthy weight category (18.5–24.9 kg/m²).

Covariates

Demographic and clinical variables that have previously been associated with loneliness and/or health behaviours were included as covariates [16, 65–71]. This included age, sex, level of education, marital status, and living arrangements. Ethnicity was dichotomised (white/any other ethnicity) due to a very high proportion reporting being white (90%). 'Has your cancer spread' was used as a proxy to determine cancer stage. Type of cancer, type of treatment, time since diagnosis, time since completion of main treatment, and number of reported comorbidities were also included.

Analyses

IBM Statistical Package for the Social Sciences (SPSS) version 26 was used [72]. Descriptive statistics were used to present participant characteristics and to describe the proportion of people reporting higher versus lower loneliness (Aim i).

Missing value analysis found that 5.5% of 518,348 values were missing and that 27.8% of 5,835 cases had at least 1 piece of missing data. Multiple imputation with 20 iterations was conducted to account for missing data [73].

To examine whether loneliness was associated with health behaviours (Aim ii), a series of binary logistic regressions were run with loneliness as the exposure, each WCRF health behaviour recommendation as the

outcome and adjusting for all covariates. To avoid the 'Table 2 fallacy' [74], only the odds ratio (OR) and 95% confidence interval (CI) for the associations between exposure and outcomes are presented here. Regression analyses were repeated in the non-imputed original data to explore whether findings were similar.

Results

A total of 13,645 surveys were sent, and 5835 were returned (43% response rate). No data were collected on non-responders.

Descriptive statistics

Demographic and clinical characteristics are presented in Table 1. Participants mean age was 67 years (SD=12, range 26–97). 44% ($n=2553$) were male and 56% ($n=3266$) were female. 48% ($n=2786$) were living with or beyond breast cancer, 32% ($n=1839$) prostate and 21% ($n=1210$) colorectal.

Descriptive data for loneliness and health behaviours are presented in Table 2. 76% ($n=4423$) participants reported lower loneliness, and 18% ($n=1035$) reported higher loneliness. 377 participants (7%) had missing data. Of the 5485 participants who completed the loneliness scale, 81% ($n=4423$) reported lower and 19% (1035) reported higher loneliness. A descriptive comparison of those with complete data versus imputed data is presented in Additional file 1.

Regression results

Pooled (20 iterations) associations between loneliness and health behaviours are presented in Table 3. After adjustment for covariates, those reporting higher levels of loneliness had lower odds of meeting the WCRF recommendations for MVPA (OR 0.78, 95% CI 0.67, 0.97), fruit and vegetables (OR 0.81, CI 0.67, 1.00), and smoking (OR 0.62, 0.46, 0.84), but not other dietary recommendations (fibre, red or processed meat, sugar, fat– OR and CIs presented in Table 3), alcohol (OR 0.89, CI 0.67, 1.19) or BMI (0.79, CI 0.46, 1.16).

Analysis with the original data

Logistic regression analyses with the complete case data showed similar associations to the imputed data (see Additional file 1).

Discussion

In this sample of 5835 people LWBC, 76% reported experiencing lower levels of loneliness, while 18% reported higher loneliness. Individuals who reported higher levels of loneliness were less likely to meet the WCRF recommendations for MVPA, fruit and vegetable intake, and smoking (i.e. they are less likely to do the recommended levels of activity (150 min a week), they are less likely to

Table 1 Participant characteristics

| Variable | Respondents (N = 5835) |
|--|---------------------------|
| Sex n(%) | |
| Male | 2553 (43.8) |
| Female | 3266 (56.0) |
| Missing | 16 (0.3) |
| Age in years | |
| Mean (SD ^a) | 67.4 (11.8) |
| Missing n(%) | 36 (0.6) |
| Highest education n(%) | |
| None | 1709 (29.3) |
| General Certificate of Secondary Education/Vocational | 1613 (27.6) |
| A-Level | 584 (10.0) |
| Degree or above | 1379 (23.6) |
| Missing | 550 (9.4) |
| Marital status n(%) | |
| Married | 4037 (69.2) |
| Divorced/Separated/Widowed/Single | 1781 (30.5) |
| Missing | 17 (0.3) |
| Living Arrangements n(%) | |
| Alone | 1268 (21.7) |
| With others | 4526 (77.6) |
| Missing | 41 (0.7) |
| Ethnicity– dichotomised n(%) | |
| White | 5249 (90.0) |
| Any other ethnicity | 554 (9.5) |
| Missing | 32 (0.5) |
| Months since most recent cancer diagnosis | |
| Mean (SD ^a) | 35.5 (13.6) |
| Cancer type n(%) | |
| Breast | 2786 (47.7) |
| Prostate | 1839 (31.5) |
| Colorectal | 1210 (20.7) |
| Missing | 0 |
| Cancer spread n(%) | |
| Yes | 558 (9.6) |
| No | 4498 (77.1) |
| Don't know/Missing | 373 (6.4) |
| Missing | 406 (7.0) |
| Treatment n(%) | |
| No treatment/active surveillance only | 296 (5.1) |
| Surgery only | 1081 (18.5) |
| Surgery and at least one other treatment | 2967 (50.8) |
| Any other combination of treatment | 1411 (24.2) |
| Missing | 80 (1.4) |
| Time since completion of main treatment^bn(%) | |
| < 1 year | 985 (16.9) |
| 1–5 years | 4122 (70.6) |
| On active surveillance | 525 (9.0) |
| Missing/Don't know | 203 (3.5) |
| Total comorbidities^c | |
| Mean (SD ^a) | 1.3 (1.3) |
| Missing | 0 |

^aSD=standard deviation. ^bTime since completion of initial treatment for their cancer that was diagnosed between 2012 and 2015. ^cNot selecting any condition was interpreted as having no comorbidities, resulting in no missing data for this variable.

Table 1 (continued)

eat 5 portions of fruit and vegetables a day and they are more likely to be smokers). No association was observed between loneliness and meeting the recommendations for fibre, red or processed meat, fat, sugar, or alcohol and BMI.

The results of this study demonstrate slightly lower levels of loneliness in people diagnosed with breast, prostate, or colorectal cancer than previous studies conducted in people LWBC (22–36%) [75, 76]. This discrepancy might be attributed to the dichotomisation of UCLA scores in this study, resulting in an arbitrary definition of being lonely or not lonely. It therefore is not directly comparable to other studies using different scales and thresholds, for example, De Boer and colleague's study in breast cancer patients used the De Jong Gierveld Scale [66], where a score above three was interpreted to mean experiencing loneliness [76]. However, where the same scale and threshold for loneliness was applied in the general population in the UK, the prevalence of loneliness in people LWBC was similar (16%; [32]). Differences in the prevalence of loneliness may also be attributed to the timing of the study, with the majority (70%) of participants being 1 to 5 years post finishing their primary treatment. Loneliness levels are likely to fluctuate considerably within this period, with loneliness scores in studies conducted during or just after initial treatment for cancer being significantly lower than loneliness scores in studies conducted in participants more than a year after diagnosis [16]. This finding is also supported by qualitative research [15, 77] and may be attributed to the plausible increase in social support in the period immediately after diagnosis and initial treatment [75].

Although the effect size observed was small, the results of this study converge with previous research reporting a decreased likelihood of engaging in physical activity in people who report higher levels of loneliness [18] and extend sparse findings of an association between loneliness and physical activity in people LWBC [34, 35]. Lemij and colleagues' study in older women (aged 70+) diagnosed with breast cancer reported that increasing loneliness was associated with lower levels of physical activity over time [46]. Although the current study used a different approach to dichotomise physical activity and loneliness, the results still support this inverse association in a younger, larger sample of adults diagnosed with breast, prostate, or colorectal cancer. This is important because there is strong evidence of improved outcomes for people LWBC who engage in higher levels of physical activity, including increased chances of survival and improvements in psychosocial outcomes [20, 78, 79]. Although this study was cross-sectional, it has identified a need for the consideration of psychosocial variables such as loneliness in efforts to increase physical

Table 2 Descriptive statistics of loneliness and meeting the recommendations for health behaviours^a

| Variable | Respondents (N = 5835) |
|---|---------------------------|
| Loneliness n(%) | |
| Higher | 1035 (17.7) |
| Lower | 4423 (75.8) |
| Missing | 377 (6.5) |
| MVPA^b recommendations n(%) | |
| Not meeting | 3359 (57.6) |
| Meeting | 1790 (30.7) |
| Missing | 686 (11.8) |
| Fibre recommendations n(%) | |
| Not meeting | 3914 (67.1) |
| Meeting | 667 (11.4) |
| Missing | 1254 (21.5) |
| Fruit and Vegetable recommendations n(%) | |
| Not meeting | 4006 (68.7) |
| Meeting | 1659 (28.4) |
| Missing | 170 (2.9) |
| Fat recommendations n(%) | |
| Not meeting | 1769 (30.3) |
| Meeting | 2300 (39.4) |
| Missing | 1766 (30.3) |
| Sugar recommendations n(%) | |
| Not meeting | 2663 (45.6) |
| Meeting | 2694 (46.2) |
| Missing | 478 (8.2) |
| Red meat recommendations n(%) | |
| Not meeting | 139 (2.4) |
| Meeting | 5035 (86.3) |
| Missing | 661 (11.3) |
| Processed meat recommendations n(%) | |
| Not meeting | 2861 (49.0) |
| Meeting | 2640 (45.2) |
| Missing | 334 (5.7) |
| Alcohol recommendations n(%) | |
| Not meeting | 714 (12.2) |
| Meeting | 4848 (83.1) |
| Missing | 273 (4.7) |
| Smoking recommendations n(%) | |
| Not meeting (i.e., current smoker) | 347 (5.9) |
| Meeting (i.e., current nonsmoker) | 5445 (93.3) |
| Missing | 43 (0.7) |
| BMI^c recommendations n(%) | |
| Not meeting | 3521 (60.3) |
| Meeting | 1978 (33.9) |
| Missing | 336 (5.8) |

^aMeeting and not meeting the recommendations is based on the World Cancer Research Fund recommendations (42). ^bMVPA=moderate-to-vigorous physical activity. ^cBMI=body mass index.

activity in this population. While physical activity interventions in oncology often include a social component and encourage social support [80, 81], a more targeted

Table 3 Pooled (20 iterations) associations between loneliness and health behaviours in 5835 people LWBC^a

| World Cancer Research Fund recommendations (not meeting = 0, meeting = 1) | OR ^b | 95% CI ^c | p |
|--|-----------------|------------------------|--------|
| Moderate-to-vigorous physical activity | 0.78 | 0.67 0.97 | 0.028* |
| Fibre | 1.07 | 0.79 1.44 | 0.663 |
| Fruit and vegetables | 0.81 | 0.67 1.00 ^d | 0.046* |
| Red Meat | 0.72 | 0.45 1.15 | 0.163 |
| Processed Meat | 1.00 | 0.83 1.19 | 0.954 |
| Sugar | 0.84 | 0.70 1.00 | 0.068 |
| Fat | 0.87 | 0.69 1.04 | 0.249 |
| Alcohol | 0.89 | 0.67 1.19 | 0.424 |
| Smoking | 0.62 | 0.46 0.84 | 0.003* |
| Body mass index | 0.79 | 0.46 1.16 | 0.790 |

^aReference category: lower loneliness (<6 on UCLA loneliness scale). Models adjusted for covariates– age, sex, ethnicity, education, marital status, cancer type, treatments, time since treatment, time since diagnosis, number of comorbidities, cancer spread; ^bOR=odds ratio; ^cCI=Confidence interval. ^d0.996 rounded up *indicates statistical significance at 0.05 alpha level.

approach may be needed to address the subjective experience of loneliness. Given the distinction between social isolation and loneliness, efforts to increase social contact and social support may not necessarily address aspects of loneliness, including sense of belonging and feeling cared for by others [82]. Supporting this, Dowd and colleagues reported that an intervention where physical activity was framed as being beneficial for both health and social skills led to increased engagement in physical activity while simultaneously improving loneliness in university students [83]. The results of the current study provide scope for investigating whether this type of interventional approach may also show promise in people LWBC.

The WCRF recommends that people LWBC follow a healthy diet by adhering to the published dietary recommendations for primary cancer prevention [23]. To the authors' knowledge, this is the first study to quantitatively explore loneliness and specific dietary component intake in people LWBC and highlights that experiencing loneliness may contribute to making poorer dietary choices. Given the sparse evidence base, more research is needed to understand the potential reasons for a lack of association between loneliness and meeting the recommendations for red and processed meat, fat, fibre, and alcohol. In the current study, this may be due to the limited variation in the sample, with a high percentage of participants meeting some of the recommendations (e.g., red meat and alcohol). Loneliness was associated with fruit and vegetable consumption in this sample, where participants who reported experiencing higher levels of loneliness were less likely to meet this dietary recommendation. However, it is important to note that this effect size was small, and the confidence intervals suggest that the impact of loneliness on intake of fruit and vegetable may be relatively weak. Richard and colleagues' also found

that lonelier men and women in a Swiss national survey had worse adherence to the recommendations for fruit and vegetables, although their study measured adherence using a subjective question on whether they perceive that they meet the recommendations, rather than being calculated from a food frequency questionnaire [84]. The observed association in this study is small, but diverges from Kobayashi and colleagues' finding of no relationship between meeting the fruit and vegetable recommendations and loneliness in the UK general population [32], and instead suggests that people diagnosed with cancer may be particularly susceptible to the negative impact of loneliness on their eating behaviours. More research is needed to investigate the potential mechanisms that underlie this relationship, to ultimately inform targeted intervention design in this population.

Our finding that loneliness was associated with smoking in people LWBC is in line with findings from a systematic review of loneliness and smoking, whereby lonely people were more likely to be smokers [36]. More recently, this association has also been found in a longitudinal analysis of the UK Biobank data, where Eloivaino and colleagues reported that smoking, alcohol, and physical activity accounted for 32-54% of the excess risk of mortality associated with loneliness in the general population [85]. Furthermore, previous research indicates a bidirectional association, where smokers are also more likely to experience higher loneliness over time [37]. In the current study, the possibility of reverse causality in associations between loneliness and health behaviours cannot be ruled out. Specifically, it is possible that loneliness may be influenced by engagement in certain health behaviours. However, with the available cross-sectional data, it is challenging to determine the temporal ordering to provide a more comprehensive understanding of causality in the observed associations. In any case, bidirectional evidence suggests a vicious cycle wherein loneliness and unfavourable health behaviours reinforce one another [27, 36, 37]. Further research, particularly longitudinal studies, is needed to unravel the complexities of the relationship between loneliness and health behaviours and to understand the directionality and underlying mechanisms involved. Using a longitudinal design would also help identify if there are critical periods where loneliness may be particularly influential on health behaviours. This is particularly important for this population as people LWBC move between the phases of diagnosis, treatment, and survivorship and each of these phases present unique demands and challenges to the individual [86].

The mechanisms linking loneliness and health behaviours remain relatively unexplored, but it is important to acknowledge the potential mediating role of depression. Loneliness and depression are considered to be

reciprocally associated [9, 87], therefore, it may be that depression lies on a causal pathway where negative affect resulting from loneliness impacts health behaviours [32]. As the data were cross-sectional, no mediation analysis was conducted and accordingly, depression was not included in the model as it was deemed inappropriate to control for potential mediators [88, 89]. Additionally, social interactions and norms can shape health behaviours and lonelier people may not be as exposed to others engaging in practices such as healthy eating and exercise due to reduced social engagement [90, 91]. In line with the recognition of the social environment in SCT [44] and the opportunity component of the COM-B model [45], studies in both the general population and people LWBC have demonstrated that witnessing health-promoting behaviours is associated with increased likelihood of engaging in these behaviours [92–95]. Lastly, as demonstrated in Newall and colleagues' study in the general population, happiness may moderate this association whereby higher levels of happiness may weaken the association between loneliness and unhealthy behaviours [29]. This may be attributed to the broadening influence of positive emotions, which can counteract the negative impact of loneliness [29, 96]. Future research should employ qualitative methods to uncover the nuances in these associations and to explore potential mechanisms. For example, qualitative interviews with a sample of people with type 2 diabetes revealed reduced motivation due to loneliness and reduced social contact inhibited engagement in physical activity during the COVID-19 pandemic [97].

The results of this study can inform policy and practice by directing support toward the creation of environments that promote social connections and reduce loneliness in this population. Addressing loneliness is a key part of public health agendas with strategies such as social prescribing being implemented into the NHS Long Term Plan [98]. This type of approach aims to combat loneliness by enabling individuals to co-develop solutions to help them cope with their health, while developing connections with communities and building social engagement [99, 100]. The impact of this approach on reducing the negative effect of loneliness on health behaviours has yet to be explored in people LWBC, but combining strategies that target both elements simultaneously shows promise in this population [101].

Strengths of the study include the use of multiple imputation to overcome any bias or loss of statistical power introduced by only performing complete case analyses [102]. Despite limitations in establishing causality, a strength of the cross-sectional design of this study is that it allowed for the identification of a new area of inquiry that requires attention, and the observed associations can help inform theory development and

intervention design [103, 104]. While the ease with which a self-report survey can be distributed to many people is a strength of this type of research, the validity of health research can be threatened by selection biases [105]. In this study, 43% of those sent the initial letter completed the survey. Previous research has demonstrated that people who agree to take part in questionnaire asking about their health behaviours often demonstrate a higher interest in their health and improving health behaviours [106, 107]. Therefore, selection biases may threaten the generalisability of our findings. Limitations of this study also include that this was not an ethnically diverse sample of LWBC, with 90% of participants identifying as white. Another limitation was the use of self-report for recording health behaviours, which might be subject to recall errors and social desirability [108]. Additionally, inherent in research is the limitation of unmeasured confounders that may have contributed to the results. In this study, direct measures of socioeconomic position (e.g., level of income) were not included in the survey and regression model. However, the observed associations remained even after controlling for education level, a variable that has been previously identified as the strongest independent predictor of health behaviours among people LWBC out of three variables indicative of socioeconomic position (including household income and occupation type) [109]. Lastly, some dietary instruments were custom-made for this study, for example, the free sugar measure and this may threaten their validity. However, any adaptations were made based on a review of available measures alongside the main components of the UK diet [47], and modifications were made to validated measures used in previous population level research [54, 110].

Conclusions

This study reports a similar prevalence of loneliness in people diagnosed with breast, prostate, and colorectal cancer in the UK to that observed in the general population and identifies the need to consider the impact of loneliness on health behaviours in this population. Given the associations between loneliness and physical activity, smoking, and fruit and vegetable consumption, future studies should aim to explore the factors predicting higher levels of loneliness in this population, to identify the people LWBC who are most at risk. Additionally, the mechanisms that might explain the association between loneliness and these health behaviours remain unexplored and future research and care would benefit from exploring why these relationships exist. Particularly following the COVID-19 pandemic and the associated heightened prevalence of loneliness among LWBC [111, 112], future research should aim to take a holistic view of the cancer experience and target aspects of loneliness in health behaviour intervention design.

Abbreviations

| | |
|----------|---|
| AICR | American Institute for Cancer Research |
| AUDIT-C | Alcohol Use Disorders Identification Test consumption questions |
| BMI | body mass index |
| CI | confidence interval |
| DINE FFQ | Dietary Instrument for Nutrition Education Food Frequency Questionnaire |
| ELSA | English longitudinal Study of Ageing |
| GCSE | General Certificate of Secondary Education |
| GLTEQ | Godin leisure time exercise questionnaire |
| LWBC | living with and beyond cancer |
| MVPA | moderate-to-vigorous physical activity |
| NHS | National Health Service |
| OR | odds ratio |
| SPSS | Statistical Package for Social Sciences |
| UK | United Kingdom |
| WCRF | World Cancer Research Fund |

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-024-17797-3>.

Supplementary Material 1

Supplementary Material 2

Acknowledgements

The authors thank Cancer Research UK (grant number C1418/A14133) for funding the Advancing Survivorship Cancer Outcomes Trial (ASCOT (47)), from which the survey data used in this study was obtained.

Author contributions

RB and AF were responsible for the funding acquisition and are joint study leads. AS, AF, and YC contributed to the study conception and design. PL was responsible for the data curation and cleaning. Data analysis was performed by AF. SS and AF interpreted the data and wrote the manuscript. All authors contributed to the manuscript revision. All authors read and approved the final manuscript.

Funding

This work was funded by Cancer Research UK (grant number C1418/A14133).

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study received ethical approval from the NHS National Research Ethics Committee—South Central Oxford B (reference 14/SC/1369). Informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare they have no competing interests.

Author details

¹Department of Behavioural Science and Health, University College London, Gower Street, WC1E 6BT London, UK

²Department of Psychological Sciences, University of Surrey, GU2 7XH Guildford, Surrey, UK

³MRC Epidemiology Unit, Institute of Metabolic Science, University of Cambridge School of Clinical Medicine, Cambridge Biomedical Campus, CB2 0QQ CambridgeBox 285, UK

⁴Leeds Institute of Health Sciences, University of Leeds, LS2 9JT Leeds, UK

Received: 19 October 2023 / Accepted: 17 January 2024

Published online: 28 February 2024

References

1. Macmillan Cancer Support. Statistics fact sheet 2022 [Available from: <https://www.macmillan.org.uk/dfsmedia/1a6f23537f7f4519bb0cf14c45b2a629/9468-10061/2022-cancer-statistics-factsheet>].
2. Maddams J, Utley M, Møller H. Projections of cancer prevalence in the United Kingdom, 2010–2040. *Br J Cancer*. 2012;107(7):1195–202. <https://doi.org/10.1038/bjc.2012.366>.
3. Cancer Council Australia. Facts and figures. Cancer statistics in Australia 2023 [Available from: <https://www.cancer.org.au/cancer-information/what-is-cancer/facts-and-figures>].
4. Independent Cancer Taskforce. Achieving world-class cancer outcomes: a strategy for England 2015–2020. 2016.
5. NHS. The NHS Long Term Plan. 2019.
6. Steptoe A, Shankar A, Demakakos P, Wardle J. Social isolation, loneliness, and all-cause mortality in older men and women. *Proc Natl Acad Sci U S A*. 2013;110(15):5797–801. <https://doi.org/10.1073/pnas.1219686110>.
7. Prohaska T, Burholt V, Burns A, Golden J, Hawkey L, Lawlor B, et al. Consensus statement: loneliness in older adults, the 21st century social determinant of health? *BMJ Open*. 2020;10(8):e034967. <https://doi.org/10.1136/bmjopen-2019-034967>.
8. Cacioppo JT, Hawkey LC, Crawford LE, Ernst JM, Burleson MH, Kowalewski RB, et al. Loneliness and health: potential mechanisms. *Psychosom Med*. 2002;64(3):407–17. <https://doi.org/10.1097/00006842-200205000-00005>.
9. Cacioppo JT, Hughes ME, Waite LJ, Hawkey LC, Thisted RA. Loneliness as a specific risk factor for depressive symptoms: cross-sectional and longitudinal analyses. *Psychol Aging*. 2006;21(1):140–51. <https://doi.org/10.1037/0882-7974.21.1.140>.
10. Shankar A, Hamer M, McMunn A, Steptoe A. Social isolation and loneliness: relationships with cognitive function during 4 years of follow-up in the English Longitudinal Study of Ageing. *Psychosom Med*. 2013;75(2):161–70. <https://doi.org/10.1097/PSY.0b013e31827f09cd>.
11. Hawkey LC, Thisted RA, Masi CM, Cacioppo JT. Loneliness predicts increased blood pressure: 5-year cross-lagged analyses in middle-aged and older adults. *Psychol Aging*. 2010;25(1):132–41. <https://doi.org/10.1037/a0017805>.
12. Kanski AA, Pajak TF, Movsas B, Coyne J, Harris J, Gwede C, et al. Disadvantage of men living alone participating in Radiation Therapy Oncology Group head and neck trials. *J Clin Oncol*. 2006;24(25):4177–83. <https://doi.org/10.1200/jco.2006.06.2901>.
13. Pinquart M, Duberstein PR. Associations of social networks with cancer mortality: a meta-analysis. *Crit Rev Oncol Hematol*. 2010;75(2):122–37. <https://doi.org/10.1016/j.critrevonc.2009.06.003>.
14. Raque-Bogdan TL, Lamphere B, Kostiuik M, Gissen M, Beranek M. Unpacking the layers: a meta-ethnography of cancer survivors' loneliness. *J Cancer Surviv*. 2019;13(1):21–33. <https://doi.org/10.1007/s11764-018-0724-6>.
15. Rosedale M. Survivor loneliness of women following breast cancer. *Number 2/March 2009*. 2009;36(2):175–83.
16. Deckx L, van den Akker M, Buntinx F. Risk factors for loneliness in patients with cancer: a systematic literature review and meta-analysis. *Eur J Oncol Nurs*. 2014;18(5):466–77. <https://doi.org/10.1016/j.ejon.2014.05.002>.
17. Hackett RA, Hamer M, Endrighi R, Brydon L, Steptoe A. Loneliness and stress-related inflammatory and neuroendocrine responses in older men and women. *Psychoneuroendocrinology*. 2012;37(11):1801–9. <https://doi.org/10.1016/j.psyneuen.2012.03.016>.
18. Shankar A, McMunn A, Banks J, Steptoe A. Loneliness, social isolation, and behavioral and biological health indicators in older adults. *Health Psychol*. 2011;30(4):377–85. <https://doi.org/10.1037/a0022826>.
19. Ergas IJ, Cespedes Feliciano EM, Bradshaw PT, Roh JM, Kwan ML, Cadenhead J, et al. Diet quality and breast cancer recurrence and survival: the pathways Study. *JNCI Cancer Spectr*. 2021;5(2). <https://doi.org/10.1093/jncics/pkab019>.
20. Friedenreich CM, Stone CR, Cheung WY, Hayes SC. Physical activity and mortality in Cancer survivors: a systematic review and Meta-analysis. *JNCI Cancer Spectr*. 2020;4(1):pkz080. <https://doi.org/10.1093/jncics/pkz080>.
21. Buffart LM, Kalter J, Sweegers MG, Courneya KS, Newton RU, Aaronson NK, et al. Effects and moderators of exercise on quality of life and physical function in patients with cancer: an individual patient data meta-analysis of 34 RCTs. *Cancer Treat Rev*. 2017;52:91–104. <https://doi.org/10.1016/j.ctrv.2016.11.010>.
22. Wang Y, Tao H, Paxton RJ, Wang J, Mubarik S, Jia Y, et al. Post-diagnosis smoking and risk of cardiovascular, cancer, and all-cause mortality in survivors of 10 adult cancers: a prospective cohort study. *Am J Cancer Res*. 2019;9(11):2493–514.
23. World Cancer Research Fund/American Institute for Cancer Research. Diet, nutrition, Physical Activity and Cancer: a Global perspective. Continuous Update Project Expert Report 2018. 2018.
24. World Cancer Research Fund/American Institute for Cancer Research. Food, Nutrition, Physical Activity, and the Prevention of Cancer: A Global Perspective. Washington, DC; 2007.
25. Turner RR, Steed L, Quirk H, Greasley RU, Saxton JM, Taylor SJ, et al. Interventions for promoting habitual exercise in people living with and beyond cancer. *Cochrane Database Syst Rev*. 2018;9:CD010192. <https://doi.org/10.1002/14651858.CD010192.pub3>.
26. Irwin ML, Ainsworth BE. Physical activity interventions following cancer diagnosis: methodologic challenges to delivery and assessment. *Cancer Invest*. 2004;22(1):30–50.
27. Pels F, Kleinert J. Loneliness and physical activity: a systematic review. *Int Rev Sport Exerc Psychol*. 2016;9(1):231–60. <https://doi.org/10.1080/1750984X.2016.1177849>.
28. Hawkey LC, Thisted RA, Cacioppo JT. Loneliness predicts reduced physical activity: cross-sectional & longitudinal analyses. *Health Psychol*. 2009;28(3):354–63. <https://doi.org/10.1037/a0014400>.
29. Newall NE, Chipperfield JG, Bailis DS, Stewart TL. Consequences of loneliness on physical activity and mortality in older adults and the power of positive emotions. *Health Psychol*. 2013;32(8):921–4. <https://doi.org/10.1037/a0029413>.
30. Theeke LA. Sociodemographic and health-related risks for loneliness and outcome differences by loneliness status in a sample of U.S. older adults. *Res Gerontol Nurs*. 2010;3(2):113–25. <https://doi.org/10.3928/19404921-20091103-99>.
31. Luo Y, Waite LJ. Loneliness and mortality among older adults in China. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*. 2014;69(4):633–45.
32. Kobayashi LC, Steptoe A. Social isolation, loneliness, and Health behaviors at older ages: Longitudinal Cohort Study. *Ann Behav Med*. 2018;52(7):582–93. <https://doi.org/10.1093/abm/kax033>.
33. Schrempft S, Jackowska M, Hamer M, Steptoe A. Associations between social isolation, loneliness, and objective physical activity in older men and women. *BMC Public Health*. 2019;19(1):74. <https://doi.org/10.1186/s12889-019-6424-y>.
34. Lemij AA, Liefers GJ, Derks MGM, Bastiaannet E, Fiocco M, Lans TE, et al. Physical function and physical activity in older breast Cancer survivors: 5-Year Follow-Up from the climb every mountain study. *Oncologist*. 2023;28(6):e317–e23. <https://doi.org/10.1093/oncolo/oyad027>.
35. Krok-Schoen JL, Pennell ML, Saquib N, Naughton M, Zhang X, Shadyab AH, et al. Correlates of physical activity among older breast cancer survivors: findings from the women's Health Initiative LILAC study. *J Geriatr Oncol*. 2022;13(2):143–51. <https://doi.org/10.1016/j.jgo.2021.11.012>.
36. Dyal SR, Valente TW. A systematic review of loneliness and smoking: small effects, Big implications. *Subst Use Misuse*. 2015;50(13):1697–716. <https://doi.org/10.3109/10826084.2015.1027933>.
37. Philip KEJ, Bu F, Polkey MI, Brown J, Steptoe A, Hopkinson NS, et al. Relationship of smoking with current and future social isolation and loneliness: 12-year follow-up of older adults in England. *Lancet Reg Health - Europe*. 2022;14:100302. <https://doi.org/10.1016/j.lanepe.2021.100302>.
38. Whitelock E, Ensaif H. On Your Own: Older Adults' Food Choice and Dietary Habits. *Nutrients*. 2018;10(4). <https://doi.org/10.3390/nu10040413>.
39. Bloom I, Lawrence W, Barker M, Baird J, Dennison E, Sayer AA, et al. What influences diet quality in older people? A qualitative study among community-dwelling older adults from the Hertfordshire Cohort Study, UK. *Public Health Nutr*. 2017;20(15):2685–93. <https://doi.org/10.1017/s1368980017001203>.
40. Jung FU, Luck-Sikorski C. Overweight and lonely? A Representative Study on loneliness in obese people and its determinants. *Obes Facts*. 2019;12(4):440–7. <https://doi.org/10.1159/000500095>.
41. Jones RA, Christiansen P, Maloney NG, Duckworth JJ, Hugh-Jones S, Ahern AL, et al. Perceived weight-related stigma, loneliness, and mental wellbeing during COVID-19 in people with obesity: a cross-sectional study from ten European countries. *Int J Obes*. 2022;46(12):2120–7. <https://doi.org/10.1038/s41366-022-01220-1>.
42. World Cancer Research Fund/American Institute for Cancer Research. Continuous Update Project Expert Report. Diet, nutrition, physical activity and breast cancer. 2018.

43. Tu H, McQuade JL, Davies MA, Huang M, Xie K, Ye Y, et al. Body mass index and survival after cancer diagnosis: a pan-cancer cohort study of 114 430 patients with cancer. *The Innovation*. 2022;3(6):100344. <https://doi.org/10.1016/j.xinn.2022.100344>.
44. Bandura A. Social cognitive theory: an agentic perspective. *Ann Rev Psychol*. 2001;52(1):1–26.
45. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013;46(1):81–95. <https://doi.org/10.1007/s12160-013-9486-6>.
46. Weemaes ATR, Sieben JM, Beelen M, Mulder LTMA, Lensen AF. Determinants of physical activity maintenance and the acceptability of a remote coaching intervention following supervised exercise oncology rehabilitation: a qualitative study. *J Cancer Surviv*. 2023. <https://doi.org/10.1007/s11764-023-01455-5>.
47. Beeken RJ, Croker H, Heinrich M, Smith L, Williams K, Hackshaw A, et al. Study protocol for a randomised controlled trial of brief, habit-based, lifestyle advice for cancer survivors: exploring behavioural outcomes for the advancing Survivorship Cancer outcomes Trial (ASCOT). *BMJ Open*. 2016;6(11):e011646. <https://doi.org/10.1136/bmjopen-2016-011646>.
48. Ye F, Moon DH, Carpenter WR, Reeve BB, Usinger DS, Green RL, et al. Comparison of Patient Report and Medical Records of Comorbidities results from a Population-based cohort of patients with prostate Cancer. *Jama Oncol*. 2017;3(8):1035–42. <https://doi.org/10.1001/jamaoncol.2016.6744>.
49. Vigen C, Kwan ML, John EM, Gomez SL, Keegan TH, Lu Y, et al. Validation of self-reported comorbidity status of breast cancer patients with medical records: the California breast Cancer Survivorship Consortium (CBCSC). *Cancer Causes Control*. 2016;27(3):391–401. <https://doi.org/10.1007/s10552-016-0715-8>.
50. Hughes ME, Waite LJ, Hawkey LC, Cacioppo JT. A short scale for measuring loneliness in large surveys: results from two Population-Based studies. *Res Aging*. 2004;26(6):655–72. <https://doi.org/10.1177/0164027504268574>.
51. Amireault S, Godin G. The Godin-Shephard leisure-time physical activity questionnaire: validity evidence supporting its use for classifying healthy adults into active and insufficiently active categories. *Percept Mot Skills*. 2015;120(2):604–22. <https://doi.org/10.2466/03.27.PMS.120v19x7>.
52. Amireault S, Godin G, Lacombe J, Sabiston CM. The use of the Godin-Shephard leisure-time physical activity questionnaire in oncology research: a systematic review. *BMC Med Res Methodol*. 2015;15:60. <https://doi.org/10.1186/s12874-015-0045-7>.
53. Amireault S, Godin G, Lacombe J, Sabiston CM. Validation of the Godin-Shephard leisure-time physical activity questionnaire classification coding system using accelerometer assessment among breast cancer survivors. *J Cancer Surviv*. 2015;9(3):532–40. <https://doi.org/10.1007/s11764-015-0430-6>.
54. Roe L, Strong C, Whiteside C, Neil A, Mant D. Dietary intervention in primary care: validity of the DINE method for diet assessment. *Fam Pract*. 1994;11(4):375–81. <https://doi.org/10.1093/fampra/11.4.375>.
55. McGowan L, Cooke LJ, Gardner B, Beeken RJ, Croker H, Wardle J. Healthy feeding habits: efficacy results from a cluster-randomized, controlled exploratory trial of a novel, habit-based intervention with parents. *Am J Clin Nutr*. 2013;98(3):769–77. <https://doi.org/10.3945/ajcn.112.052159>.
56. Cappuccio FP, Rink E, Perkins-Porras L, McKay C, Hilton S, Steptoe A. Estimation of fruit and vegetable intake using a two-item dietary questionnaire: a potential tool for primary health care workers. *Nutr Metab Cardiovasc Dis*. 2003;13(1):12–9. [https://doi.org/10.1016/s0939-4753\(03\)80163-1](https://doi.org/10.1016/s0939-4753(03)80163-1).
57. Steptoe A, Perkins-Porras L, McKay C, Rink E, Hilton S, Cappuccio FP. Behavioural counselling to increase consumption of fruit and vegetables in low income adults: randomised trial. *BMJ*. 2003;326(7394):855. <https://doi.org/10.1136/bmj.326.7394.855>.
58. Public Health England. Scientific Advisory Committee on Nutrition: carbohydrates and health report. Public Health England under license from the Controller of Her Majesty's... 2015.
59. Kennedy F, Lally P, Miller NE, Conway RE, Roberts A, Croker H, et al. Fatigue, quality of life and associations with adherence to the World Cancer Research Fund guidelines for health behaviours in 5835 adults living with and beyond breast, prostate and colorectal cancer in England: a cross-sectional study. *Cancer Med*. 2023;12(11):12705–16. <https://doi.org/10.1002/cam4.5899>.
60. Craig R, Mindell J, Hirani V. Health Survey for England 2008. Volume 1: physical activity and fitness. London: The Health and Social Care Information Centre. NHS; 2009.
61. Bush K, Kivlahan DR, McDonell MB, Fihn SD, Bradley KA. The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. Ambulatory Care Quality Improvement Project (ACQUIP). Alcohol Use disorders Identification Test. *Arch Intern Med*. 1998;158(16):1789–95. <https://doi.org/10.1001/archinte.158.16.1789>.
62. de Meneses-Gaya C, Zuardi AW, Loureiro SR, Crippa JAS. Alcohol Use disorders Identification Test (AUDIT): an updated systematic review of psychometric properties. *Psychol Neurosci*. 2009;2(1):83–97. <https://doi.org/10.3922/j.psns.2009.1.12>.
63. Department of Health and Social Care. UK chief medical officer's low risk drinking guidelines. 2016.
64. World Health Organisation. Physical Status: The use and interpretation of anthropometry; Report of a WHO Expert Committee. Geneva; 1995.
65. Yang K, Victor C. Age and loneliness in 25 European nations. *Ageing Soc*. 2011;31(8):1368–88.
66. De Jong Gierveld J, Van Tilburg T. The De Jong Gierveld short scales for emotional and social loneliness: tested on data from 7 countries in the UN generations and gender surveys. *Eur J Ageing*. 2010;7(2):121–30. <https://doi.org/10.1007/s10433-010-0144-6>.
67. Barreto M, Victor C, Hammond C, Eccles A, Richins MT, Qualter P. Loneliness around the world: age, gender, and cultural differences in loneliness. *Pers Indiv Differ*. 2021;169:110066. <https://doi.org/10.1016/j.paid.2020.110066>.
68. Cornelius ME, Loretan CG, Jamal A, Davis Lynn BC, Mayer M, Alcantara IC, et al. Tobacco product use among adults— United States, 2021. *MMWR Morbidity and Mortality Weekly Report*. 2023;72(18):475–83. <https://doi.org/10.15585/mmwr.mm7218a1>.
69. Herbec A, Schneider V, Fisher A, Kale D, Shahab L, Lally P. Correlates of and changes in aerobic physical activity and strength training before and after the onset of COVID-19 pandemic in the UK: findings from the HEBECO study. *BMJ Open*. 2022;12(6):e054029. <https://doi.org/10.1136/bmjopen-2021-054029>.
70. Dibble KE, Connor AE. Evaluation of disparities in maintaining healthy lifestyle behaviors among female cancer survivors by race/ethnicity and US nativity. *Cancer Epidemiol*. 2022;80:102235. <https://doi.org/10.1016/j.canep.2022.102235>.
71. Bourassa KJ, Ruiz JM, Sbarra DA. Smoking and physical activity explain the increased mortality risk following marital separation and divorce: evidence from the English Longitudinal Study of Ageing. *Ann Behav Med*. 2019;53(3):255–66. <https://doi.org/10.1093/abm/kay038>.
72. IBM Corp. IBM SPSS Statistics for Windows Version 26.0. Armonk, NY 2019.
73. He Y. Missing data analysis using multiple imputation: getting to the heart of the matter. *Circulation Cardiovasc Qual Outcomes*. 2010;3(1):98–105. <https://doi.org/10.1161/circoutcomes.109.875658>.
74. Westreich D, Greenland S. The table 2 fallacy: presenting and interpreting confounder and modifier coefficients. *Am J Epidemiol*. 2013;177(4):292–8. <https://doi.org/10.1093/aje/kws412>.
75. Deckx L, van den Akker M, van Driel M, Bulens P, van Abbema D, Tjan-Heijnen V, et al. Loneliness in patients with cancer: the first year after cancer diagnosis. *Psycho-oncology*. 2015;24(11):1521–8. <https://doi.org/10.1002/pon.3818>.
76. de Boer AZ, Derks MGM, de Glas NA, Bastiaannet E, Liefers GJ, Stiggelbout AM, et al. Metastatic breast cancer in older patients: a longitudinal assessment of geriatric outcomes. *J Geriatric Oncol*. 2020;11(6):969–75. <https://doi.org/10.1016/j.jgo.2020.04.002>.
77. Ekwall E, Ternstedt B-M, Sorbe B. Recurrence of ovarian Cancer-living in Limbo. *Cancer Nurs*. 2007;30(4):270–7. <https://doi.org/10.1097/O1.NCC.0000281729.10362.3a>.
78. Aune D, Markozannes G, Abar L, Balducci K, Cariolou M, Nanu N, et al. Physical activity and Health-Related Quality of Life in women with breast Cancer: a Meta-analysis. *JNCI Cancer Spectrum*. 2022;6(6). <https://doi.org/10.1093/jncics/pkac072>.
79. Mishra SI, Scherer RW, Geigle PM, Berlanstein DR, Topaloglu O, Gotay CC, et al. Exercise interventions on health-related quality of life for cancer survivors. *Cochrane Database of Systematic Reviews*. 2012;8:CD007566. <https://doi.org/10.1002/14651858.CD007566.pub2>.
80. Salisbury CE, Hyde MK, Cooper ET, Stennett RC, Gomersall SR, Skinner TL. Physical activity behaviour change in people living with and beyond cancer following an exercise intervention: a systematic review. *J Cancer Surviv*. 2023;17(3):569–94. <https://doi.org/10.1007/s11764-023-01377-2>.
81. Grimmett C, Corbett T, Brunet J, Shepherd J, Pinto BM, May CR, et al. Systematic review and meta-analysis of maintenance of physical activity behaviour change in cancer survivors. *Int J Behav Nutr Phys Act*. 2019;16(1):37. <https://doi.org/10.1186/s12966-019-0787-4>.

82. O'Rourke HM, Collins L, Sidani S. Interventions to address social connectedness and loneliness for older adults: a scoping review. *BMC Geriatr*. 2018;18(1):214. <https://doi.org/10.1186/s12877-018-0897-x>.
83. Dowd AJ, Schmader T, Sylvester BD, Jung ME, Zumbo BD, Martin LJ, et al. Effects of Social Belonging and Task Framing on Exercise cognitions and Behavior. *J Sport Exerc Psychol*. 2014;36(1):80–92. <https://doi.org/10.1123/jsep.2013-0114>.
84. Richard A, Rohrmann S, Vandeleur CL, Schmid M, Barth J, Eichholzer M. Loneliness is adversely associated with physical and mental health and lifestyle factors: results from a Swiss national survey. *PLoS ONE*. 2017;12(7):e0181442. <https://doi.org/10.1371/journal.pone.0181442>.
85. Elovainio M, Hakulinen C, Pulkki-Råback L, Virtanen M, Josefsson K, Jokela M, et al. Contribution of risk factors to excess mortality in isolated and lonely individuals: an analysis of data from the UK Biobank cohort study. *The Lancet Public Health*. 2017;2(6):e260–e6. [https://doi.org/10.1016/S2468-2667\(17\)30075-0](https://doi.org/10.1016/S2468-2667(17)30075-0).
86. Halpern MT, McCabe MS, Burg MA. The Cancer Survivorship Journey: models of Care, disparities, barriers, and future directions. *Am Soc Clin Oncol Educational Book*. 2016;36231–9. https://doi.org/10.1200/edbk_156039.
87. Hawkey LC, Cacioppo JT. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Ann Behav Med*. 2010;40(2):218–27. <https://doi.org/10.1007/s12160-010-9210-8>.
88. Tennant PWG, Murray EJ, Arnold KF, Berrie L, Fox MP, Gadd SC, et al. Use of directed acyclic graphs (DAGs) to identify confounders in applied health research: review and recommendations. *Int J Epidemiol*. 2021;50(2):620–32. <https://doi.org/10.1093/ije/dyaa213>.
89. Fairchild AJ, McDaniel HL. Best (but oft-forgotten) practices: mediation analysis 1,2. *Am J Clin Nutr*. 2017;105(6):1259–71. <https://doi.org/10.3945/ajcn.117.152546>.
90. Heller K. Prevention activities for older adults: social structures and personal competencies that maintain useful social roles. *J Couns Dev*. 1993;72(2):124–30.
91. Peplau LA, Perlman D. Loneliness. A sourcebook of current theory, research, and therapy. (No Title). 1982.
92. Ball K, Jeffery RW, Abbott G, McNaughton SA, Crawford D. Is healthy behavior contagious: associations of social norms with physical activity and healthy eating. *Int J Behav Nutr Phys*. 2010;7(1):86. <https://doi.org/10.1186/1479-5868-7-86>.
93. Rogers LQ, Markwell S, Hopkins-Price P, Vicari S, Courneya KS, Hoelzer K, et al. Reduced barriers mediated physical activity maintenance among breast Cancer survivors. *J Sport Exerc Psychol*. 2011;33(2):235–54. <https://doi.org/10.1123/jsep.33.2.235>.
94. Park CL, Gaffey AE. Relationships between psychosocial factors and health behavior change in cancer survivors: an integrative review. *Ann Behav Med*. 2007;34(2):115–34.
95. Keaver L, Douglas P, O'Callaghan N. Perceived barriers and facilitators to a healthy Diet among Cancer survivors: a qualitative exploration using the TDF and COM-B. *Dietetics*. 2023;2(1):123–39.
96. Fredrickson BL. What good are positive emotions? *Rev Gen Psychol*. 1998;2(3):300–19. <https://doi.org/10.1037/1089-2680.2.3.300>.
97. Leite NJC, Raimundo AMM, Mendes RDC, Marmeleira JFF. Impact of COVID-19 pandemic on Daily Life, Physical Exercise, and General Health among older people with type 2 diabetes: a qualitative interview study. *Int J Environ Res Public Health*. 2022;19(7):3986.
98. Drinkwater C, Wildman J, Moffatt S. Social prescribing. *BMJ*. 2019;364:l1285. <https://doi.org/10.1136/bmj.l1285>.
99. Dayson C. Social prescribing 'plus': a model of asset-based collaborative innovation? *People. Place and Policy*. 2017;11(2):90–104.
100. Foster A, Thompson J, Holding E, Ariss S, Mukuria C, Jacques R, et al. Impact of social prescribing to address loneliness: a mixed methods evaluation of a national social prescribing programme. *Health Soc Care Commun*. 2021;29(5):1439–49. <https://doi.org/10.1111/hsc.13200>.
101. Macmillan Social Prescribing Service. Macmillan Social Prescribing Service Summary evaluation report phase 1 pilot July 2015– June 2017. London: Bromley by Bow Centre; 2018.
102. Carreras G, Miccinesi G, Wilcock A, Preston N, Nieboer D, Deliens L, et al. Missing not at random in end of life care studies: multiple imputation and sensitivity analysis on data from the ACTION study. *BMC Med Res Methodol*. 2021;21(1):13. <https://doi.org/10.1186/s12874-020-01180-y>.
103. Markovitz AR, Goldstick JE, Levy K, Cevallos W, Mukherjee B, Trostle JA, et al. Where science meets policy: comparing longitudinal and cross-sectional designs to address diarrhoeal disease burden in the developing world. *Int J Epidemiol*. 2012;41(2):504–13. <https://doi.org/10.1093/ije/dyr194>.
104. Spector PE. Do not Cross Me: optimizing the Use of cross-sectional designs. *J Bus Psychol*. 2019;34(2):125–37. <https://doi.org/10.1007/s10869-018-09613-8>.
105. Kho ME, Duffett M, Willison DJ, Cook DJ, Brouwers MC. Written informed consent and selection bias in observational studies using medical records: systematic review. *BMJ*. 2009;338:b866. <https://doi.org/10.1136/bmj.b866>.
106. Clark T. On 'being researched': why do people engage with qualitative research? *Qualitative Res*. 2010;10(4):399–419. <https://doi.org/10.1177/1468794110366796>.
107. Tarpey M. Why people get involved in health and social care research: a working paper 2006.
108. Newell SA, Girgis A, Sanson-Fisher RW, Savolainen NJ. The accuracy of self-reported health behaviors and risk factors relating to cancer and cardiovascular disease in the general population. *Am J Prev Med*. 1999;17(3):211–29. [https://doi.org/10.1016/S0749-3797\(99\)00069-0](https://doi.org/10.1016/S0749-3797(99)00069-0).
109. Naik H, Qiu X, Brown MC, Eng L, Pringle D, Mahler M, et al. Socioeconomic status and lifestyle behaviours in cancer survivors: smoking and physical activity. *Curr Oncol*. 2016;23(6):e546–e55. <https://doi.org/10.3747/co.23.3166>.
110. National Cancer Institute. National Health and Nutrition Examination Survey (NHANES) Dietary Screener Questionnaire 2010 [Available from: <https://epi.grants.cancer.gov/nhanes/dietscreen/questionnaires.html#paper>].
111. Swainston J, Chapman B, Grunfeld EA, Derakshan N. COVID-19 lockdown and its adverse impact on Psychological Health in breast Cancer. *Front Psychol*. 2020;11:2033. <https://doi.org/10.3389/fpsyg.2020.02033>.
112. Rentscher KE, Zhou X, Small BJ, Cohen HJ, Dilawari AA, Patel SK, et al. Loneliness and mental health during the COVID-19 pandemic in older breast cancer survivors and noncancer controls. *Cancer*. 2021;127(19):3671–9. <https://doi.org/10.1002/cncr.33687>.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.