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Title

What is scanxiety? A systematic scoping review

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Abstract

Objectives: To identify the available literature on the prevalence, severity and contributing factors of scan-associated anxiety ('scanxiety'), and interventions to reduce it.

Design: Systematic scoping review.

Data sources: Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane Central Register of Controlled Trials, Scopus, EBSCO CINAHL and PubMed up to July 2020.

Study selection: Eligible studies recruited people having a cancer-related non-invasive scan (including screening) and contained a quantitative assessment of scanxiety.

Data extraction: Demographics and scanxiety outcomes were recorded for each study and the data summarised by descriptive statistics.

Results: Of 26,693 citations, 57 studies were eligible for inclusion across a range of scan types (mammogram 26/57, 46%; positron-emission tomography 14/57, 25%; computed tomography 14/57, 25%) and designs (observation 47/57, 82%; intervention 10/57, 18%). Eighty-one measurement tools were used to quantify the prevalence and/or severity of scanxiety, including purpose-designed Likert scales (17/81, 21%); the State Trait Anxiety Inventory (14/81, 17%) and the Hospital Anxiety and Depression Scale (9/81, 11%). Scanxiety prevalence ranged from 0% to 83%. Mean severity scores were low in almost all measures which quantitatively measured scanxiety (54/62, 87%). Moderate to severe scanxiety occurred in 4% to 28% of people in studies using descriptive measures. Nine of 20 studies assessing scanxiety pre- and post-scan reported a significant post-scan reduction in scanxiety, although absolute differences were low. Lower education, smoking, higher levels of pain, higher perceived risk of cancer and diagnostic scans (v screening scans) consistently correlated with higher scanxiety severity, but not age, gender, ethnicity or marital status. Interventions included relaxation, distraction, education and psychological support. Six of the 10 interventions showed a reduction in scanxiety.

Conclusions: Prevalence and severity of scanxiety varied widely likely due to heterogeneous methods of measurement. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide interventions.

Strengths and limitations of this study

- This is the first scoping review on scanxiety
- A comprehensive search strategy and broad inclusion criteria have resulted in an extensive summary of all available literature
- Summary statistics for prevalence and severity of scanxiety were not possible due to heterogeneity in the type and timing of measurement tools between the studies**.**

INTRODUCTION

Anxiety may increase when people have scans to screen for, diagnose, or stage cancer, or to monitor cancer for recurrence or progression. Scan-associated anxiety, or the distress before, during or after a scan, was first dubbed 'scanxiety' by a patient writing for the Time Magazine in 2011[1].

Qualitative research on the experience of having a scan has shown some people experience dread in the weeks before a scan[2], perceive scans as dehumanising, unpleasant or causing claustrophobia[2-5], and find scans trigger fear of the unknown and fear of cancer recurrence[2, 3, 6]. Scanxiety is recognised as a common clinical concern on social media and public forums, and is acknowledged by international cancer institutions[7, 8] and cancer-specific support networks[9-11]. Despite this, scanxiety is not uniformly recognised or measured in published studies. We conducted a systematic scoping review to identify the available literature on scanxiety in people having cancer-related scans.

METHODS

We conducted a systematic scoping review based on the six-step methodological framework developed by Arskey & O'Malley[12] and modified by Levac *et al.*[13], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis protocols extension for Scoping Reviews (PRISMA-ScR) checklist[14]. The study protocol is available (**Supplementary File 1**).

Step 1: Research question

Our aims were to: determine the prevalence and severity of scanxiety; identify contributing factors to scanxiety; and, identify interventions to reduce scanxiety in people having cancer-related scans.

Step 2: Search strategy

Published studies were identified from seven electronic databases: Ovid MEDLINE (1946 onwards), Ovid EMBASE (1947 onwards), Ovid PsycINFO (1806 onwards), Ovid Cochrane Central Register of Controlled Trials (1991 onwards), Scopus (any year), EBSCO CINAHL (any year) and PubMed (any year). The search strategy combined the subject headings and keywords of cancer, imaging and anxiety. An example is provided in **Figure 1**. Reference lists of included articles were hand-searched for additional studies. All references were imported into Endnote V9.

The initial search was conducted on April 11, 2019, and updated on July 3, 2020.

Step 3: Study selection

Inclusion criteria were full-text original research studies that recruited adults (≥18 years old) who had a non-invasive scan for a cancer-related reason, and which quantitatively assessed the prevalence or severity of scanxiety, reported a statistical comparison between pre- and post-scan scanxiety, reported a

statistical comparison between scanxiety and possible contributing factors, or evaluated the impact of an intervention on scanxiety.

The measurement of scanxiety was defined as any measure of anxiety, distress or worry occurring around the time of a scan. All non-invasive imaging modalities were accepted. No date restrictions were applied. Foreign language material was included if an English translation was available.

After initial review of citations and based on increasing familiarity with the literature, and in line with recommendations on scoping review methodology[12], exclusion criteria were developed *post hoc*. Exclusion criteria were: studies involving invasive scans (eg transvaginal ultrasound, ultrasound with fine needle aspirate, or endoscopic ultrasound) due to potential confounding from significant differences in scan preparation and increased risk of adverse events; studies of follow-up scans for a positive initial screening result due to the potential confounding from the experience of being recalled for another investigation; and, studies reporting only a qualitative assessment of scanxiety.

After removal of duplicate citations, two authors (KTB and RL) independently reviewed and screened publication titles and abstracts based on the eligibility criteria. Of the studies deemed potentially eligible, full texts were evaluated for final inclusion. Discrepancies were resolved by discussion between the two authors (KTB and RL) and were escalated to all authors if a consensus could not be reached.

Step 4: Charting the data

Relevant data were independently extracted by two authors (KTB and RL) into an electronic data extraction form, which included study demographics and methodology, scanxiety measurement tools, and the outcome measures of prevalence and severity of scanxiety, contributing factors to scanxiety, and interventions to reduce scanxiety.

Step 5: Collating, summarizing and reporting the results

Study data was tabulated to assist with a descriptive numerical summary of the range of cancer types, imaging modalities, study methodology and scanxiety measurement tools. Associations between scanxiety and potential contributing factors were tabulated if three or more studies reported a statistical comparison.

The prevalence of scanxiety was identified in two ways:

- The percentage of people who scored above the pre-specified clinically important anxiety threshold, if reported; or,
- The percentage of people who scored any degree of anxiety, if no pre-specified threshold was reported.

Severity of scanxiety was defined in three ways:

- Any mean score of the anxiety measure above the pre-specified clinically important anxiety threshold, if reported;

- Any mean score of the anxiety measure that was at least half the total score, if an anxiety threshold was not reported; or
- At least 'moderate' anxiety (or its equivalent) on a descriptive range.

The components of intervention studies and their effect on scanxiety were summarised and reported descriptively.

Step 6: Consultation

Medical oncologists (PB, BK) and a behavioural scientist (HD) were consulted for content expertise to share preliminary findings and improve clarity on clinically relevant interpretations of the data.

Patient and public involvement

This research did not directly involve patients and public. Our research was initiated by repeated observations of scanxiety in oncology patients.

RESULTS

The study search identified 26,693 citations. The selection process is outlined in **Figure 2**. After removal of duplicates, abstract and title screening, and full-text review, 57 eligible studies involving 21,352 people were included.

Demographics and study details

Observational studies

There were 47 observational studies (**Table 1**) involving 19,498 people[15-61]. Participants commonly had scans for breast cancer (22 studies, *n*=14,338 women[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56, 58]), and lung cancer (6 studies, *n*=2,758 people[30, 32, 35, 49, 54, 57]). The most common scans were mammograms (21 studies[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56]), standalone computed tomography (CT) scans (13 studies[17, 30, 32-35, 37, 44, 49, 52, 54, 57, 60]), positron-emission tomography (PET) with or without CT scans (11 studies[33, 34, 39, 46, 47, 49-53, 59]) and magnetic resonance imaging (MRI) (10 studies[38, 42, 44, 48, 49, 52, 53, 58, 60, 61]). There were 27 cross-sectional studies[15, 17, 19, 22, 27, 28, 33, 34, 36, 37, 39-41, 43-47, 49, 53-60] and 20 were longitudinal[16, 18, 20, 21, 23-26, 29-32, 35, 38, 42, 48, 50-52, 61]. Most studies used self-report surveys to assess scanxiety (40 studies[15, 16, 18-36, 38, 40-54, 56, 58, 59]), and seven studies used interviews[17, 37, 39, 55, 57, 60, 61].

Table 1. Demographics and study details for the 47 observational studies

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Methods
Andolf[15]	1990	275	Sweden	Ovarian	NR	100	NR	NR	NR	Abdominal ultrasound	Screening	Cross-sectional survey
Bull[b,c][16]	1991	541	UK	Breast	50 to 54: 23% 55 to 59s 29% 60 to 64: 34% 65 to 70: 7% Unknown: 7%	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Peteet[17]	1992	79	USA	Any	NR	NR	NR	NR	4	CT	Any (except screening)	Cross-sectional interview
Cockburn[c][18]	1994	200	Australia	Breast	NR	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Ellman[c][19]	1995	331	UK	Breast	50 to 64: 52% 65 to 78: 48%	100	NR	NR	NR	Mammogram	Screening or surveillance	Cross-sectional survey
Sutton[c,d][20]	1995	306	UK	Breast	58	100	76	50	NR	Mammogram	Screening	Longitudinal surveys
Bakker[21]	1998	315	Canada	Breast	61	100	71	76	50	Mammogram	Screening	Longitudinal surveys
Gupta[22]	1999	167	Kuwait	Breast	Range 14 to 63	100	NR	82	NR	Mammogram ± ultrasound	Screening or diagnosis	Cross-sectional survey
Hafslund[23]	2000	170	Norway	Breast	NR	100	NR	NR	NR	Mammogram	Diagnosis	Longitudinal surveys
Meystre-Agustoni[24]	2001	887	Switzerland	Breast	50 to 54: 36% 55 to 59: 22% 60 to 64: 20% 65 to 69: 22%	100	77	62	27	Mammogram	Screening	Longitudinal surveys
Drossaert[25]	2002	2657	Netherlands	Breast	58	100	78	32	NR	Mammogram	Screening	Longitudinal surveys
Sandin[c,d][26]	2002	598	Spain	Breast	51	100	77	41	NR	Mammogram	Screening	Longitudinal surveys
Brunton[27]	2005	584	New Zealand	Breast	50 to 54: 38% 55 to 59: 35% 60 to 64: 27%	100	NR	74	<20%	Mammogram	Screening	Cross-sectional survey
Geurts[28]	2006	106	Netherlands	Head and neck	56	36	NR	29	NR	Chest X-ray	Surveillance	Cross-sectional survey
Tyndel[c][29]	2007	1174	UK	Breast	43	100	83	33	87	Mammogram	Screening	Longitudinal surveys
Bunge[b][30]	2008	324	Netherlands, Belgium	Lung	60	49	NR	NR	NR	CT	Screening	Longitudinal surveys
Brown Sofair[b][31]	2008	47	USA	Breast	50	100	34	80	NR	Mammogram	Screening	Longitudinal surveys
van den Bergh[b][32]	2008	324	Netherlands, Belgium	Lung	60	49	64	82	66	CT	Screening	Longitudinal surveys
Westerterp[b][33]	2008	82	Netherlands	Oesophageal	64	18	NR	NR	NR	CT + PET	Diagnosis & staging	Cross-sectional survey
Bastiaannet[34]	2009	59	Netherlands	Melanoma	Median: 59	44	69	66	NR	CT, PET ± Chest X-ray	Staging	Cross-sectional survey
Vierikko[b][35]	2009	601	Finland	Lung	65	0	36	NR	NR	CT	Screening	Longitudinal surveys

Bolukbas[36]	2010	93	Turkey	Breast	48	100	97	10	45	Mammogram	Screening or diagnosis	Cross-sectional survey
Thompson[37]	2010	70	USA	Lymphoma	Median: 47	64	53	97	NR	CT	Surveillance	Cross-sectional interview
Hutton[b][38]	2011	527	UK	Breast	Median: 40	100	79	NR	75	Mammogram ± MRI	Screening	Longitudinal surveys
Pifarre[39]	2011	200	Spain	Any	52	51	NR	NR	67	PET/CT	Any (except screening)	Cross-sectional interview
Steinemann[40]	2011	227	USA	Breast	NR	100	NR	NR	NR	Mammogram	Screening or diagnosis	Cross-sectional survey
Yu[41]	2011	398	Brazil	Any	54	79	56	57	27	Any	Any (except screening)	Cross-sectional survey
Bredart[b][42]	2012	637	France	Breast	50	100	NR	87	NR	Mammogram ± ultrasound ± MRI	Screening or surveillance	Longitudinal surveys
Hafslund[c][43]	2012	4249	Norway	Breast	58	100	NR	52	NR	Mammogram	Screening	Cross-sectional survey
Adams[e][44]	2014	36	Netherlands	Lymphoma	50	42	NR	NR	NR	CT & MRI	Staging	Cross-sectional survey
Baena-Canada[45]	2014	434	Spain	Breast	54	100	72	43	18	Mammogram	Screening	Cross-sectional survey
Andersson[46]	2015	169	Sweden	Any	64	47	62	62	100	PET/CT	Any (except screening)	Cross-sectional survey
Elboga[47]	2015	144	Turkey	Any	63	46	83	52	NR	PET/CT	Any (except screening)	Cross-sectional survey
Hobbs[48]	2015	49	Australia	Breast	55	100	79	NR	75	Mammogram ± MRI	Diagnosis	Longitudinal surveys
Bauml[49]	2016	103	USA	Lung	Median: 67	61	73	53	NR	CT, PET ± MRI	Monitoring	Cross-sectional survey
Abreu[50]	2017	232	Portugal	Any	61	51	NR	73	71	PET/CT	Any (except screening)	Longitudinal surveys
Grilo[51]	2017	81	Spain, Portugal	Any	55	53	NR	41	47	PET/CT	Any (except screening)	Longitudinal surveys
Evans[52]	2018	115	UK	Colorectal or Lung	66	33	NR	NR	NR	Whole body MRI, PET + CT	Staging	Longitudinal surveys
Goense[53]	2018	27	Netherlands	Oesophageal	64	15	NR	NR	NR	MRI + PET/CT	Staging & monitoring	Cross-sectional survey
Hall[54]	2018	169	USA	Lung	64	51	58	96	NR	Low dose CT	Screening	Cross-sectional survey
Derry[55]	2019	94	USA	Any	61	72	NR	69	0	Any	Monitoring	Longitudinal interview
Soriano[56]	2019	57	USA	Breast	58	100	93	NR	0	Mammogram	Surveillance	Longitudinal survey
Taghizadeh[57]	2019	1237	Canada	Lung	63	56	NR	85	NR	CT	Screening	Longitudinal interview
Bancroft[58]	2020	88	UK, Ireland	Breast	38	61	50	83	NR	MRI	Screening	Longitudinal survey
Grilo[59]	2020	94	Portugal	Any	61	54	NR	99	77	PET + bone scan	Staging, monitoring & surveillance	Longitudinal survey
Morreale[60]	2020	87	USA	Gastrointestinal and Lung	62	55	NR	92	NR	CT or MRI	Monitoring	Longitudinal interview
Paiella[61]	2020	54	Italy	Pancreatic	50	61	NR	NR	NR	MRI – MRCP	Screening	Cross-sectional interview

UK United Kingdom, USA United States of America, NR not reported, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging, MRCP Magnetic resonance cholangiopancreatography

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Demographic data is based on participants who completed the first survey

[c]These studies collected data from other groups who were not included in this review as they did not meet eligibility criteria. This included people having invasive procedures such as fine needle aspirate or open surgical biopsy[16, 33], people with abnormal screening results[18, 26, 29] and people who did not have a scan[18-20, 43]

[d]Demographics based on the entire population even if not all participants were eligible for this review.

[e]Four paediatric participants were included in this study.

Twenty-one studies were conducted in people having scans for screening[15, 16, 18, 20, 21, 24-27, 29-32, 35, 38, 43, 45, 54, 57, 58, 61]. In the remaining studies, reasons for scanning included diagnosis[23, 48], staging[34, 44, 52], monitoring[49, 55, 60], surveillance to detect recurrence[28, 37, 56] or a combination of reasons in people with known or suspected cancers (17 studies[17, 39, 41, 46, 47, 50, 51, 53, 59]). Five studies permitted scans for both screening and non-screening reasons (namely, diagnosis[22, 36, 40] or surveillance[19, 42])

The mean age of participants, reported by 33 studies, was 56.9 years (range 38 to 66 years)[20, 21, 25, 26, 28-33, 35, 36, 39, 41-48, 50-61]. The majority of participants were women (87%)[15, 16, 18-61]. When studies involving scans for breast cancer were excluded, there were similar proportions of men and women (women 49%, men 51%)[15, 27, 28, 30, 32-35, 37, 39, 41, 44, 46, 47, 49-55, 57, 59-61]. There was variation in the reporting and proportion of participants who were married (22 studies, range 34% to 97%[20, 21, 24-26, 29, 31, 32, 34-38, 41, 45-49, 54, 56, 58]), who received at least secondary education (29 studies, range 10% to 99%[20-22, 24-29, 31, 32, 34, 36, 37, 41-43, 45-47, 49-51, 54, 55, 57-60]) and who were attending their first scan (18 studies, range 0% to 100%[17, 21, 24, 27, 29, 32, 36, 38, 39, 41, 45, 46, 48, 50, 51, 55, 56, 59]).

Intervention studies

There were ten intervention studies (**Table 2**) involving 1,854 people[62-71]. This included people having scans for breast cancer (6 studies, *n*=1,449 people[62-65, 69, 70]) and lung cancer (1 study, *n*=16 people[68]). Scans included mammogram (5 studies[62-64, 69, 70]), PET/CT (3 studies[66, 67, 71]), MRI[65], CT[68] and ultrasound[70] (1 study each). Four studies involved scans for screening[63, 64, 68, 69], one for diagnosis[65], three for any reason in people with known or suspected cancers[66, 67, 71], and two where scans for screening, surveillance and/or diagnosis were permitted[62, 70].

The mean age of participants was reported by five studies and ranged from 47 to 65 years[63, 65, 68, 69, 71]. The majority were women (94%[62-66, 68-71]). There was variation in the reporting and proportion of participants who were married (2 studies, 73% and 75%[64, 65]), received at least secondary education (6 studies, range 28 to 100%[62-65, 68, 69]), and participants attending their first scan (5 studies, range 4% to 54%[62-64, 66, 71]).

Eight studies allocated participants to an intervention or control group[63-69, 71], one study compared two interventions[62] and one study delivered the intervention to all participants[70]. Two interventions were multifaceted[64, 65]. Types of interventions included: relaxation, distraction, and/or meditation (6 studies[62, 63, 66, 69-71]); education (4 studies[62, 64, 65, 68]); emotional or psychosocial support (2 studies[64, 65]); or, adjustments to routine logistics of the scan (1 study[67]).

Table 2. Demographics and study details for the 10 intervention studies to reduce scanxiety

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Allocation	Intervention and control groups
Mainiero[62]	2001	613	USA	Breast	< 40: 8% 50 to 50: 39% 50 to 60: 28% >70: 9%	100	NR	95	7	Mammogram	Screening or surveillance	Consecutive[b]	Educational or entertaining video in waiting room
Domar[63]	2005	143	USA	Breast	52	100	NR	81	8	Mammogram	Screening	Randomised	Relaxation, music or blank audiotape in waiting room and during scan
Fernandez-Feito[64]	2005	436	Spain	Breast	50 to 54: 24% 55 to 59: 30% 60 to 64: 23% 65 to 69: 22%	100	73	28	4	Mammogram	Screening	Randomised	Pre-scan nursing intervention or usual care
Caruso[65]	2006	44	Italy	Breast	47	100	75	89	NR	MRI	Diagnosis	Randomised	Pre-scan informative-emotive psychological support or routine information
Vogel[66]	2012	101	Netherlands	Any	Median: 58	51	NR	NR	41	PET/CT	Any (except screening)	Randomised	Audiovisual installation or usual care during FDG uptake
Acuff[67]	2014	180	USA	Any	NR	NR	NR	NR	NR	PET/CT	Any (except screening)	Unclear	Hand-held communication device or usual care during scan
Raz[68]	2014	16	USA	Lung	65	75	NR	100	NR	CT	Screening	Sequential[c]	Pre-scan multimedia education or usual care
Zavotsky[69]	2014	100	USA	Breast	54	100	NR	98	NR	Mammogram	Screening	Non-randomised[d]	Music or no music during scan
Ashton[70]	2019	113	USA	Breast	18 to 39: 3.6% 40 to 59: 51.8% 60 to 79: 39.3% > 80: 5.4%	100	NR	NR	NR	Mammogram ± ultrasound	Screening, surveillance or diagnosis	NA[e]	Shoulder & neck massage ± hand massage
Lorca[71]	2019	108	Spain	Any	59	57	NR	NR	54	PET/CT	Any (except screening)	Randomised	Mindfulness meditation or usual care during FDG uptake

USA United States of America, NR not reported, MRI magnetic resonance imaging, PET positron emission tomography, CT computed tomography, FDG fluorodeoxyglucose

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Each intervention was administered during one half of the study period

[c]Participants were enrolled into the control arm first, followed by the intervention arm

[d]Participants attending on Mondays, Wednesdays and Fridays were allocated to the intervention arm, and participants attending on Tuesdays and Thursdays were allocated to the control arm

[e]All participants received the intervention

Scanxiety measurement

Anxiety measurements varied across the studies, with different measurement tools, variants of the same tool, and different range and thresholds applied to tools.

Observational studies

The 47 observational studies (**Supplementary Table 3**) used a total of 81 measures of anxiety, with 30 studies using one measure only[15-19, 21, 22, 25-28, 30, 33, 34, 36, 39, 40, 43, 44, 46, 48-51, 53, 55-57, 59, 61], and 17 studies using at least two measures[20, 23, 24, 29, 31, 32, 35, 37, 38, 41, 42, 45, 47, 52, 54, 58, 60].

The most common measures used were: purposed-designed Likert scales (17 studies); the State-Trait Anxiety Inventory (STAI) (14 studies); the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS) (9 studies); the Impact of Event Scale (IES) (6 studies); the Psychological Consequences Questionnaire (PCQ) (3 studies), the Cancer Worry Scale (3 studies), and; the Perceived Stress Scale (2 studies). There were 17 measures used by one study only[15, 20, 22, 26, 31, 32, 35, 52, 54, 56, 58, 60].

Likert scales were varied, with a numerical lower range limit of 0 or 1, and an upper range limit between 3 and 12[17, 20, 24, 25, 33, 40, 44, 46, 48, 50, 52, 53]. Seven studies used a descriptive range[21, 25, 27, 28, 33, 34, 55]. Two studies used both a numerical and a descriptive range[25, 33].

The STAI compromises State and Trait Anxiety subscales with a possible subscale range of 20 to 80. It has no validated anxiety threshold and is usually calculated as a sum of 4-point response options[72]. Included studies used and reported the STAI as a total score[37, 39], using one or both subscales[20, 23, 36, 37, 41, 42, 47, 51, 57, 59], or as a variant (e.g. STAI-6[32, 38, 58]). There were different ranges: none reported[47, 57]; no reported lower limit[41]; no reported upper limit[36]; 0 to 60[39, 51], or; based on a mean of individual item scores[20]. Some studies pre-specified an anxiety threshold of 39[57], 40[37, 41], 46[42], calculated based on the relationship between the anxiety and trait subscales[39], or based on investigator-determined categories[36]. One study used a different method to calculate scores (ie subtracting the points of reversed statements from direct statements, which were valued at 1, 2, 3 and 20, and then added to a constant of 50[36]).

The HADS Anxiety subscale has a range of 0 to 21 and a validated anxiety threshold of 11[73]. One study reported a range of 0 to 14[38], one study reported anxiety categories rather than a threshold[60], two studies reported an anxiety threshold of 8[41, 43] and one study reported an anxiety threshold of 10 (though there was overlap the 'tendency to anxiety' and 'anxiety' categories, classified as scores of 8 to 10 and 10 or more, respectively)[47].

The IES was used in its original form[30, 32, 38, 42, 58] or as a variant (IES-6[49]), and was reported as a total score[30, 32, 38, 49] or as Intrusion and Avoidance subscale scores[42, 58]. The two studies using subscale scores reported threshold levels of 20 or 21[42] and 8.5[58]. When using the PCQ, researchers used either the Emotional subscale[18] or the Negative Consequences subscale[24, 29]. The Cancer Worry Scale and the Perceived Stress Scale were used in original[45, 61] or variant[29, 54, 58] forms. The Symptom Checklist-90-Revised score could not be interpreted because the authors did not report a range[31], and a raw score or a transformed score could have been used[74].

Supplementary Table 3. Prevalence and severity of scanxiety

Author	Year	Measurement	Range (Anxiety threshold)	Timing of scanxiety assessment	Prevalence (%)	Severity (Mean[a])	Pre- & post-scan comparison
Andolf[15]	1990	Visual analogue scale	0-100 (NA)	Post-scan: 1-3 years	81	Median 3.5	NA
Bull[16]	1991	HADS: Anxiety subscale	0-21 (≥11)[b]	Pre-scan: specific timing NR	4.9	4.97	Less severe post-scan scanxiety, p<0.001
				Post-scan: post-result, specific timing NR	4	4.43	
Peteet[17]	1992	10-point Likert scale	1-10 (NA)	Post-scan: specific timing NR	NR	First scan 5.5, Recent scan 3.5	NA
Cockburn[18]	1994	PCQ: Emotional subscale	0-15 (NA)	Pre-scan: day of scan	NR	<2	No difference
				Post-scan: pre-results, 1-week post-result & at 8 months	NR	<2	
Ellman[19]	1995	HADS: Anxiety subscale	0-21 (≥11)	Pre-scan: day of scan	6	NR	NA
Sutton[20]	1995	STAI: State Anxiety subscale	1-4# (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		STAI: Trait Anxiety subscale	1-4# (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences in scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		GHQ: Anxiety subscale	0-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<1	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<1	
		3-point Likert scale	1-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<2	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<2	
Bakker[21]	1998	5-point Likert scale	Descriptive range (NA)	Post-scan: immediate & at 3 weeks	39-40	Somewhat, very or extremely: 9 to 15%	NA
Gupta[22]	1999	HSCL-25	0-3 (NA)	Post-scan: specific timing NR	40	Moderate to severe: 25%	NA
Hafslund[23]	2000	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.5	No statistical comparison reported
				Post-scan: day of scan	NR	32.1	
		STAI: Trait Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.9	No statistical comparison reported
				Post-scan: day of scan	NR	NR	
Meystre-Agustoni[24]	2001	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: day of scan	NR	<1	No statistical comparison reported
				Post-scan: pre- result, 2 weeks post-result & 8 weeks post-result	NR	<2	
		6-point Likert scale	0-5 (NA)	Pre-scan: immediate	26	<1	
				Post-scan: pre-result, 2 weeks post-result & 8 weeks post-result	NR	<1	

Drossaert[25]	2002	Composite 7-item score of 4-point Likert scales	1-4 (NA)	Baseline: 8 weeks post-first scan	NR	1.6	No statistical comparison reported
				Pre-scan: 6 weeks (second & third scans)	NR	1.6 to 1.7	
				Post-scan: 6 weeks (second & third scans)	NR	1.5	
			Descriptive range (NA)	Baseline: 8 weeks post-first scan	NR	Moderate to severe: 10%	NA
Sandin[26]	2002	HSCL-90-R: Anxiety subscale	0-4 (NA)	Pre-scan: day of scan	NR	0.41	No statistical comparison reported
				Post-scan: 2 weeks	NR	0.28	
Brunton[27]	2005	4-point Likert scale, 3 items	Descriptive range (NA)	Post-scan: within 4 years	56-77	Quite or very: 11 to 28%	NA
Geurts[28]	2006	4-point Likert scale	1-4 (NA)	Peri-scan: specific timing NR	61	Moderate to severe: 21%	NA
Tyndel[29]	2007	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: 1 month	NR	5.1	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	3.8 to 4.2	
		Cancer Worry Scale - Revised	6-24 (NA)	Pre-scan: 1 month	NR	11.0	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	10.1 to 10.6	
Bunge[30]	2008	IES in low affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	5.6	Less severe post-scan scanxiety in both low and high affective risk groups, p<0.05
				Post-scan: 6 months	NR	4.3	
		IES in high affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	14.7	
				Post-scan: 6 months	NR	10.3	
Brown Sofair[31]	2008	Penn State Worry Questionnaire	16-80 (60)	Pre-scan: within 1 month	NR	50.18	No statistical comparison reported
				Post-scan: day of scan (post-result)	NR	NR	
		SCL-90-R: Anxiety subscale	NR (NA)	Pre-scan: within 1 month	NR	48.75	No difference
				Post-scan: day of scan (post-result)	NR	42.07	
		Individualized Questionnaire: Anxiety response	1-3 (2)	Pre-scan: within 1 month	35	NR	No statistical comparison reported
				Post-scan: day of scan (post-result)	24	NR	
van den Bergh[32]	2008	STAI-6	20-80 (NA)	Pre-scan: 1 day	NR	34.1	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	32.7 to 34.3	
		IES	0-75 (NA)	Pre-scan: 1 day	NR	6.9	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	5.1 to 5.6	
		EuroQol questionnaire: Anxiety subscale	1-3 (NA)	Pre-scan: 1 day	23	NR	No statistical comparison reported
				Post-scan: 6 months	NR	NR	
Westerterp[33]	2008	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): 2 weeks	NR	CT 1.2, PET 1.4	NA
			Descriptive range (NA)	Post-scan (after both scans): 2 weeks	CT 13, PET 23	Moderate to severe: CT 4%, PET 10%	NA
Bastiaannet[34]	2009	5-point Likert scale	1-5 (NA)	Post-scan: 2-6 weeks after lymph node dissection	Chest x-ray 20, CT 31, PET 36	Moderate to severe: Chest X-ray 13%, CT 5%, PET: 9%	NA
Vierikko[35]	2009	Health anxiety inventory	0-24 (NA)	Pre-scan: specific timing NR	NR	6.7	Less severe post-scan scanxiety, p<0.001
				Post-scan: 1 year	NR	5.8	
		Worry about lung cancer	0-8 (NA)	Pre-scan: specific timing NR	NR	3.0	No difference

				Post-scan: 1 year	NR	3.1	
Bolukbas[36]	2010	STAI: State Anxiety subscale	0-NR (20-39 mild, 40-59 moderate, 60-79 severe, ≥ 80 help needed)#	Peri-scan: specific timing NR	NR	46.2	NA
Thompson[37]	2010	STAI	40-160 (NA)	Post-scan: specific timing NR	37	65.8	NA
		STAI: State Anxiety subscale	20-80 (≥40)#	Post-scan: specific timing NR	NR	30.4	NA
		STAI: Trait Anxiety subscale	20-80 (≥40)#	Post-scan: specific timing NR	NR	35.4	NA
Hutton[38]	2011	HADS: Anxiety subscale	0-14 (≥11)#	Baseline: 4 weeks pre-first scan	20	6.9	No difference
				Pre-scan: day of each scan (for 5 scans)	MRI 17, Mammogram 20	MRI 5.2 to 6.5, Mammogram 5.0 to 6.5	
				Post-scan: 6 weeks (for 5 scans)	10 to 13	5.1 to 5.9	
		STAI-6	20-80 (NA)	Pre-scan: day of scan (for 5 scans)	NR	MRI 10.8 to 12.1, Mammogram 10.1 to 11.3	Less severe post-scan scanxiety for MRI (p<0.0005) & mammogram (p=0.002)
				Post-scan: day of scan (for 5 scans)	NR	MRI 9.6 to 10.7, Mammogram 9.7 to 10.5	
		IES	0-75 (NA)	Post-scan: 6 weeks (for 5 scans)	NR	MRI 17.8 to 19.3, Mammogram 17.2 to 18.6	NA
Pifarre[39]	2011	STAI	0-60 for each subscale (state more than 10 than trait)#	Pre-scan: day of scan	68	NR	NA
Steinemann[40]	2011	7-point Likert scale	1-7 (NA)	Pre-scan: day of scan	NR	4.1	NA
Yu[41]	2011	HADS: Anxiety subscale	0-21 (≥8)#	Pre-scan: day of scan	38	NR	NA
		STAI: State Anxiety subscale	NR-80 (≥40)#	Pre-scan: day of scan	46	39.4	NA
		STAI: Trait Anxiety subscale	NR-80 (≥40)#	Pre-scan: day of scan	46	39.9	NA
		Dichotomous reporting[c]	Yes/No (NA)	Pre-scan: day of scan	41	NR	NA
Bredart[42]	2012	STAI: State Anxiety subscale	20-80 (≥46)#	Pre-scan: 1 week	NR	MRI 42.1, Mammogram 41.1	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 34.9, 40.8, Mammogram 34.3, 38.8	
		IES: Intrusion subscale	0-35 (≥20)#	Pre-scan: 1 week	NR	MRI 8.9, Mammogram 8.4	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 8.5, Mammogram 7.7	
		IES: Avoidance subscale	0-40 (≥21)#	Pre-scan: 1 week	NR	MRI 12.1, Mammogram 9.8	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 11.8, Mammogram 8.9	
Hafslund[43]	2012	HADS: Anxiety subscale	0-21 (≥8)#	Pre-scan: within 2 weeks	15	4.1	NA
Adams[44]	2014	4-point Likert scale	1-4 (NA)	Post-scan: day of scan (after each scan)	NR	MRI 1.5, CT 1.8	NA
Baena-Canada[45]	2014	HADS: Anxiety subscale	0-21 (≥11)	Post-scan: specific timing NR	4	1.86	NA
		Cancer Worry Scale	6-24 (NA)	Post-scan: specific timing NR	NR	9.4	NA

Andersson[46]	2015	Sum of 3 items on 5-point Likert scale	0-12 (NA)	Post-scan: within four weeks	NR	4	NA
Elboga[47]	2015	HADS: Anxiety subscale	0-21 (≥10)	Pre-scan: day of scan	NR	9.2	NA
		STAI: State Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	40.4	NA
		STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	46.6	NA
Hobbs[48]	2015	5-point Likert scale	1-5 (NA)	Post-scan (after both scans), specific timing NR	Mammogram 17, MRI 44	NR	NA
Bauml[49]	2016	IES-6	0-24 (NA)	Post-scan: specific timing NR	83	6.4	NA
Abreu[50]	2017	10-point Likert scale	1-10 (NA)	Pre-scan: day of scan	NR	6.4	Less severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	5.7	
Grilo[51]	2017	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: day of scan	NR	31.1	More severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	33.0	
Evans[52]	2018	GHQ-12	0-12 (≥4)	Peri-scans: specific timing NR	42	NR	NA
		7-point Likert scale	1-7 (NA)	Post-scan: 1 month	NR	MRI 2.5, CT or PET/CT 2.2	NA
Goense[53]	2018	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): day of scan	NR	MRI 1.0, PET 1.0	NA
Hall[54]	2018	Generalized Anxiety Disorder 2-item	0-6 (≥3)	Peri-scan: specific timing NR	26	1.62	NA
		Perceived Stress Scale 4	0-16 (NA)	Peri-scan: specific timing NR	NR	5.14	NA
Derry[55]	2019	4-point Likert scale	Descriptive range (NA)	Peri-scan: pre-result	NR	'A great deal' or 'completely': 23%	NA
Soriano[56]	2019	PROMIS Anxiety Short Form	1-5 (NA)	Pre-scan: two weeks	NR	1.55	NA
Taghizadeh[57]	2019	STAI: State Anxiety subscale	NR (39)	Baseline	NR	30.9	More severe post-scan scanxiety, p<0.001
				Post-scan: one-month post-result & at 12 months	NR	33.1, 31.7	
Bancroft[58]	2020	HADS: Anxiety subscale	0-21 (11)	Baseline	Carriers[d]: 14 Controls: 7	Carriers: 6.2 Controls: 4.9	No difference in prevalence Less severe post-scan in carriers (p=0.04)
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 5 to 14 Controls: 2 to 7	Carriers: 5.3 to 5.9 Controls: 4.1 to 4.6	
		Cancer Worry Scale – Revised	8-32 (NA)	Baseline	NR	Carriers: 14.4 Controls: 12.2	No difference
				Post-scan: at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 13.6 to 14.7 Controls: 11.9 to 12.1	
		IES-cancer: Intrusion subscale	0-35 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 35 to 58 Controls: 5 to 13	Carriers: 8.3 to 11.4 Controls: 1.7 to 3.0	NA
		IES-cancer: Avoidance subscale	0-40 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 55 to 64 Controls: 12 to 37	Carriers: 9.9 to 13.3 Controls: 2.6 to 7.0	NA
		IES-MRI: Intrusion subscale	0-35 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 4 to 7 Controls: 0 to 3	Carriers: 1.2 to 3.1 Controls: 0.1 to 0.5	NA
		IES-MRI: Avoidance subscale	0-40 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 14 Controls: 8	Carriers: 1.8 Controls: 2.8	NA
		STAI-6	6-24 (NA)	Pre-scan: day of scan	NR	Carriers: 7.2 Controls: 7.3	NA
		Health Questionnaire	0-14 (NA)	Baseline	NR	Carriers: 7.0 Controls: 6.8	No difference

				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 8.1, 7.1 Controls: 6.9, 7.7	
Grilo[59]	2020	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	Bone scan: 51.75 PET/CT: 44.76	Less severe post-scan scanxiety for both: Bone scan. p=0.02 PET/CT, p<0.001
				Post-scan: day of scan	NR	Bone scan: 36.70 PET/CT: 38.82	
Morreale[60]	2020	Distress thermometer	0-10 (4)	Peri-scan: day of scan	NR	3.73	No statistical comparison
				Post-scan: one-week post-result	NR	3.91	
		HADS: Anxiety subscale	0-21 (0-7 none, 8-10 mild, 11-14 moderate, 15-21 high)	Peri-scan: day of scan	NR	6.12	No statistical comparison
				Post-scan: one-week post-result	NR	5.32	
Paiella[61]	2020	Perceived Stress Scale	0-40 (15-18 moderate, ≥ 19 high)	Post-scan: pre-result	NR	14.8	NA

NA not applicable, NR not reported, HADS Hospital Anxiety and Depression Scale, PCQ Psychological Consequences Questionnaire, STAI State-Trait Anxiety Inventory, GHQ General Health Questionnaire, HSCL Hopkins Symptom Checklist, IES Impact of Event Scale, SCL-90-R Symptom Checklist-90-Revised, HSCL-90-R Hopkins Symptom Checklist 90-Revised, PROMIS Patient-Reported Outcomes Measurement Information System, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging

All percentages were rounded to the nearest whole number

[a]Unless otherwise described

[b]This study did not specify an anxiety threshold; however, the Anxiety subscale of the Hospital Anxiety and Depression Scale has validated thresholds. These thresholds were included in this table

[c]Dichotomous reporting assumed given description of question (self-perception of anxiety) and results "40.5% of the patients considered themselves to be anxious"[41]

[d]This study included participants who were *TP53* mutation carriers, and population controls

Intervention studies

The ten intervention studies (**Table 4**) used 19 measures of anxiety, with five studies using one measure only[62, 66, 67, 69, 70], and five studies at least two[63-65, 68, 71]. The measures included subscales of the STAI (7 studies), Likert scales (5 studies), a variant of the Psychological Consequences Questionnaire (1 study[68]) and the Crown Crisp Experimental Index (1 study[65]).

Likert scales were varied, with a lower range limit of 0 or 1, and an upper range limit between 5 and 10[62, 63, 69-71]. The STAI was used and reported using one or both subscales[63-65, 67, 68, 71], or as a variant (8-item STAI[66]). There was variation from the usual STAI parameters, with studies using a different range (i.e. not reported[63, 65], 0 to 60[64], or 18 to 32[66]) or pre-specified anxiety thresholds of 40[68] or 16[66].

Scanxiety outcomes

Prevalence and severity of scanxiety for each study are provided in **Supplementary Table 3**. Summary statistics for prevalence and severity were not calculated due to heterogeneity in the type and timing of measurement between the studies.

Prevalence of scanxiety

Twenty-four of the 47 studies reported the prevalence of scanxiety. The prevalence of scanxiety ranged between 0% and 64% across the 16 measures with pre-specified anxiety thresholds[16, 19, 31, 38, 41, 43, 45, 52, 54, 58], though eight of these measures came from only two studies[41, 58]. The prevalence of scanxiety ranged between 13% and 83% using the 14 measures without pre-specified anxiety thresholds[15, 21, 22, 24, 27, 28, 32-34, 37, 39, 41, 48, 49].

There were insufficient numbers to compare the prevalence of scanxiety using measures with pre-specified anxiety thresholds of people having scans for screening (11 measures[16, 31, 38, 43, 45, 54, 58]), reasons other than screening (four measures[41, 52]) and for screening or non-screening reasons (1 measure[19]). When no threshold was reported, the prevalence of scanxiety had a similar range (screening 23% to 81%, five measures[15, 21, 24, 27, 32]; reasons other than screening 14% to 83%, eight measures[28, 33, 34, 37, 39, 41, 48, 49]; either screening or reasons other than screening (40%, one measure[22]).

Severity of scanxiety

Severity of scanxiety was reported in 44 of 47 observational studies. Mean severity scores were low in almost all measures which quantitatively measured scanxiety (54/62, 87%).

Table 4. Effect of interventions to reducing scanxiety

First author	Year	Intervention	Scanxiety measurement	Range (Anxiety threshold)	Timing of scanxiety assessment	Impact of intervention on scanxiety	P-value
Mainiero[62]	2001	Arm A: an educational video about breast cancer and mammography Arm B: an entertaining movie (from the 1940s to 1960s)	6-point Likert score	0-5 (NA)	Pre-scan: immediate Post-scan: immediate	No difference	NR
Domar[63]	2005	Arm A: relaxation audiotape, or; Arm B: music audiotape, or; Arm C: control (blank audiotape)	STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 34.8 v 33.6 v 33.2	0.18
					Post-scan: immediate	No difference Arm A v Arm B v Arm C: 30.4 v 30.9 v 33.2	0.78
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 32.6 v 32.7 v 32.5	0.99
			11-point Likert scale	1-10 (NA)	Post-scan	No difference Arm A v Arm B v Arm C: 2.6 v 3.2 v 2.8	0.43
					Post-scan: immediate	NR	NR
Fernandez-Feito[64]	2005	Arm A: A protocolised nursing intervention (information and emotional support) and usual care, or; Arm B: Usual care alone	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	Less severe	<0.001
						Less severe if fear of cancer present	0.002
						Less severe if no fear of cancer present	0.003
						No difference if fear of cancer outcome present	0.09
						Less severe if no fear of scan outcome	<0.001
			STAI: Trait Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	No difference	0.34
Caruso[65]	2006	Arm A: routine information and 45 minutes of informative-emotive psychological support with a psychologist, or; Arm B: routine information	Crown Crisp Experimental Index	NR (0-96)	Pre-scan: immediate (post-intervention)	Less severe Arm A v Arm B: 39.4 v 42.3	0.03
			STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	No difference Arm A v Arm B: 57.7 v 58.6	0.77
					Post-scan: immediate	Less severe	0.048
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	NR	NR
Vogel[66]	2012	Arm A: Uptake room with an audio-visual installation involving a video of nature scenes on a 119cm television, dynamic lighting & ambient electronic music Arm B: Uptake room without the audio-visual installation	8-item STAI	18-32 (≥16)	Pre-scan: immediately before & immediately after fluorodeoxyglucose uptake period	Less severe Arm A v Arm B: reduction by 2.39 v 1.02	0.04
Acuff[67]	2014	Arm A: Receive a hand-held device to contact imaging staff during the scan Arm B: No device	STAI: State Anxiety subscale	20-80 (NA)	During scan: immediately before completion of the scan	Less severe Arm A v Arm B: 22.87 v 26.45	0.014
						Less severe if previous PET/CT Arm A v Arm B: 20.78 v 24.64	0.023
						No difference if first time PET/CT Arm A v Arm B: 23.09 v 27.25, p=0.249	0.249

Raz[68]	2014	Arm A: multimedia education session and usual care, or; Arm B: Usual care	STAI: State Anxiety subscale	20-80 (≥40)	Pre-scan: within 2 weeks Post-scan: immediate, at 1 week & 3-7 months post-scan	No difference at any time point	NR
			STAI: Trait Anxiety subscale	20-80 (≥40)		No difference at any time point	NR
			PCQ: Lung Cancer adaptation, Anxiety subscale	0-18 (NR)		No difference at any time point	0.11 to 0.76
Zavotsky[69]	2014	Arm A: music of their choice played via dock during the scan Arm B: no music	11-point Likert scale	0-10 (NA)	Post-scan: immediate	No difference Arm A v Arm B: 2.36 v 2.98	0.21
Ashton[70]	2019	All participants: 10-minute shoulder & neck massage and/or hand massage before, during or after imaging, or between two imaging tests	11-pointLikert scale	0-10 (NA)	Post-intervention (pre- or post- scan)	81% had a reduction in anxiety following massage[a]	<0.01
Lorca[71]	2019	Arm A: mindfulness meditation Arm B: routine care	STAI: State Anxiety subscale	NR (NA)	Post-scan: immediate	Less severe Arm A v Arm B: 10.47 v 29.07	0.000
			STAI: Trait Anxiety subscale	NR (NA)		No difference	NS
			11-item Likert scale	0-10 (NA)		Less severe Arm A v Arm B, 1.07 v 5.70	0.000

NR not reported, STAI State-Trait Anxiety Inventory, PCQ Psychological Consequences Questionnaire

[a]Mean scores for overall study population not provided

The mean severity scores were below pre-specified anxiety thresholds on 17 of the 19 measures where a threshold was reported[16, 31, 37, 38, 41-43, 45, 47, 54, 57, 58]. The two exceptions were observed in a study comparing people with *TP53* mutations ('carriers') to controls, with all participants undergoing screening scans. In carriers, mean scores were maximally 11.4 (IES Intrusion subscale, threshold 8.5), and 13.3 (IES Avoidance subscale, threshold 8.5). Mean severity scores for controls were below the thresholds[58].

Of the 43 measures without a pre-specified threshold, the majority had numerically low mean scores[15, 18, 20, 23-26, 29, 30, 32, 33, 35, 37, 38, 44-46, 49, 52-54, 56, 58, 60, 61]. There were six exceptions, which reported maximal mean severity scores of: 5.5 out of 10 (Likert scale)[17]; 6.4 out of 10 (Likert scale)[50]; 4.1 out of 7 (Likert scale)[40], 33 out of 60 (STAI State Anxiety subscale)[51], 8.1 out of 14 (Health Questionnaire)[58], and; 51.75 out of 80 (STAI)[59]. Four of these scores occurred in studies where scans were performed for reasons other than screening[17, 50, 51, 59], one allowed scans for diagnosis or screening[40], and one allowed scans for screening only[58].

Eight measures used a descriptive range of severity, with more severe levels of scanxiety in 4% to 28% of participants[21, 22, 25, 27, 28, 33, 34, 55].

Four measures could not be interpreted because they failed to report a range and anxiety threshold[31, 36, 47].

Scanxiety before and after a scan

Of the 20 studies that reported a pre- and post-scan scanxiety measurement, 14 studies reported a statistical comparison[16, 18, 20, 29-32, 35, 38, 50, 51, 57-59] and six did not[23-26, 42, 60](**Supplementary Table 3**). There was variation in the timing of scanxiety measurement before a scan from four weeks before the scan until immediately before the scan, and after a scan from immediately after the scan until one year after the scan. Five studies reported a post-scan reduction in scanxiety severity compared to pre-scan levels[16, 29, 30, 32, 50, 59]. Two studies reported an increase in post-scan scanxiety severity[51, 57], and two studies no difference in pre- and post-scan scanxiety severity[18, 31].

Four studies reported mixed findings on the change in scanxiety severity across different measures (**Table 5**).

Table 5. Studies with discrepant results on pre- and post-scan scanxiety severity using different measures

First author	Measurement tool	
	Post-scan reduction in scanxiety	**No difference in pre- or post-scan scanxiety**
Sutton[20]	General Health Questionnaire: Anxiety subscale 3-point Likert scale	STAI: State Anxiety subscale STAI: Trait Anxiety subscale
Vierikko[35]	Health Anxiety Inventory	Worry about lung cancer
Hutton[38]	6-item STAI	HADS: Anxiety subscale
Bancroft[58]	HADS: Anxiety subscale	Cancer Worry Scale – Revised Health Questionnaire

STAI: State Trait Anxiety Inventory, HADS: Hospital Anxiety and Depression Scale

Although Bancroft *et al.*[58] reported a reduction in scanxiety severity using HADS (anxiety subscale), there was no difference in scanxiety prevalence.

For most measures where a statistically significant difference in pre-scan and post-scan scanxiety was reported, the absolute differences in mean scores were numerically low. The exception was a 15-point reduction in scanxiety severity using the STAI (range 20-80) in people having a bone scan for non-screening reasons[59].

Contributing factors to scanxiety

Multiple comparisons were made between scanxiety and possible contributing factors across the included studies (**Table 6**).

Table 6. Contributing factors to scanxiety

Variable	Comparison	Effect on scanxiety	Studies	*n*	*P*-value
Age	Younger v older	More prevalent	1	398	0.008[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	5	1883	0.005[45], <0.01[20], <0.01 (for screening)[70], 0.01[24], NR[63]
		No difference in severity	11	6804	NS[22, 27, 36, 37, 42, 43, 49, 51, 59, 62], NS (for surveillance)[70]
Gender	Men v women	More prevalent	1	200	<0.001[39]
		Less prevalent	1	298	0.021[41]
		No difference in prevalence	1	106	NS[28]
		More severe	1	232	0.033 (post-scan)[50]
		Less severe	2	1381	0.000[47], <0.05[57]
		No difference in severity	5	580	NS[37, 49, 51, 59], NS (pre-scan)[50]
Ethnicity	White v other races	More severe	1	143	NR[63]
	Maori & Pacific Islanders v New Zealand European or Asian	More severe	1	584	<0.001[27]
	Any	No difference in severity	5	1454	NS[22, 24, 37, 40, 49]
Education	Lower v higher	More prevalent	1	398	<0.001[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	8	7400	0.003[62], 0.007[36], <0.01[22], ≤0.01[42], 0.012[24], 0.018[27], 0.04[43], <0.05[23]
		No difference in severity	6	591	NS[37, 49, 51, 59, 63, 69]
Employment	Unemployed v employed	More prevalent	1	398	0.046[41]
		More severe	3	5056	0.01[43], 0.05[23], ≤0.05[42]
		No difference in severity	2	654	NS[27, 37]
Income	Higher v lower	No difference in severity	3	757	NS[27, 37, 49]
Marital status	Married or de facto v single	More severe	1	637	≤0.01 (using IES - Intrusion subscale)[42]
		No difference in severity	5	1790	NS[24, 36, 37, 49], NS (using STAI - State anxiety subscale)[42]
Children	Children v no children	No difference in severity	3	5206	NS[24, 37, 43]
Smoking status	Current v non-smoking[a]	More severe	3	4562	<0.001[43, 54], 0.031[47]
		No difference in severity	2	330	NS[40, 49]
Reason for scan	Diagnostic v screening	More severe	3	1104	0.007[41], 0.047[36], NR[62]
	Staging or surveillance v monitoring	More severe	1	200	<0.001[39]
	Lower v higher referral clarity	More severe	1	169	0.048[54]
	Any	No difference in severity	3	480	NS[22, 50, 51]
Type of scan	MRI v mammogram	More severe	1	49	0.009[48]
		Less severe	1	637	NR[42]

	CT v MRI	More severe	1	36	0.007[44]
		Less severe	1	115	NR[52]
	PET v CT	More severe	1	82	0.01[33]
	Nuclear medicine scan v non-nuclear medicine scan	More severe	1	398	0.004[41]
	MRI v PET/CT	No difference in severity	2	142	NS[52, 53]
	CT v PET v chest X-ray	No difference in severity	1	59	NS[34]
	Bone scan v PET scan	More severe	1	94	<0.001 (post-scan)[59]
		No difference in severity	1	94	NS (pre-scan)[59]
Scan-naïve	First v subsequent scans	More prevalent	1	398	0.001[41]
		No difference in prevalence	1	200	NS[39]
		More severe	5	3796	<0.0005[38], <0.01[25], <0.02[19], <0.05[67], NR[66]
		Less severe	1	93	0.038[36]
		No difference in severity	6	2491	NS[24, 27, 50, 51, 59, 62]
Pain	Pain v no pain during scan	More severe	6	4291	<0.0001[25], <0.001[27], 0.001[62], <0.01[23, 69] <0.05[22]
Risk of cancer	Past history v no past history of cancer	More severe	2	864	≤0.001[42], <0.05[40]
		Less severe	1	434	0.013[45]
		No difference in severity	3	1206	NS[15, 24, 58]
	Family history v no family history of cancer	More severe	1	584	0.002[27]
		No difference in severity	3	1255	NS[15, 24, 36]
	Mutation carrier v not a carrier	More severe	1	88	<0.05 (three comparisons, using IES cancer – Intrusion and Avoidance subscales, and post-scan Health Questionnaire)[58]
		No difference	1	88	NS (five comparisons, using HADS- Anxiety subscale, Cancer Worry Scale – Revised, IES MRI – Intrusion and Avoidance subscales, and pre-scan Health Questionnaire)[58]
	Higher, not otherwise specified v lower	More severe	1	70	<0.05[37]
Perceived risk of cancer	Higher v lower	More severe	3	1545	<0.001[27], ≤0.001[42], <0.01[30]

NS not significant, NR not reported, IES Impact of Event Scale, STAI State Trait Anxiety Inventory, HADS Hospital Anxiety and Depression Scale, MRI Magnetic Resonance Imaging

[a]One study compared current smokers v former smokers[54], and one study compared current and former smokers v never smokers[49]

In summary, higher scanxiety severity was associated with people with:

- Lower education (compared to higher education, eight of 14 studies[22-24, 27, 36, 37, 42, 43, 49, 51, 59, 62, 63, 69]);
- A history of smoking (compared to non-smoking, three of five studies[40, 43, 47, 49, 54]);
- Higher pain levels during the scan (compared to no pain, all six studies[22, 23, 25, 27, 62, 69]);
- Higher perceived risk of cancer (compared to lower perceived risk of cancer, all three studies[27, 30, 42]), and;
- Diagnostic scans (compared to screening scans, all three studies[36, 41, 62])

The prevalence or severity of scanxiety was not consistently affected by age (13 of 19 comparisons[20, 22, 24, 27, 28, 36, 37, 41-43, 45, 49-51, 59, 62, 63, 70]), gender (six of 11 comparisons[28, 37, 39, 41, 47, 49-51, 57, 59]), ethnicity (five of seven comparisons[22, 24, 27, 37, 40, 49, 63]), income (all three comparisons[27, 37, 49]), marital status (five of six comparisons[24, 36, 37, 42, 49]) or having children (all three comparisons[24, 37, 43]).

Inconclusive results occurred in the following comparisons:

- Employment (unemployed compared to employed, four of six comparisons[23, 27, 37, 41-43])
- Scan-naivety (first scan compared to subsequent scans, six of 13 comparisons[19, 24, 25, 27, 36, 38, 39, 41, 50, 51, 62, 66, 67])
- Risk of cancer (higher compared to lower risk of cancer, seven of 19 comparisons[15, 24, 27, 36, 37, 40, 42, 45, 58])

Although nine studies reported differences in scanxiety between different imaging modalities, the number of comparisons between specific scans were insufficient to draw conclusions[33, 34, 41, 42, 44, 48, 52, 53, 59].

Interventions that reduce scanxiety

Five of the 10 intervention studies showed a reduction in scanxiety compared to controls[64-67, 71]. Four studies reported no difference in scanxiety between the intervention arms[62, 63, 68, 69]. The study where all participants received the same intervention showed a reduction in anxiety[70]. Details of these results are listed in **Table 4**.

Both multi-faceted interventions studies incorporating education and emotional or psychological support showed a reduction in scanxiety[64, 65].

Of the six studies with relaxation, distraction and/or meditation components, three studies showed a reduction in scanxiety[66, 70, 71], while three studies did not[62, 63, 69].

Interventions with only educational components did not show a reduction in scanxiety[62, 68].

A reduction in scanxiety severity was also observed when a hand-held device was available to communicate with radiology staff. This reduction was observed in the subgroup of participants who had had a previous scan, but not in participants having their first scan[67].

DISCUSSION

This is the first systematic scoping review aimed at quantifying the phenomenon of scanxiety in people having cancer-related scans. Scanxiety is a common and important clinical problem, as supported by the large number of studies identified by our search. There is a wide range of reported scanxiety prevalence (0 to 83%), and scanxiety is generally not severe. Severity of scanxiety may be lower after a scan and is higher in people who have a lower education, currently smoke, experience pain during a scan, have higher perceived risk of cancer, and who are having diagnostic (rather than screening) scans. Interventions are more likely to reduce scanxiety if they involve active participation (eg psychological and emotional support, meditation or a hand-held communication device) rather than passive participation (listening to music or education only).

Firm conclusions about prevalence and severity could not be drawn due to considerable methodological heterogeneity of the included studies, limiting the interpretation of results and comparisons between studies, and which highlights the need for a universally accepted measure to quantify scanxiety and

evaluate scanxiety interventions in the future. A recent literature review by Al-Dibouni[75] provided a narrative overview of scanxiety in studies involving people having scans for both cancer and non-cancer reasons. It also recognised the lack of a specific measurement tool for scanxiety and the variable scanxiety prevalence among studies[75].

Given the STAI and Likert scales were the most common tools used, we propose that future studies use the state anxiety subscale of the STAI, with a range of 20-80 and no specific anxiety threshold[72] (or variants, such as the STAI-6[76]), and/or the distress thermometer, with a range of 0-10 and a clinically significant threshold of ≥4[77], to measure scanxiety. These tools can be combined with other validated anxiety measures, such as the HADS, to further refine the relationship between tools. Using existing measures rather than developing a scanxiety specific tool allows scanxiety assessment to occur immediately and broadly in clinical research.

Strengths of this scoping review include the rigorous methodology using a published framework[12, 13], two independent researchers for study selection and data extraction, and the implementation of a comprehensive search strategy and broad inclusion criteria to achieve an exhaustive review of the available literature. Limitations include a broad definition of scanxiety which resulted in heterogeneity in the type and timing of scanxiety measurement. This broad definition was necessary as there is no universal definition or specific measurement tool for scanxiety. Generalisability of the results are likely limited by heterogeneity in cancer type, reason for scan and imaging modality between the studies, and because the search strategy was restricted to English language databases. Finally, scanxiety in people who were recalled after an abnormal screening result or who had false-positive results were excluded from this review due to confounding and feasibility. These populations may be at higher risk of scanxiety, and further research may provide further insight about the scanxiety experience in this population.

Additional research implications of our review include the need for research into high-risk populations for scanxiety, including people with advanced cancer. This population was included in only three studies [49, 55, 60]; however, people with cancer have higher rates of anxiety compared to the general population[78]. As they may be more likely to develop scanxiety, experience more severe scanxiety, or have higher post-scan scanxiety while waiting for scan results, longitudinal assessment of scanxiety is required. Further research into effective and feasible interventions is also required, though these will face implementation challenges due to variations in health systems and available resources.

CONCLUSIONS

Prevalence and severity of scanxiety varied widely, although heterogeneity in scanxiety measurement limited comparisons between studies. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide the development of interventions to high-risk populations.

FOOTNOTES

Contributions: KTB, PB, BK, HD and CB contributed to the concept and design of this review. KTB developed and implemented the search strategy. KTB and RL independently screened and reviewed titles, abstracts and full-text articles for inclusion. KTB and RL independently extracted data from the included studies. PB, BK and HD contributed content expertise to ensure clinically relevant interpretation of the data. KTB drafted the initial manuscript, and RL, PB, BK, HD and CB reviewed and approved the manuscript prior to submission.

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FIGURE CAPTIONS

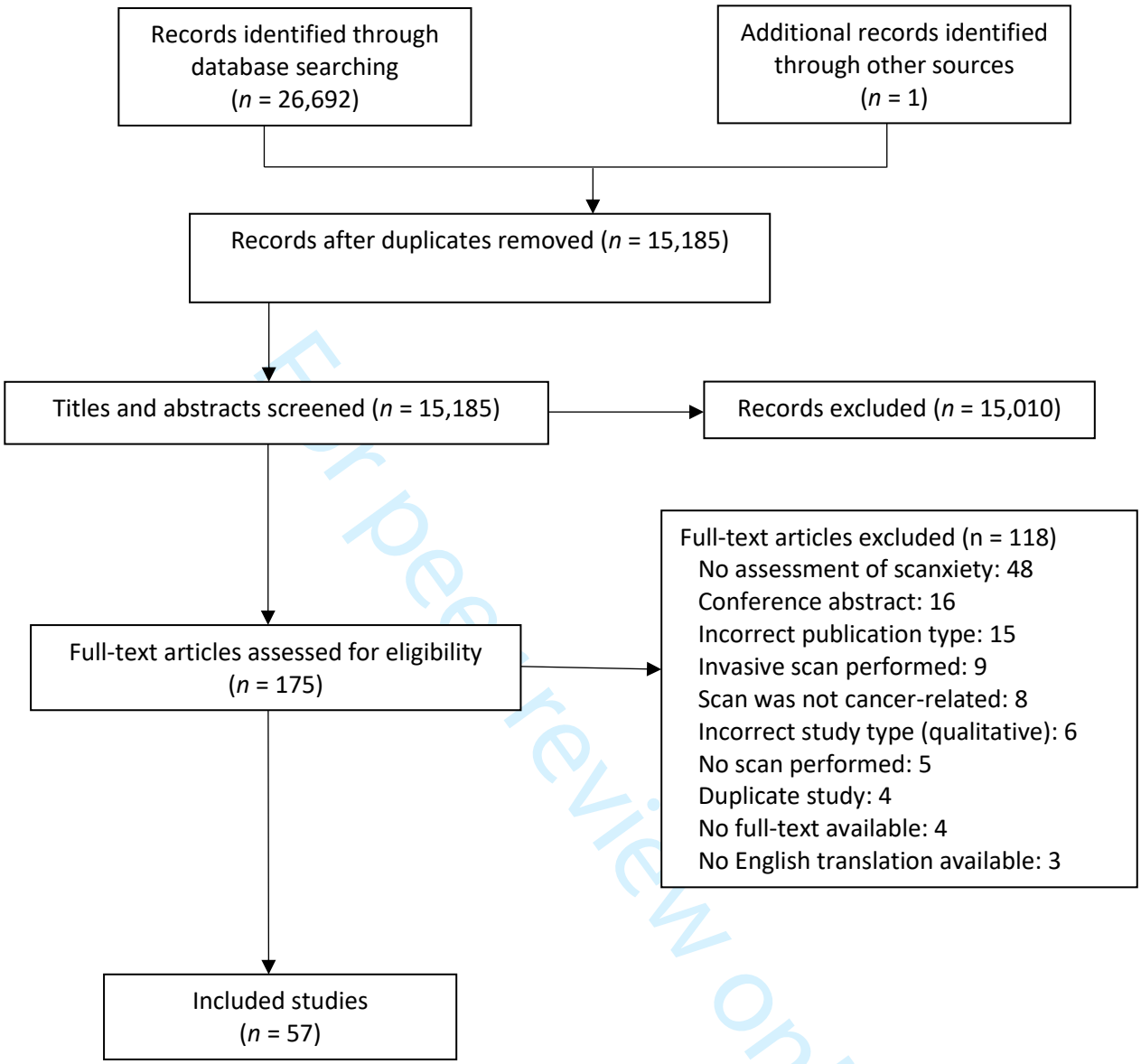
Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

Figure 2. Study search and selection flow diagram

Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

#	Search	#	Search	#	Search	#	Search
1	Exp Neoplasms/	9	carcinoma*.ti,ab	15	exp Anxiety/	22	or/1-8
2	Exp Medical oncology/	10	Exp Diagnostic Imaging/	16	exp Anxiety Disorders/	23	or/9-14
3	neoplasm*.ti,ab	11	imaging.ti,ab	17	exp Fear/	24	or/15-21
4	cancer*.ti,ab	12	scan.ti,ab	18	anxi*.ti,ab	25	22 and 23 and 24
5	neoplasm*.ti,ab	13	tomography.ti,ab	19	fear.ti,ab		
6	malignan*.ti,ab	14	ultraso*.ti,ab	20	worr*.ti,ab		
7	tum??r*.ti,ab			21	distress*.ti,ab		
8	oncolog*.ti,ab						

Figure 2. Study search and selection flow diagram



Supplementary File 1. Protocol

Scanxiety for cancer-related scans: A systematic scoping review

Protocol

Version 1.0, 10/04/2019

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Introduction

Radiological scans are necessary to diagnose and stage cancers, to monitor for cancer recurrence or progression or to investigate new cancer- or treatment-related problems. Imaging modalities include plain X-rays, computed tomography (CT) scans, positron-emission tomography (PET) scans, magnetic resonance imaging (MRI), ultrasound and nuclear medicine bone scans.

Distress before, during or after a scan has been dubbed "scanxiety" by a patient writing for the Time Magazine in 2011[1]. This is a common clinical problem that is widely discussed on social media and patient forms, but there is a paucity in the literature about this topic. This systematic scoping study aims to increase the understanding about scanxiety.

Objectives

The objectives of this study are to:

- determine the incidence and severity of scanxiety in adults who have scans for cancer-related reasons;
- compare tools that measure scanxiety;
- identify contributing and exacerbating determinants of scanxiety;
- identify strategies or interventions that reduce scanxiety; and,
- explore the experiences of scanxiety for patients and other stakeholders

Methods

This protocol is based on the six-step methodological framework developed by Arskey & O'Malley[2] and modified by Levac *et al.*[3], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols extension for Scoping Reviews (PRISMA-ScR) checklist[4].

Inclusion and exclusion criteria

Publications will be included if they were original full-text research articles that addressed scanxiety in adults over 18 years of age who had a scan for a cancer-related reason. Outcome measures have to include at least one of the following: the incidence of scanxiety; severity of scanxiety; contributing or exacerbating factors of scanxiety; intervention to improve scanxiety, or; experiences of patients with scanxiety. All types of non-interventional imaging modalities are acceptable. Any type or stage of cancer is acceptable, including populations undergoing cancer screening. No date or language restriction will be applied to electronic database searching.

Interventional imaging will be excluded. Review articles, editorials, letters and protocols will be excluded.

Search protocol

A systematic review of the following electronic databases will be conducted by one author (KTB): Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane, Scopus, ESCBO CINAHL and PubMed. The search strategy will combine the subject headings and keywords of cancer (neoplasm* or cancer* or malignan* or tum??r* or oncolog* or carcinoma*), imaging (diagnostic imaging or imaging or scan* or tomograpy or ultraso* or radionucl*) and anxiety (anxi* or fear* or worr* or distress*). Hand searching of reference lists of included articles will be undertaken.

All references will be imported into Endnote V9. After removal of duplicates, two authors (KTB and RL) will independently review and screen publication titles and abstracts for eligibility. Of the articles deemed potentially eligible, the full text of the article will be evaluated for final inclusion. Discrepancies will be decided by discussion between the two authors (KTB and RL), and will be escalated to all authors if a consensus cannot be reached.

Data extraction and analysis

Standardised data collection forms will be developed. Relevant data will be independently extracted from by two authors (KTB and RL) into an electronic data extraction form (Table 1).

Table 1. Included data items on the electronic data extraction form

Publication details	Study name/Title of article Study authors Date of publication (year) Country the study was held
Study details	Study aims Population including age, gender, type of cancer Study design Measurement tool used for scanxiety
Results/outcomes	Sample size Demographics – gender, age Cancer factors – type of cancers included Incidence of scanxiety

	Severity of scanxiety Contributing and exacerbating determinants of scanxiety Experiences of scanxiety for patients and other stakeholders If intervention: efficacy

Data will analysed depending on the population who underwent imaging (eg for screening, for early cancer or for advanced cancer) and the type of study (eg observational or intervention). Quantitative findings will be synthesised using summary statistics including the mean and range.

Consultation

Health care professionals with clinical experience in oncology and psychology will be consulted for content expertise and to discuss preliminary findings.

References

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Research checklist. Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3-4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Figure 1
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	4
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 2
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	5-10, including Tables 1 and 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	11-18, including Tables 3,4, 5 and 6
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-19
Limitations	20	Discuss the limitations of the scoping review process.	19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

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Scanxiety: A scoping review about scan-associated anxiety

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Primary Subject Heading:	Oncology
Secondary Subject Heading:	Radiology and imaging
Keywords:	Adult oncology < ONCOLOGY, Diagnostic radiology < RADIOLOGY & IMAGING, Anxiety disorders < PSYCHIATRY

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Title

Scanxiety: A scoping review about scan-associated anxiety

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Presentations
Bui, K.T., Liang, R., Kiely, B.E., Brown, C., Dhillon, H.M. & Blinman, P. What is scanxiety? A systematic scoping review [Poster]. Proceedings of the 2020 MOGA Abstract and Poster Program for Medical Oncology Advanced Trainees and Young Oncologists, 2020 August 14-21; Asia Pac J Clin Oncol, 16(2), 30-31.

Abstract

Objectives: To identify the available literature on the prevalence, severity and contributing factors of scan-associated anxiety ('scanxiety'), and interventions to reduce it.

Design: Systematic scoping review.

Data sources: Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane Central Register of Controlled Trials, Scopus, EBSCO CINAHL and PubMed up to July 2020.

Study selection: Eligible studies recruited people having a cancer-related non-invasive scan (including screening) and contained a quantitative assessment of scanxiety.

Data extraction: Demographics and scanxiety outcomes were recorded for each study and the data summarised by descriptive statistics.

Results: Of 26,693 citations, 57 studies were eligible for inclusion across a range of scan types (mammogram 26/57, 46%; positron-emission tomography 14/57, 25%; computed tomography 14/57, 25%) and designs (observation 47/57, 82%; intervention 10/57, 18%). Eighty-one measurement tools were used to quantify the prevalence and/or severity of scanxiety, including purpose-designed Likert scales (17/81, 21%); the State Trait Anxiety Inventory (14/81, 17%) and the Hospital Anxiety and Depression Scale (9/81, 11%). Scanxiety prevalence ranged from 0% to 83%. Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%). Moderate to severe scanxiety occurred in 4% to 28% of people in studies using descriptive measures. Nine of 20 studies assessing scanxiety pre- and post-scan reported a significant post-scan reduction in scanxiety. Lower education, smoking, higher levels of pain, higher perceived risk of cancer and diagnostic scans (v screening scans) consistently correlated with higher scanxiety severity, but not age, gender, ethnicity or marital status. Interventions included relaxation, distraction, education and psychological support. Six of the 10 interventions showed a reduction in scanxiety.

Conclusions: Prevalence and severity of scanxiety varied widely likely due to heterogeneous methods of measurement. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide interventions.

Strengths and limitations of this study

- This is the first scoping review on scanxiety
- A comprehensive search strategy and broad inclusion criteria have resulted in an extensive summary of all available literature
- Summary statistics for prevalence and severity of scanxiety were not possible due to heterogeneity in the type and timing of measurement tools between the studies**.**

INTRODUCTION

Anxiety may increase when people have scans to screen for, diagnose, or stage cancer, or to monitor cancer for recurrence or progression. Scan-associated anxiety, or the distress before, during or after a scan, was first dubbed 'scanxiety' by a patient writing for the Time Magazine in 2011[1].

Qualitative research on the experience of having a scan has shown some people experience dread in the weeks before a scan[2], perceive scans as dehumanising, unpleasant or causing claustrophobia[2-5], and find scans trigger fear of the unknown and fear of cancer recurrence[2, 3, 6]. Scanxiety is recognised as a common clinical concern on social media and public forums, and is acknowledged by international cancer institutions[7, 8] and cancer-specific support networks[9-11]. Despite this, scanxiety is not uniformly recognised or measured in published studies. We conducted a systematic scoping review to identify the available literature on scanxiety in people having cancer-related scans.

METHODS

We conducted a systematic scoping review based on the six-step methodological framework developed by Arskey & O'Malley[12] and modified by Levac *et al.*[13], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis protocols extension for Scoping Reviews (PRISMA-ScR) checklist[14]. The study protocol and amendments are available (**Supplementary File 1 & 2**).

Step 1: Research question

Our aim was to increase the understanding of scanxiety by: determining the prevalence and severity of scanxiety; identifying contributing factors to scanxiety; identifying interventions to reduce scanxiety in people having cancer-related scans; and, exploring patient experiences with scanxiety.

Step 2: Search strategy

Published studies were identified from seven electronic databases: Ovid MEDLINE (1946 onwards), Ovid EMBASE (1947 onwards), Ovid PsycINFO (1806 onwards), Ovid Cochrane Central Register of Controlled Trials (1991 onwards), Scopus (any year), EBSCO CINAHL (any year) and PubMed (any year). The search strategy combined the subject headings and keywords of cancer, imaging and anxiety. An example is provided in **Figure 1**. Reference lists of included articles were hand-searched for additional studies. All references were imported into Endnote V9.

The initial search was conducted on April 11, 2019, and updated on July 3, 2020.

Step 3: Study selection

Inclusion criteria were full-text original research studies that recruited adults (≥18 years old) who had a non-invasive scan for a cancer-related reason, and which quantitatively assessed the prevalence or severity of scanxiety, reported a statistical comparison between pre- and post-scan scanxiety, reported a

statistical comparison between scanxiety and possible contributing factors, or evaluated the impact of an intervention on scanxiety.

Cancer-related reasons included screening (detection of cancer in asymptomatic person), diagnosis (detection of cancer in symptomatic person), staging (determining extent of cancer in person with confirmed or suspected cancer), surveillance (detection of recurrence in person with cancer treated with curative intent) or monitoring (detection of progression in person with cancer treated with non-curative intent).

The measurement of scanxiety was defined as any measure of anxiety, distress or worry occurring around the time of a scan. This included any period before, during or after a scan where the scan was used as a reference point for the measurement of scanxiety. All non-invasive imaging modalities were accepted. No date restrictions were applied. Foreign language material was included if an English translation was available.

After initial review of citations and based on increasing familiarity with the literature, and in line with recommendations on scoping review methodology[12], exclusion criteria were developed *post hoc*. Exclusion criteria were: studies involving invasive scans (eg transvaginal ultrasound, ultrasound with fine needle aspirate, or endoscopic ultrasound) due to differences in scan preparation and risk of adverse events; and, studies of scans performed to investigate a positive initial screening result because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attributable to scanxiety. Due to feasibility of conducting quantitative and qualitative analysis with the volume of literature identified, studies reporting only a qualitative assessment of scanxiety were also excluded, and the objective to explore patient experiences was abandoned.

After removal of duplicate citations, two authors (KTB, RL) independently reviewed and screened publication titles and abstracts based on the eligibility criteria. Of the studies deemed potentially eligible, full texts were evaluated for final inclusion. Discrepancies were resolved by discussion between the two authors (KTB, RL) and were escalated to all authors if a consensus could not be reached.

Step 4: Charting the data

Relevant data were independently extracted by two authors (KTB, RL) into an electronic data extraction form in Microsoft Excel, which included study demographics and methodology, scanxiety measurement tools, and the outcome measures of prevalence and severity of scanxiety, contributing factors to scanxiety, and interventions to reduce scanxiety.

Step 5: Collating, summarizing and reporting the results

Study data was tabulated to assist with a descriptive numerical summary of the range of cancer types, imaging modalities, study methodology and scanxiety measurement tools. Associations between scanxiety and potential contributing factors were tabulated if three or more studies reported a statistical comparison.

The prevalence of scanxiety was identified in two ways:

- The percentage of people who scored above the pre-specified clinically important anxiety threshold, if reported; or,
- The percentage of people who scored any degree of anxiety, if no pre-specified threshold was reported.

Severity of scanxiety was defined in three ways:

- Any mean score of the anxiety measure above the pre-specified clinically important anxiety threshold, if reported;
- Any mean score of the anxiety measure that was at least half the total score, if an anxiety threshold was not reported; or
- At least 'moderate' anxiety (or its equivalent) on a descriptive range.

The definitions of prevalence and severity were purposed-designed to allow descriptive comparisons between the studies as we anticipated heterogeneity in scanxiety measurement would preclude meaningful summary statistics.

The components of intervention studies and their effect on scanxiety were summarised and reported descriptively.

Step 6: Consultation

Medical oncologists (PB, BK), a behavioural scientist (HD) and a statistician (CB) were consulted for content expertise to develop the study objectives and to improve clarity on clinically relevant interpretations of the data.

Patient and public involvement

This research did not directly involve patients and public. Our research was initiated by repeated observations of scanxiety in oncology patients.

RESULTS

The study search identified 26,693 citations. The selection process is outlined in **Figure 2**. After removal of duplicates, abstract and title screening, and full-text review, 57 eligible studies involving 21,352 people were included.

Demographics and study details

Observational studies

There were 47 observational studies (**Table 1**) involving 19,498 people[15-61]. Participants most commonly had scans for breast cancer (22 studies, *n*=14,338 women[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56, 58]), the most common scans were mammograms (21 studies[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56]), and most studies used self-report surveys to assess scanxiety (40 studies[15, 16, 18-36, 38, 40-54, 56, 58, 59]).

Table 1. Demographics and study details for the 47 observational studies

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Methods
Andolf[15]	1990	275	Sweden	Ovarian	NR	100	NR	NR	NR	Abdominal ultrasound	Screening	Cross-sectional survey
Bull[b,c][16]	1991	541	UK	Breast	50 to 54: 23% 55 to 59s 29% 60 to 64: 34% 65 to 70: 7% Unknown: 7%	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Peteet[17]	1992	79	USA	Any	NR	NR	NR	NR	4	CT	Any (except screening)	Cross-sectional interview
Cockburn[c][18]	1994	200	Australia	Breast	NR	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Ellman[c][19]	1995	331	UK	Breast	50 to 64: 52% 65 to 78: 48%	100	NR	NR	NR	Mammogram	Screening or surveillance	Cross-sectional survey
Sutton[c,d][20]	1995	306	UK	Breast	58	100	76	50	NR	Mammogram	Screening	Longitudinal surveys
Bakker[21]	1998	315	Canada	Breast	61	100	71	76	50	Mammogram	Screening	Longitudinal surveys
Gupta[22]	1999	167	Kuwait	Breast	Range 14 to 63	100	NR	82	NR	Mammogram ± ultrasound	Screening or diagnosis	Cross-sectional survey
Hafslund[23]	2000	170	Norway	Breast	NR	100	NR	NR	NR	Mammogram	Diagnosis	Longitudinal surveys
Meystre-Agustoni[24]	2001	887	Switzerland	Breast	50 to 54: 36% 55 to 59: 22% 60 to 64: 20% 65 to 69: 22%	100	77	62	27	Mammogram	Screening	Longitudinal surveys
Drossaert[25]	2002	2657	Netherlands	Breast	58	100	78	32	NR	Mammogram	Screening	Longitudinal surveys
Sandin[c,d][26]	2002	598	Spain	Breast	51	100	77	41	NR	Mammogram	Screening	Longitudinal surveys
Brunton[27]	2005	584	New Zealand	Breast	50 to 54: 38% 55 to 59: 35% 60 to 64: 27%	100	NR	74	<20%	Mammogram	Screening	Cross-sectional survey
Geurts[28]	2006	106	Netherlands	Head and neck	56	36	NR	29	NR	Chest X-ray	Surveillance	Cross-sectional survey
Tyndel[c][29]	2007	1174	UK	Breast	43	100	83	33	87	Mammogram	Screening	Longitudinal surveys
Bunge[b][30]	2008	324	Netherlands, Belgium	Lung	60	49	NR	NR	NR	CT	Screening	Longitudinal surveys
Brown Sofair[b][31]	2008	47	USA	Breast	50	100	34	80	NR	Mammogram	Screening	Longitudinal surveys
van den Bergh[b][32]	2008	324	Netherlands, Belgium	Lung	60	49	64	82	66	CT	Screening	Longitudinal surveys
Westerterp[b][33]	2008	82	Netherlands	Oesophageal	64	18	NR	NR	NR	CT + PET	Diagnosis & staging	Cross-sectional survey
Bastiaannet[34]	2009	59	Netherlands	Melanoma	Median: 59	44	69	66	NR	CT, PET ± Chest X-ray	Staging	Cross-sectional survey
Vierikko[b][35]	2009	601	Finland	Lung	65	0	36	NR	NR	CT	Screening	Longitudinal surveys

Bolukbas[36]	2010	93	Turkey	Breast	48	100	97	10	45	Mammogram	Screening or diagnosis	Cross-sectional survey
Thompson[37]	2010	70	USA	Lymphoma	Median: 47	64	53	97	NR	CT	Surveillance	Cross-sectional interview
Hutton[b][38]	2011	527	UK	Breast	Median: 40	100	79	NR	75	Mammogram ± MRI	Screening	Longitudinal surveys
Pifarre[39]	2011	200	Spain	Any	52	51	NR	NR	67	PET/CT	Any (except screening)	Cross-sectional interview
Steinemann[40]	2011	227	USA	Breast	NR	100	NR	NR	NR	Mammogram	Screening or diagnosis	Cross-sectional survey
Yu[41]	2011	398	Brazil	Any	54	79	56	57	27	Any	Any (except screening)	Cross-sectional survey
Bredart[b][42]	2012	637	France	Breast	50	100	NR	87	NR	Mammogram ± ultrasound ± MRI	Screening or surveillance	Longitudinal surveys
Hafslund[c][43]	2012	4249	Norway	Breast	58	100	NR	52	NR	Mammogram	Screening	Cross-sectional survey
Adams[e][44]	2014	36	Netherlands	Lymphoma	50	42	NR	NR	NR	CT & MRI	Staging	Cross-sectional survey
Baena-Canada[45]	2014	434	Spain	Breast	54	100	72	43	18	Mammogram	Screening	Cross-sectional survey
Andersson[46]	2015	169	Sweden	Any	64	47	62	62	100	PET/CT	Any (except screening)	Cross-sectional survey
Elboga[47]	2015	144	Turkey	Any	63	46	83	52	NR	PET/CT	Any (except screening)	Cross-sectional survey
Hobbs[48]	2015	49	Australia	Breast	55	100	79	NR	75	Mammogram ± MRI	Diagnosis	Longitudinal surveys
Bauml[49]	2016	103	USA	Lung	Median: 67	61	73	53	NR	CT, PET ± MRI	Monitoring	Cross-sectional survey
Abreu[50]	2017	232	Portugal	Any	61	51	NR	73	71	PET/CT	Any (except screening)	Longitudinal surveys
Grilo[51]	2017	81	Spain, Portugal	Any	55	53	NR	41	47	PET/CT	Any (except screening)	Longitudinal surveys
Evans[52]	2018	115	UK	Colorectal or Lung	66	33	NR	NR	NR	Whole body MRI, PET + CT	Staging	Longitudinal surveys
Goense[53]	2018	27	Netherlands	Oesophageal	64	15	NR	NR	NR	MRI + PET/CT	Staging & monitoring	Cross-sectional survey
Hall[54]	2018	169	USA	Lung	64	51	58	96	NR	Low dose CT	Screening	Cross-sectional survey
Derry[55]	2019	94	USA	Any	61	72	NR	69	0	Any	Monitoring	Longitudinal interview
Soriano[56]	2019	57	USA	Breast	58	100	93	NR	0	Mammogram	Surveillance	Longitudinal survey
Taghizadeh[57]	2019	1237	Canada	Lung	63	56	NR	85	NR	CT	Screening	Longitudinal interview
Bancroft[58]	2020	88	UK, Ireland	Breast	38	61	50	83	NR	MRI	Screening	Longitudinal survey
Grilo[59]	2020	94	Portugal	Any	61	54	NR	99	77	PET + bone scan	Staging, monitoring & surveillance	Longitudinal survey
Morreale[60]	2020	87	USA	Gastrointestinal and Lung	62	55	NR	92	NR	CT or MRI	Monitoring	Longitudinal interview
Paiella[61]	2020	54	Italy	Pancreatic	50	61	NR	NR	NR	MRI – MRCP	Screening	Cross-sectional interview

UK United Kingdom, USA United States of America, NR not reported, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging, MRCP Magnetic resonance cholangiopancreatography

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Demographic data is based on participants who completed the first survey

[c]These studies collected data from other groups who were not included in this review as they did not meet eligibility criteria. This included people having invasive procedures such as fine needle aspirate or open surgical biopsy[16, 33], people with abnormal screening results[18, 26, 29] and people who did not have a scan[18-20, 43]

[d]Demographics based on the entire population even if not all participants were eligible for this review.

[e]Four paediatric participants were included in this study.

Twenty-one studies were conducted in people having scans for screening[15, 16, 18, 20, 21, 24-27, 29-32, 35, 38, 43, 45, 54, 57, 58, 61]. In the remaining studies, reasons for scanning included diagnosis[23, 48], staging[34, 44, 52], monitoring[49, 55, 60], surveillance to detect recurrence[28, 37, 56] or a combination of reasons in people with known or suspected cancers (17 studies[17, 39, 41, 46, 47, 50, 51, 53, 59]). Five studies permitted scans for both screening and non-screening reasons (namely, diagnosis[22, 36, 40] or surveillance[19, 42])

The mean age of participants, reported by 33 studies, was 56.9 years (range 38 to 66 years)[20, 21, 25, 26, 28-33, 35, 36, 39, 41-48, 50-61]. The majority of participants were women (87%)[15, 16, 18-61]. When studies involving scans for breast cancer were excluded, there were similar proportions of men and women (women 49%, men 51%)[15, 27, 28, 30, 32-35, 37, 39, 41, 44, 46, 47, 49-55, 57, 59-61]. There was variation in the reporting and proportion of participants who were married (22 studies, range 34% to 97%[20, 21, 24-26, 29, 31, 32, 34-38, 41, 45-49, 54, 56, 58]), who received at least secondary education (29 studies, range 10% to 99%[20-22, 24-29, 31, 32, 34, 36, 37, 41-43, 45-47, 49-51, 54, 55, 57-60]) and who were attending their first scan (18 studies, range 0% to 100%[17, 21, 24, 27, 29, 32, 36, 38, 39, 41, 45, 46, 48, 50, 51, 55, 56, 59]).

Intervention studies

There were ten intervention studies (**Table 2**) involving 1,854 people[62-71]. This included people having scans for breast cancer (6 studies, *n*=1,449 people[62-65, 69, 70]) and lung cancer (1 study, *n*=16 people[68]). Scans included mammogram (5 studies[62-64, 69, 70]), positron emission tomography (PET) with computed tomography (CT; 3 studies[66, 67, 71]), magnetic resonance imaging (MRI)[65], CT[68] and ultrasound[70] (1 study each). Four studies involved scans for screening[63, 64, 68, 69], one for diagnosis[65], three for any reason in people with known or suspected cancers[66, 67, 71], and two where scans for screening, surveillance and/or diagnosis were permitted[62, 70].

The mean age of participants was reported by five studies and ranged from 47 to 65 years[63, 65, 68, 69, 71]. The majority were women (94%[62-66, 68-71]). There was variation in the reporting and proportion of participants who were married (2 studies, 73% and 75%[64, 65]), received at least secondary education (6 studies, range 28 to 100%[62-65, 68, 69]), and participants attending their first scan (5 studies, range 4% to 54%[62-64, 66, 71]).

Eight studies allocated participants to an intervention or control group[63-69, 71], one study compared two interventions[62] and one study delivered the intervention to all participants[70]. Two interventions were multifaceted[64, 65]. Types of interventions included: relaxation, distraction, and/or meditation (6 studies[62, 63, 66, 69-71]); education (4 studies[62, 64, 65, 68]); emotional or psychosocial support (2 studies[64, 65]); or, adjustments to routine logistics of the scan (1 study[67]).

Table 2. Demographics and study details for the 10 intervention studies to reduce scanxiety

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Allocation	Intervention and control groups
Mainiero[62]	2001	613	USA	Breast	< 40: 8% 50 to 50: 39% 50 to 60: 28% >70: 9%	100	NR	95	7	Mammogram	Screening or surveillance	Consecutive[b]	Educational or entertaining video in waiting room
Domar[63]	2005	143	USA	Breast	52	100	NR	81	8	Mammogram	Screening	Randomised	Relaxation, music or blank audiotape in waiting room and during scan
Fernandez-Feito[64]	2005	436	Spain	Breast	50 to 54: 24% 55 to 59: 30% 60 to 64: 23% 65 to 69: 22%	100	73	28	4	Mammogram	Screening	Randomised	Pre-scan nursing intervention or usual care
Caruso[65]	2006	44	Italy	Breast	47	100	75	89	NR	MRI	Diagnosis	Randomised	Pre-scan informative-emotive psychological support or routine information
Vogel[66]	2012	101	Netherlands	Any	Median: 58	51	NR	NR	41	PET/CT	Any (except screening)	Randomised	Audiovisual installation or usual care during FDG uptake
Acuff[67]	2014	180	USA	Any	NR	NR	NR	NR	NR	PET/CT	Any (except screening)	Unclear	Hand-held communication device or usual care during scan
Raz[68]	2014	16	USA	Lung	65	75	NR	100	NR	CT	Screening	Sequential[c]	Pre-scan multimedia education or usual care
Zavotsky[69]	2014	100	USA	Breast	54	100	NR	98	NR	Mammogram	Screening	Non-randomised[d]	Music or no music during scan
Ashton[70]	2019	113	USA	Breast	18 to 39: 3.6% 40 to 59: 51.8% 60 to 79: 39.3% > 80: 5.4%	100	NR	NR	NR	Mammogram ± ultrasound	Screening, surveillance or diagnosis	NA[e]	Shoulder & neck massage ± hand massage
Lorca[71]	2019	108	Spain	Any	59	57	NR	NR	54	PET/CT	Any (except screening)	Randomised	Mindfulness meditation or usual care during FDG uptake

USA United States of America, NR not reported, MRI magnetic resonance imaging, PET positron emission tomography, CT computed tomography, FDG fluorodeoxyglucose

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Each intervention was administered during one half of the study period

[c]Participants were enrolled into the control arm first, followed by the intervention arm

[d]Participants attending on Mondays, Wednesdays and Fridays were allocated to the intervention arm, and participants attending on Tuesdays and Thursdays were allocated to the control arm

[e]All participants received the intervention

Scanxiety measurement

Anxiety measurements varied across the studies, with different measurement tools, variants of the same tool, and different range and thresholds applied to tools.

Observational studies

The 47 observational studies (**Table 3**) used a total of 81 measures of anxiety, with 30 studies using one measure only[15-19, 21, 22, 25-28, 30, 33, 34, 36, 39, 40, 43, 44, 46, 48-51, 53, 55-57, 59, 61], and 17 studies using at least two measures[20, 23, 24, 29, 31, 32, 35, 37, 38, 41, 42, 45, 47, 52, 54, 58, 60].

The most common measures used were: purpose-designed Likert scales (17 studies); the State-Trait Anxiety Inventory (STAI) (14 studies); the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS) (9 studies); the Impact of Event Scale (IES) (6 studies); the Psychological Consequences Questionnaire (PCQ) (3 studies), the Cancer Worry Scale (3 studies), and; the Perceived Stress Scale (2 studies). There were 17 measures used by one study only[15, 20, 22, 26, 31, 32, 35, 52, 54, 56, 58, 60].

Likert scales were varied, with a numerical lower range limit of 0 or 1, and an upper range limit between 3 and 12[17, 20, 24, 25, 33, 40, 44, 46, 48, 50, 52, 53]. Seven studies used a descriptive range[21, 25, 27, 28, 33, 34, 55]. Two studies used both a numerical and a descriptive range[25, 33].

The STAI compromises State and Trait Anxiety subscales with a possible subscale range of 20 to 80. It has no validated anxiety threshold and is usually calculated as a sum of 4-point response options[72]. Included studies used and reported the STAI as a total score[37, 39], using one or both subscales[20, 23, 36, 37, 41, 42, 47, 51, 57, 59], or as a variant (e.g. STAI-6[32, 38, 58]). There were different ranges: none reported[47, 57]; no reported lower limit[41]; no reported upper limit[36]; 0 to 60[39, 51], or; based on a mean of individual item scores[20]. Some studies pre-specified an anxiety threshold of 39[57], 40[37, 41], 46[42], calculated based on the relationship between the anxiety and trait subscales[39], or based on investigator-determined categories[36]. One study used a different method to calculate scores (ie subtracting the points of reversed statements from direct statements, which were valued at 1, 2, 3 and 20, and then added to a constant of 50[36]).

The HADS Anxiety subscale has a range of 0 to 21 and a validated anxiety threshold of 11[73]. One study reported a range of 0 to 14[38], one study reported anxiety categories rather than a threshold[60], two studies reported an anxiety threshold of 8[41, 43] and one study reported an anxiety threshold of 10 (though there was overlap the 'tendency to anxiety' and 'anxiety' categories, classified as scores of 8 to 10 and 10 or more, respectively)[47].

The IES was used in its original form[30, 32, 38, 42, 58] or as a variant (IES-6[49]), and was reported as a total score[30, 32, 38, 49] or as Intrusion and Avoidance subscale scores[42, 58]. The two studies using subscale scores reported threshold levels of 20 or 21[42] and 8.5[58]. When using the PCQ, researchers used either the Emotional subscale[18] or the Negative Consequences subscale[24, 29]. The Cancer Worry Scale and the Perceived Stress Scale were used in original[45, 61] or variant[29, 54, 58] forms. The Symptom Checklist-90-Revised score could not be interpreted because the authors did not report a range[31], and a raw score or a transformed score could have been used[74].

Table 3. Prevalence and severity of scanxiety

Author	Year	Measurement	Range (Anxiety threshold)	Timing of scanxiety assessment	Prevalence (%)	Severity (Mean[a])	Pre- & post-scan comparison
Andolf[15]	1990	Visual analogue scale	0-100 (NA)	Post-scan: 1-3 years	81	Median 3.5	NA
Bull[16]	1991	HADS: Anxiety subscale	0-21 (≥11)[b]	Pre-scan: specific timing NR	4.9	4.97	Less severe post-scan scanxiety, p<0.001
				Post-scan: post-result, specific timing NR	4	4.43	
Peteet[17]	1992	10-point Likert scale	1-10 (NA)	Post-scan: specific timing NR	NR	First scan 5.5, Recent scan 3.5	NA
Cockburn[18]	1994	PCQ: Emotional subscale	0-15 (NA)	Pre-scan: day of scan	NR	<2	No difference
				Post-scan: pre-results, 1-week post-result & at 8 months	NR	<2	
Ellman[19]	1995	HADS: Anxiety subscale	0-21 (≥11)	Pre-scan: day of scan	6	NR	NA
Sutton[20]	1995	STAI: State Anxiety subscale	1-4# (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		STAI: Trait Anxiety subscale	1-4# (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences in scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		GHQ: Anxiety subscale	0-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<1	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<1	
		3-point Likert scale	1-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<2	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<2	
Bakker[21]	1998	5-point Likert scale	Descriptive range (NA)	Post-scan: immediate & at 3 weeks	39-40	Somewhat, very or extremely: 9 to 15%	NA
Gupta[22]	1999	HSCL-25	0-3 (NA)	Post-scan: specific timing NR	40	Moderate to severe: 25%	NA
Hafslund[23]	2000	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.5	No statistical comparison reported
				Post-scan: day of scan	NR	32.1	
		STAI: Trait Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.9	No statistical comparison reported
				Post-scan: day of scan	NR	NR	
Meystre-Agustoni[24]	2001	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: day of scan	NR	<1	No statistical comparison reported
				Post-scan: pre- result, 2 weeks post-result & 8 weeks post-result	NR	<2	
		6-point Likert scale	0-5 (NA)	Pre-scan: immediate	26	<1	
				Post-scan: pre-result, 2 weeks post-result & 8 weeks post-result	NR	<1	
Drossaert[25]	2002	Composite 7-item score of 4-point Likert scales	1-4 (NA)	Baseline: 8 weeks post-first scan	NR	1.6	No statistical comparison reported
				Pre-scan: 6 weeks (second & third scans)	NR	1.6 to 1.7	

				Post-scan: 6 weeks (second & third scans)	NR	1.5	
			Descriptive range (NA)	Baseline: 8 weeks post-first scan	NR	Moderate to severe: 10%	NA
Sandin[26]	2002	HSCL-90-R: Anxiety subscale	0-4 (NA)	Pre-scan: day of scan	NR	0.41	No statistical comparison reported
				Post-scan: 2 weeks	NR	0.28	
Brunton[27]	2005	4-point Likert scale, 3 items	Descriptive range (NA)	Post-scan: within 4 years	56-77	Quite or very: 11 to 28%	NA
Geurts[28]	2006	4-point Likert scale	1-4 (NA)	Peri-scan: specific timing NR	61	Moderate to severe: 21%	NA
Tyndel[29]	2007	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: 1 month	NR	5.1	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	3.8 to 4.2	
		Cancer Worry Scale - Revised	6-24 (NA)	Pre-scan: 1 month	NR	11.0	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	10.1 to 10.6	
Bunge[30]	2008	IES in low affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	5.6	Less severe post-scan scanxiety in both low and high affective risk groups, p<0.05
				Post-scan: 6 months	NR	4.3	
		IES in high affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	14.7	
				Post-scan: 6 months	NR	10.3	
Brown Sofair[31]	2008	Penn State Worry Questionnaire	16-80 (60)	Pre-scan: within 1 month	NR	50.18	No statistical comparison reported
				Post-scan: day of scan (post-result)	NR	NR	
		SCL-90-R: Anxiety subscale	NR (NA)	Pre-scan: within 1 month	NR	48.75	No difference
				Post-scan: day of scan (post-result)	NR	42.07	
		Individualized Questionnaire: Anxiety response	1-3 (2)	Pre-scan: within 1 month	35	NR	No statistical comparison reported
				Post-scan: day of scan (post-result)	24	NR	
van den Bergh[32]	2008	STAI-6	20-80 (NA)	Pre-scan: 1 day	NR	34.1	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	32.7 to 34.3	
		IES	0-75 (NA)	Pre-scan: 1 day	NR	6.9	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	5.1 to 5.6	
		EuroQol questionnaire: Anxiety subscale	1-3 (NA)	Pre-scan: 1 day	23	NR	No statistical comparison reported
				Post-scan: 6 months	NR	NR	
Westerterp[33]	2008	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): 2 weeks	NR	CT 1.2, PET 1.4	NA
			Descriptive range (NA)	Post-scan (after both scans): 2 weeks	CT 13, PET 23	Moderate to severe: CT 4%, PET 10%	NA
Bastiaannet[34]	2009	5-point Likert scale	1-5 (NA)	Post-scan: 2-6 weeks after lymph node dissection	Chest x-ray 20, CT 31, PET 36	Moderate to severe: Chest X-ray 13%, CT 5%, PET: 9%	NA
Vierikko[35]	2009	Health anxiety inventory	0-24 (NA)	Pre-scan: specific timing NR	NR	6.7	Less severe post-scan scanxiety, p<0.001
				Post-scan: 1 year	NR	5.8	
		Worry about lung cancer	0-8 (NA)	Pre-scan: specific timing NR	NR	3.0	No difference
				Post-scan: 1 year	NR	3.1	
Bolukbas[36]	2010	STAI: State Anxiety subscale	0-NR (20-39 mild, 40-59 moderate,	Peri-scan: specific timing NR	NR	46.2	NA

			60-79 severe, ≥ 80 help needed)#				
Thompson[37]	2010	STAI	40-160 (NA)	Post-scan: specific timing NR	37	65.8	NA
		STAI: State Anxiety subscale	20-80 (≥40)#	Post-scan: specific timing NR	NR	30.4	NA
		STAI: Trait Anxiety subscale	20-80 (≥40)#	Post-scan: specific timing NR	NR	35.4	NA
Hutton[38]	2011	HADS: Anxiety subscale	0-14 (≥11)#	Baseline: 4 weeks pre-first scan	20	6.9	No difference
				Pre-scan: day of each scan (for 5 scans)	MRI 17, Mammogram 20	MRI 5.2 to 6.5, Mammogram 5.0 to 6.5	
				Post-scan: 6 weeks (for 5 scans)	10 to 13	5.1 to 5.9	
		STAI-6	20-80 (NA)	Pre-scan: day of scan (for 5 scans)	NR	MRI 10.8 to 12.1, Mammogram 10.1 to 11.3	Less severe post-scan scanxiety for MRI (p<0.0005) & mammogram (p=0.002)
				Post-scan: day of scan (for 5 scans)	NR	MRI 9.6 to 10.7, Mammogram 9.7 to 10.5	
		IES	0-75 (NA)	Post-scan: 6 weeks (for 5 scans)	NR	MRI 17.8 to 19.3, Mammogram 17.2 to 18.6	NA
Pifarre[39]	2011	STAI	0-60 for each subscale (state more than 10 than trait)#	Pre-scan: day of scan	68	NR	NA
Steinemann[40]	2011	7-point Likert scale	1-7 (NA)	Pre-scan: day of scan	NR	4.1	NA
Yu[41]	2011	HADS: Anxiety subscale	0-21 (≥8)#	Pre-scan: day of scan	38	NR	NA
		STAI: State Anxiety subscale	NR-80 (≥40)#	Pre-scan: day of scan	46	39.4	NA
		STAI: Trait Anxiety subscale	NR-80 (≥40)#	Pre-scan: day of scan	46	39.9	NA
		Dichotomous reporting[c]	Yes/No (NA)	Pre-scan: day of scan	41	NR	NA
Bredart[42]	2012	STAI: State Anxiety subscale	20-80 (≥46)#	Pre-scan: 1 week	NR	MRI 42.1, Mammogram 41.1	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 34.9, 40.8, Mammogram 34.3, 38.8	
		IES: Intrusion subscale	0-35 (≥20)#	Pre-scan: 1 week	NR	MRI 8.9, Mammogram 8.4	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 8.5, Mammogram 7.7	
		IES: Avoidance subscale	0-40 (≥21)#	Pre-scan: 1 week	NR	MRI 12.1, Mammogram 9.8	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 11.8, Mammogram 8.9	
Hafslund[43]	2012	HADS: Anxiety subscale	0-21 (≥8)#	Pre-scan: within 2 weeks	15	4.1	NA
Adams[44]	2014	4-point Likert scale	1-4 (NA)	Post-scan: day of scan (after each scan)	NR	MRI 1.5, CT 1.8	NA
Baena-Canada[45]	2014	HADS: Anxiety subscale	0-21 (≥11)	Post-scan: specific timing NR	4	1.86	NA
		Cancer Worry Scale	6-24 (NA)	Post-scan: specific timing NR	NR	9.4	NA
Andersson[46]	2015	Sum of 3 items on 5-point Likert scale	0-12 (NA)	Post-scan: within four weeks	NR	4	NA
Elboga[47]	2015	HADS: Anxiety subscale	0-21 (≥10)	Pre-scan: day of scan	NR	9.2	NA

		STAI: State Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	40.4	NA
		STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	46.6	NA
Hobbs[48]	2015	5-point Likert scale	1-5 (NA)	Post-scan (after both scans), specific timing NR	Mammogram 17, MRI 44	NR	NA
Bauml[49]	2016	IES-6	0-24 (NA)	Post-scan: specific timing NR	83	6.4	NA
Abreu[50]	2017	10-point Likert scale	1-10 (NA)	Pre-scan: day of scan	NR	6.4	Less severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	5.7	
Grilo[51]	2017	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: day of scan	NR	31.1	More severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	33.0	
Evans[52]	2018	GHQ-12	0-12 (≥4)	Peri-scans: specific timing NR	42	NR	NA
		7-point Likert scale	1-7 (NA)	Post-scan: 1 month	NR	MRI 2.5, CT or PET/CT 2.2	NA
Goense[53]	2018	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): day of scan	NR	MRI 1.0, PET 1.0	NA
Hall[54]	2018	Generalized Anxiety Disorder 2-item	0-6 (≥3)	Peri-scan: specific timing NR	26	1.62	NA
		Perceived Stress Scale 4	0-16 (NA)	Peri-scan: specific timing NR	NR	5.14	NA
Derry[55]	2019	4-point Likert scale	Descriptive range (NA)	Peri-scan: pre-result	NR	'A great deal' or 'completely': 23%	NA
Soriano[56]	2019	PROMIS Anxiety Short Form	1-5 (NA)	Pre-scan: two weeks	NR	1.55	NA
Taghizadeh[57]	2019	STAI: State Anxiety subscale	NR (39)	Baseline	NR	30.9	More severe post-scan scanxiety, p<0.001
				Post-scan: one-month post-result & at 12 months	NR	33.1, 31.7	
Bancroft[58]	2020	HADS: Anxiety subscale	0-21 (11)	Baseline	Carriers[d]: 14 Controls: 7	Carriers: 6.2 Controls: 4.9	No difference in prevalence Less severe post-scan in carriers (p=0.04)
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 5 to 14 Controls: 2 to 7	Carriers: 5.3 to 5.9 Controls: 4.1 to 4.6	
		Cancer Worry Scale – Revised	8-32 (NA)	Baseline	NR	Carriers: 14.4 Controls: 12.2	No difference
				Post-scan: at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 13.6 to 14.7 Controls: 11.9 to 12.1	
		IES-cancer: Intrusion subscale	0-35 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 35 to 58 Controls: 5 to 13	Carriers: 8.3 to 11.4 Controls: 1.7 to 3.0	NA
		IES-cancer: Avoidance subscale	0-40 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 55 to 64 Controls: 12 to 37	Carriers: 9.9 to 13.3 Controls: 2.6 to 7.0	NA
		IES-MRI: Intrusion subscale	0-35 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 4 to 7 Controls: 0 to 3	Carriers: 1.2 to 3.1 Controls: 0.1 to 0.5	NA
		IES-MRI: Avoidance subscale	0-40 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 14 Controls: 8	Carriers: 1.8 Controls: 2.8	NA
		STAI-6	6-24 (NA)	Pre-scan: day of scan	NR	Carriers: 7.2 Controls: 7.3	NA
		Health Questionnaire	0-14 (NA)	Baseline	NR	Carriers: 7.0 Controls: 6.8	No difference

				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 7.1 to 8.1 Controls: 6.9, to 7.7	
Grilo[59]	2020	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	Bone scan: 51.75 PET/CT: 44.76	Less severe post-scan scanxiety for both: Bone scan. p=0.02 PET/CT, p<0.001
				Post-scan: day of scan	NR	Bone scan: 36.70 PET/CT: 38.82	
Morreale[60]	2020	Distress thermometer	0-10 (4)	Peri-scan: day of scan	NR	3.73	No statistical comparison
				Post-scan: one-week post-result	NR	3.91	
		HADS: Anxiety subscale	0-21 (0-7 none, 8-10 mild, 11-14 moderate, 15-21 high)	Peri-scan: day of scan	NR	6.12	No statistical comparison
				Post-scan: one-week post-result	NR	5.32	
Paiella[61]	2020	Perceived Stress Scale	0-40 (15-18 moderate, ≥ 19 high)	Post-scan: pre-result	NR	14.8	NA

NA not applicable, NR not reported, HADS Hospital Anxiety and Depression Scale, PCQ Psychological Consequences Questionnaire, STAI State-Trait Anxiety Inventory, GHQ General Health Questionnaire, HSCL Hopkins Symptom Checklist, IES Impact of Event Scale, SCL-90-R Symptom Checklist-90-Revised, HSCL-90-R Hopkins Symptom Checklist 90-Revised, PROMIS Patient-Reported Outcomes Measurement Information System, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging

All percentages were rounded to the nearest whole number

[a]Unless otherwise described

[b]This study did not specify an anxiety threshold; however, the Anxiety subscale of the Hospital Anxiety and Depression Scale has validated thresholds. These thresholds were included in this table

[c]Dichotomous reporting assumed given description of question (self-perception of anxiety) and results "40.5% of the patients considered themselves to be anxious"[41]

[d]This study included participants who were *TP53* mutation carriers, and population controls

Intervention studies

The ten intervention studies (**Table 4**) used 19 measures of anxiety, with five studies using one measure only[62, 66, 67, 69, 70], and five studies at least two[63-65, 68, 71]. The measures included subscales of the STAI (7 studies), Likert scales (5 studies), a variant of the Psychological Consequences Questionnaire (1 study[68]) and the Crown Crisp Experimental Index (1 study[65]).

Likert scales were varied, with a lower range limit of 0 or 1, and an upper range limit between 5 and 10[62, 63, 69-71]. The STAI was used and reported using one or both subscales[63-65, 67, 68, 71], or as a variant (8-item STAI[66]). There was variation from the usual STAI parameters, with studies using a different range (i.e. not reported[63, 65], 0 to 60[64], or 18 to 32[66]) or pre-specified anxiety thresholds of 40[68] or 16[66].

Scanxiety outcomes

Prevalence and severity of scanxiety for each study are provided in **Table 3**. Summary statistics for prevalence and severity were not calculated due to heterogeneity in the type and timing of measurement between the studies.

Prevalence of scanxiety

Twenty-four of the 47 studies reported the prevalence of scanxiety. The prevalence of scanxiety ranged between 0% and 64% across the 16 measures with pre-specified anxiety thresholds[16, 19, 31, 38, 41, 43, 45, 52, 54, 58], though eight of these measures came from only two studies[41, 58]. The prevalence of scanxiety ranged between 13% and 83% using the 14 measures without pre-specified anxiety thresholds[15, 21, 22, 24, 27, 28, 32-34, 37, 39, 41, 48, 49].

There were insufficient numbers to compare the prevalence of scanxiety using measures with pre-specified anxiety thresholds of people having scans for screening (11 measures[16, 31, 38, 43, 45, 54, 58]), reasons other than screening (four measures[41, 52]) and for screening or non-screening reasons (1 measure[19]). When no threshold was reported, the prevalence of scanxiety had a similar range (screening 23% to 81%, five measures[15, 21, 24, 27, 32]; reasons other than screening 14% to 83%, eight measures[28, 33, 34, 37, 39, 41, 48, 49]; either screening or reasons other than screening (40%, one measure[22]).

Severity of scanxiety

Severity of scanxiety was reported in 44 of 47 observational studies. Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%).

Table 4. Effect of interventions to reducing scanxiety

First author	Year	Intervention	Scanxiety measurement	Range (Anxiety threshold)	Timing of scanxiety assessment	Impact of intervention on scanxiety	P-value
Mainiero[62]	2001	Arm A: an educational video about breast cancer and mammography Arm B: an entertaining movie (from the 1940s to 1960s)	6-point Likert score	0-5 (NA)	Pre-scan: immediate Post-scan: immediate	No difference	NR
Domar[63]	2005	Arm A: relaxation audiotape, or; Arm B: music audiotape, or; Arm C: control (blank audiotape)	STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 34.8 v 33.6 v 33.2	0.18
					Post-scan: immediate	No difference Arm A v Arm B v Arm C: 30.4 v 30.9 v 33.2	0.78
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 32.6 v 32.7 v 32.5	0.99
			11-point Likert scale	1-10 (NA)	Post-scan	No difference Arm A v Arm B v Arm C: 2.6 v 3.2 v 2.8	0.43
					Post-scan: immediate	NR	NR
Fernandez-Feito[64]	2005	Arm A: A protocolised nursing intervention (information and emotional support) and usual care, or; Arm B: Usual care alone	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	Less severe	<0.001
						Less severe if fear of cancer present	0.002
						Less severe if no fear of cancer present	0.003
						No difference if fear of cancer outcome present	0.09
						Less severe if no fear of scan outcome	<0.001
			STAI: Trait Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	No difference	0.34
Caruso[65]	2006	Arm A: routine information and 45 minutes of informative-emotive psychological support with a psychologist, or; Arm B: routine information	Crown Crisp Experimental Index	NR (0-96)	Pre-scan: immediate (post-intervention)	Less severe Arm A v Arm B: 39.4 v 42.3	0.03
			STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	No difference Arm A v Arm B: 57.7 v 58.6	0.77
					Post-scan: immediate	Less severe	0.048
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	NR	NR
Vogel[66]	2012	Arm A: Uptake room with an audio-visual installation involving a video of nature scenes on a 119cm television, dynamic lighting & ambient electronic music Arm B: Uptake room without the audio-visual installation	8-item STAI	18-32 (≥16)	Pre-scan: immediately before & immediately after fluorodeoxyglucose uptake period	Less severe Arm A v Arm B: reduction by 2.39 v 1.02	0.04
Acuff[67]	2014	Arm A: Receive a hand-held device to contact imaging staff during the scan Arm B: No device	STAI: State Anxiety subscale	20-80 (NA)	During scan: immediately before completion of the scan	Less severe Arm A v Arm B: 22.87 v 26.45	0.014
						Less severe if previous PET/CT Arm A v Arm B: 20.78 v 24.64	0.023
						No difference if first time PET/CT Arm A v Arm B: 23.09 v 27.25, p=0.249	0.249

Raz[68]	2014	Arm A: multimedia education session and usual care, or; Arm B: Usual care	STAI: State Anxiety subscale	20-80 (≥40)	Pre-scan: within 2 weeks Post-scan: immediate, at 1 week & 3-7 months post-scan	No difference at any time point	NR
			STAI: Trait Anxiety subscale	20-80 (≥40)		No difference at any time point	NR
			PCQ: Lung Cancer adaptation, Anxiety subscale	0-18 (NR)		No difference at any time point	0.11 to 0.76
Zavotsky[69]	2014	Arm A: music of their choice played via dock during the scan Arm B: no music	11-point Likert scale	0-10 (NA)	Post-scan: immediate	No difference Arm A v Arm B: 2.36 v 2.98	0.21
Ashton[70]	2019	All participants: 10-minute shoulder & neck massage and/or hand massage before, during or after imaging, or between two imaging tests	11-pointLikert scale	0-10 (NA)	Post-intervention (pre- or post- scan)	81% had a reduction in anxiety following massage[a]	<0.01
Lorca[71]	2019	Arm A: mindfulness meditation Arm B: routine care	STAI: State Anxiety subscale	NR (NA)	Post-scan: immediate	Less severe Arm A v Arm B: 10.47 v 29.07	0.000
			STAI: Trait Anxiety subscale	NR (NA)		No difference	NS
			11-item Likert scale	0-10 (NA)		Less severe Arm A v Arm B, 1.07 v 5.70	0.000

NR not reported, STAI State-Trait Anxiety Inventory, PCQ Psychological Consequences Questionnaire

[a]Mean scores for overall study population not provided

The mean severity scores were below pre-specified anxiety thresholds on 17 of the 19 measures where a threshold was reported[16, 31, 37, 38, 41-43, 45, 47, 54, 57, 58]. The two exceptions were observed in a study comparing people with *TP53* mutations ('carriers') to controls, with all participants undergoing screening scans. In carriers, mean scores were maximally 11.4 (IES Intrusion subscale, threshold 8.5), and 13.3 (IES Avoidance subscale, threshold 8.5). Mean severity scores for controls were below the thresholds[58].

Of the 43 measures without a pre-specified threshold, the majority had mean scores that were less than half the total scores[15, 18, 20, 23-26, 29, 30, 32, 33, 35, 37, 38, 44-46, 49, 52-54, 56, 58, 60, 61]. There were six exceptions, which reported maximal mean severity scores of: 5.5 out of 10 (Likert scale)[17]; 6.4 out of 10 (Likert scale)[50]; 4.1 out of 7 (Likert scale)[40], 33 out of 60 (STAI State Anxiety subscale)[51], 8.1 out of 14 (Health Questionnaire)[58], and; 51.75 out of 80 (STAI)[59]. Four of these scores occurred in studies where scans were performed for reasons other than screening[17, 50, 51, 59], one allowed scans for diagnosis or screening[40], and one allowed scans for screening only[58].

Eight measures used a descriptive range of severity, with more severe levels of scanxiety in 4% to 28% of participants[21, 22, 25, 27, 28, 33, 34, 55].

Four measures could not be interpreted because they failed to report a range and anxiety threshold[31, 36, 47].

Scanxiety before and after a scan

Of the 20 studies that reported a pre- and post-scan scanxiety measurement, 14 studies reported a statistical comparison[16, 18, 20, 29-32, 35, 38, 50, 51, 57-59] and six did not[23-26, 42, 60](**Table 3**). There was variation in the timing of scanxiety measurement before a scan from four weeks before the scan until immediately before the scan, and after a scan from immediately after the scan until one year after the scan. Five studies reported a post-scan reduction in scanxiety severity compared to pre-scan levels[16, 29, 30, 32, 50, 59]. Two studies reported an increase in post-scan scanxiety severity[51, 57], and two studies no difference in pre- and post-scan scanxiety severity[18, 31].

Four studies reported mixed findings on the change in scanxiety severity across different measures (**Table 5**).

Table 5. Studies with discrepant results on pre- and post-scan scanxiety severity using different measures

First author	Measurement tool	
	Post-scan reduction in scanxiety	**No difference in pre- or post-scan scanxiety**
Sutton[20]	General Health Questionnaire: Anxiety subscale 3-point Likert scale	STAI: State Anxiety subscale STAI: Trait Anxiety subscale
Vierikko[35]	Health Anxiety Inventory	Worry about lung cancer
Hutton[38]	6-item STAI	HADS: Anxiety subscale
Bancroft[58]	HADS: Anxiety subscale	Cancer Worry Scale – Revised Health Questionnaire

STAI: State Trait Anxiety Inventory, HADS: Hospital Anxiety and Depression Scale

Although Bancroft *et al.*[58] reported a reduction in scanxiety severity using HADS (anxiety subscale), there was no difference in scanxiety prevalence.

Contributing factors to scanxiety

Multiple comparisons were made between scanxiety and possible contributing factors across the included studies (**Table 6**).

Table 6. Contributing factors to scanxiety

Variable	Comparison	Effect on scanxiety	Studies	*n*	*P*-value
Age	Younger v older	More prevalent	1	398	0.008[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	5	1883	0.005[45], <0.01[20], <0.01 (for screening)[70], 0.01[24], NR[63]
		No difference in severity	11	6804	NS[22, 27, 36, 37, 42, 43, 49, 51, 59, 62], NS (for surveillance)[70]
Gender	Men v women	More prevalent	1	200	<0.001[39]
		Less prevalent	1	298	0.021[41]
		No difference in prevalence	1	106	NS[28]
		More severe	1	232	0.033 (post-scan)[50]
		Less severe	2	1381	0.000[47], <0.05[57]
		No difference in severity	5	580	NS[37, 49, 51, 59], NS (pre-scan)[50]
Ethnicity	White v other races	More severe	1	143	NR[63]
	Maori & Pacific Islanders v New Zealand European or Asian	More severe	1	584	<0.001[27]
	Any	No difference in severity	5	1454	NS[22, 24, 37, 40, 49]
Education	Lower v higher	More prevalent	1	398	<0.001[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	8	7400	0.003[62], 0.007[36], <0.01[22], ≤0.01[42], 0.012[24], 0.018[27], 0.04[43], <0.05[23]
		No difference in severity	6	591	NS[37, 49, 51, 59, 63, 69]
Employment	Unemployed v employed	More prevalent	1	398	0.046[41]
		More severe	3	5056	0.01[43], 0.05[23], ≤0.05[42]
		No difference in severity	2	654	NS[27, 37]
Income	Higher v lower	No difference in severity	3	757	NS[27, 37, 49]
Marital status	Married or de facto v single	More severe	1	637	≤0.01 (using IES - Intrusion subscale)[42]
		No difference in severity	5	1790	NS[24, 36, 37, 49], NS (using STAI - State anxiety subscale)[42]
Children	Children v no children	No difference in severity	3	5206	NS[24, 37, 43]
Smoking status	Current v non-smoking[a]	More severe	3	4562	<0.001[43, 54], 0.031[47]
		No difference in severity	2	330	NS[40, 49]
Reason for scan	Diagnostic v screening	More severe	3	1104	0.007[41], 0.047[36], NR[62]
	Staging or surveillance v monitoring	More severe	1	200	<0.001[39]
	Lower v higher referral clarity	More severe	1	169	0.048[54]
Type of scan	MRI v mammogram	More severe	1	49	0.009[48]
		Less severe	1	637	NR[42]
	CT v MRI	More severe	1	36	0.007[44]
		Less severe	1	115	NR[52]
	PET v CT	More severe	1	82	0.01[33]
	Nuclear medicine scan v non-nuclear medicine scan	More severe	1	398	0.004[41]
	MRI v PET/CT	No difference in severity	2	142	NS[52, 53]
	CT v PET v chest X-ray	No difference in severity	1	59	NS[34]

	Bone scan v PET scan	More severe	1	94	<0.001 (post-scan)[59]
		No difference in severity	1	94	NS (pre-scan)[59]
Scan-naïve	First v subsequent scans	More prevalent	1	398	0.001[41]
		No difference in prevalence	1	200	NS[39]
		More severe	5	3796	<0.0005[38], <0.01[25], <0.02[19], <0.05[67], NR[66]
		Less severe	1	93	0.038[36]
		No difference in severity	6	2491	NS[24, 27, 50, 51, 59, 62]
Pain	Pain v no pain during scan	More severe	6	4291	<0.0001[25], <0.001[27], 0.001[62], <0.01[23, 69] <0.05[22]
Risk of cancer	Past history v no past history of cancer	More severe	2	864	≤0.001[42], <0.05[40]
		Less severe	1	434	0.013[45]
		No difference in severity	3	1206	NS[15, 24, 58]
	Family history v no family history of cancer	More severe	1	584	0.002[27]
		No difference in severity	3	1255	NS[15, 24, 36]
	Mutation carrier v not a carrier	More severe	1	88	<0.05 (three comparisons, using IES cancer – Intrusion and Avoidance subscales, and post-scan Health Questionnaire)[58]
		No difference	1	88	NS (five comparisons, using HADS- Anxiety subscale, Cancer Worry Scale – Revised, IES MRI – Intrusion and Avoidance subscales, and pre-scan Health Questionnaire)[58]
	Higher, not otherwise specified v lower	More severe	1	70	<0.05[37]
Perceived risk of cancer	Higher v lower	More severe	3	1545	<0.001[27], ≤0.001[42], <0.01[30]

NS not significant, NR not reported, IES Impact of Event Scale, STAI State Trait Anxiety Inventory, HADS Hospital Anxiety and Depression Scale, MRI Magnetic Resonance Imaging

[a]One study compared current smokers v former smokers[54], and one study compared current and former smokers v never smokers[49]

In summary, higher scanxiety severity was associated with people with:

- Lower education (compared to higher education, eight of 14 studies[22-24, 27, 36, 37, 42, 43, 49, 51, 59, 62, 63, 69]);
- A history of smoking (compared to non-smoking, three of five studies[40, 43, 47, 49, 54]);
- Higher pain levels during the scan (compared to no pain, all six studies[22, 23, 25, 27, 62, 69]);
- Higher perceived risk of cancer (compared to lower perceived risk of cancer, all three studies[27, 30, 42]), and;
- Diagnostic scans (compared to screening scans, all three studies[36, 41, 62])

The prevalence or severity of scanxiety was not consistently affected by age (13 of 19 comparisons[20, 22, 24, 27, 28, 36, 37, 41-43, 45, 49-51, 59, 62, 63, 70]), gender (six of 11 comparisons[28, 37, 39, 41, 47, 49-51, 57, 59]), ethnicity (five of seven comparisons[22, 24, 27, 37, 40, 49, 63]), income (all three comparisons[27, 37, 49]), marital status (five of six comparisons[24, 36, 37, 42, 49]) or having children (all three comparisons[24, 37, 43]).

Inconclusive results occurred in the following comparisons:

- Employment (unemployed compared to employed, four of six comparisons[23, 27, 37, 41-43])
- Scan-naivety (first scan compared to subsequent scans, six of 13 comparisons[19, 24, 25, 27, 36, 38, 39, 41, 50, 51, 62, 66, 67])

- Risk of cancer (higher compared to lower risk of cancer, seven of 19 comparisons[15, 24, 27, 36, 37, 40, 42, 45, 58])

Although nine studies reported differences in scanxiety between different imaging modalities, the number of comparisons between specific scans were insufficient to draw conclusions[33, 34, 41, 42, 44, 48, 52, 53, 59].

Interventions that reduce scanxiety

Five of the 10 intervention studies showed a reduction in scanxiety compared to controls[64-67, 71]. Four studies reported no difference in scanxiety between the intervention arms[62, 63, 68, 69]. The study where all participants received the same intervention showed a reduction in anxiety[70]. Details of these results are listed in **Table 4**.

Both multi-faceted interventions studies incorporating education and emotional or psychological support showed a reduction in scanxiety[64, 65].

Of the six studies with relaxation, distraction and/or meditation components, three studies showed a reduction in scanxiety[66, 70, 71], while three studies did not[62, 63, 69].

Interventions with only educational components did not show a reduction in scanxiety[62, 68].

A reduction in scanxiety severity was also observed when a hand-held device was available to communicate with radiology staff. This reduction was observed in the subgroup of participants who had had a previous scan, but not in participants having their first scan[67].

DISCUSSION

This is the first systematic scoping review aimed at quantifying the phenomenon of scanxiety in people having cancer-related scans. Scanxiety is a common and important clinical problem, as supported by the large number of studies identified by our search. There is a wide range of reported scanxiety prevalence (0 to 83%), and scanxiety is generally not severe. Severity of scanxiety may be lower after a scan and is higher in people who have a lower education, currently smoke, experience pain during a scan, have higher perceived risk of cancer, and who are having diagnostic (rather than screening) scans. Interventions are more likely to reduce scanxiety if they involve active participation (eg psychological and emotional support, meditation or a hand-held communication device) rather than passive participation (listening to music or education only).

Firm conclusions about prevalence and severity could not be drawn due to considerable methodological heterogeneity of the included studies, especially in relation to scanxiety measurement tools. None were designed and validated for scanxiety, and some tools and their thresholds were not designed and/or validated for anxiety. This review did use purpose-designed definitions of prevalence and severity to allow some comparison between studies; however, the lack of a universal definition or specific measurement tool for scanxiety limits confidence in the interpretation of the results and interstudy comparisons. This highlights the need for a universally accepted measure to quantify scanxiety and evaluate scanxiety interventions in the future. A recent literature review by Al-Dibouni[75] provided a

narrative overview of scanxiety in people having scans for any reason, and also recognised the lack of a specific measurement tool for scanxiety and variable scanxiety prevalence among studies[75].

Given the STAI and Likert scales were the most common tools used, we propose that future studies use the state anxiety subscale of the STAI, with a range of 20-80 and no specific anxiety threshold[72] (or variants, such as the STAI-6[76]), and/or the distress thermometer, with a range of 0-10 and a clinically significant threshold of ≥4[77], to measure scanxiety. These tools can be combined with other validated anxiety measures, such as the HADS, to further refine the relationship between tools. Using existing measures rather than developing a scanxiety specific tool allows scanxiety assessment to occur immediately and broadly in clinical research.

Strengths of this scoping review include the rigorous methodology using a published framework[12, 13], two independent researchers for study selection and data extraction, and the implementation of a comprehensive search strategy and broad inclusion criteria to achieve an exhaustive review of the available literature. Limitations include the use of purpose-designed definitions of prevalence and severity and the limited generalisability of the results due to heterogeneity in cancer type, reason for scan and imaging modality between the studies, and because the search strategy was restricted to English language databases. Finally, scanxiety in people who were recalled after an abnormal screening result were excluded from this review due to confounding and feasibility. These populations may be at higher risk of scanxiety, and further research may provide further insight about the scanxiety experience in this population.

Additional research implications of our review include the need for research into high-risk populations for scanxiety, including people with advanced cancer. This population was included in only three studies [49, 55, 60]; however, people with cancer have higher rates of anxiety compared to the general population[78]. As they may be more likely to develop scanxiety, experience more severe scanxiety, or have higher post-scan scanxiety while waiting for scan results, longitudinal assessment of scanxiety is required. Further research into effective and feasible interventions is also required, though these will face implementation challenges due to variations in health systems and available resources.

CONCLUSIONS

Prevalence and severity of scanxiety varied widely, although heterogeneity in scanxiety measurement interpretation. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide the development of interventions to high-risk populations.

FOOTNOTES

Contributions: KTB, PB, BK, HD and CB contributed to the concept and design of this review. KTB developed and implemented the search strategy. KTB and RL independently screened and reviewed titles, abstracts and full-text articles for inclusion. KTB and RL independently extracted data from the included studies. PB, BK, HD and CB contributed content expertise to ensure clinically relevant interpretation of the data. KTB drafted the initial manuscript, and RL, PB, BK, HD and CB reviewed and approved the manuscript prior to submission.

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FIGURE CAPTIONS

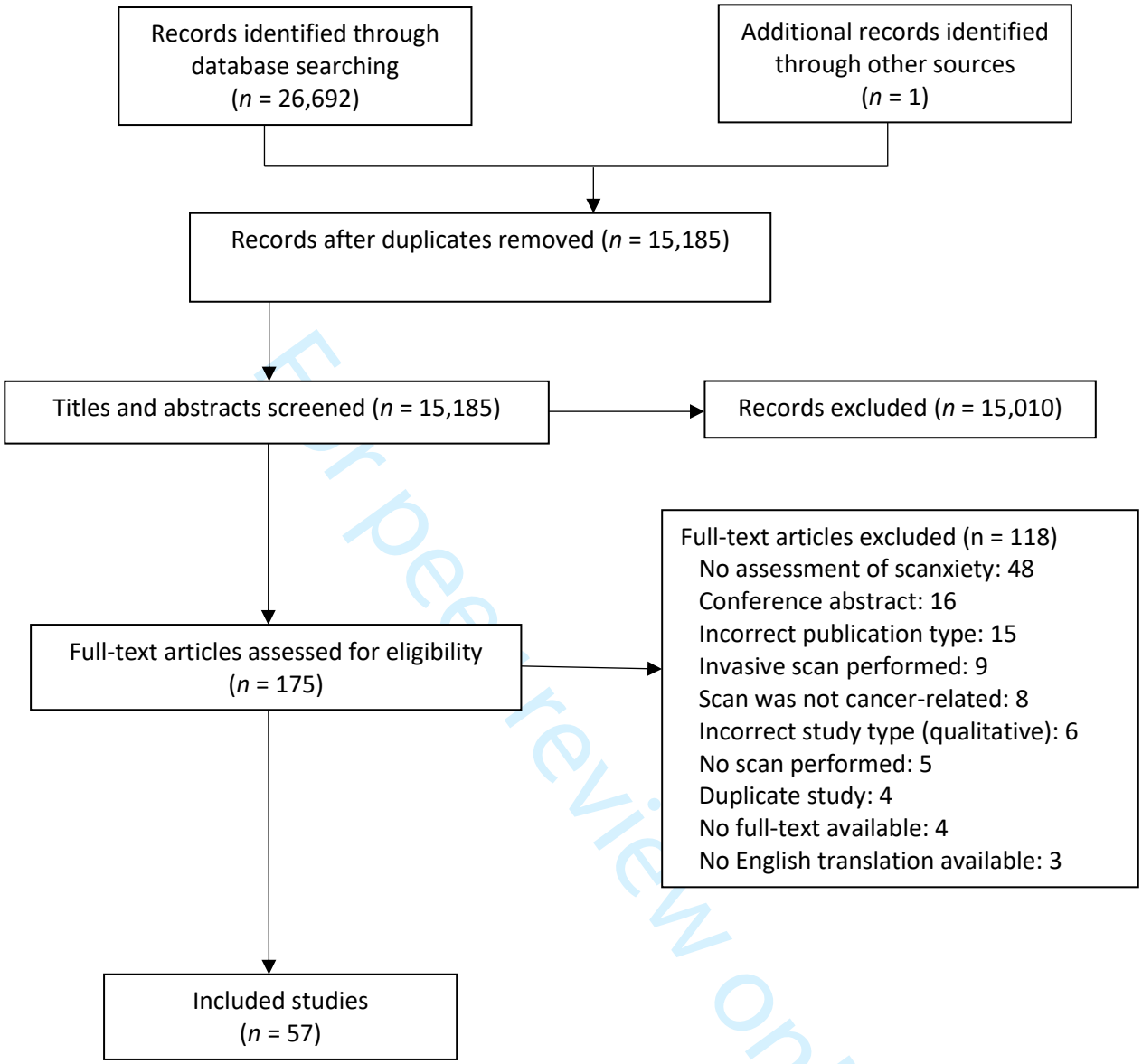
Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

Figure 2. Study search and selection flow diagram

Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

#	Search	#	Search	#	Search	#	Search
1	Exp Neoplasms/	10	Exp Diagnostic Imaging/	15	exp Anxiety/	22	or/1-9
2	Exp Medical oncology/	11	imaging.ti,ab	16	exp Anxiety Disorders/	23	or/10-14
3	neoplasm*.ti,ab	12	scan.ti,ab	17	exp Fear/	24	or/15-21
4	cancer*.ti,ab	13	tomography.ti,ab	18	anxi*.ti,ab	25	22 and 23 and 24
5	neoplasm*.ti,ab	14	ultraso*.ti,ab	19	fear.ti,ab		
6	malignan*.ti,ab			20	worr*.ti,ab		
7	tum??r*.ti,ab			21	distress*.ti,ab		
8	oncolog*.ti,ab						
9	carcinoma*.ti,ab						

Figure 2. Study search and selection flow diagram



Supplementary File 1. Protocol

Scanxiety: A scoping review about scan-associated anxiety

Protocol

Version 1.0, 10/04/2019

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Introduction

Radiological scans are necessary to diagnose and stage cancers, to monitor for cancer recurrence or progression or to investigate new cancer- or treatment-related problems. Imaging modalities include plain X-rays, computed tomography (CT) scans, positron-emission tomography (PET) scans, magnetic resonance imaging (MRI), ultrasound and nuclear medicine bone scans.

Distress before, during or after a scan has been dubbed "scanxiety" by a patient writing for the Time Magazine in 2011[1]. This is a common clinical problem that is widely discussed on social media and patient forms, but there is a paucity in the literature about this topic. This systematic scoping study aims to increase the understanding about scanxiety.

Objectives

The objectives of this study are to:

- determine the incidence and severity of scanxiety in adults who have scans for cancer-related reasons;
- compare tools that measure scanxiety;
- identify contributing and exacerbating determinants of scanxiety;
- identify strategies or interventions that reduce scanxiety; and,
- explore the experiences of scanxiety for patients and other stakeholders

Methods

This protocol is based on the six-step methodological framework developed by Arskey & O'Malley[2] and modified by Levac *et al.*[3], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols extension for Scoping Reviews (PRISMA-ScR) checklist[4].

Inclusion and exclusion criteria

Publications will be included if they were original full-text research articles that addressed scanxiety in adults over 18 years of age who had a scan for a cancer-related reason. Outcome measures have to include at least one of the following: the incidence of scanxiety; severity of scanxiety; contributing or exacerbating factors of scanxiety; intervention to improve scanxiety, or; experiences of patients with scanxiety. All types of non-interventional imaging modalities are acceptable. Any type or stage of cancer is acceptable, including populations undergoing cancer screening. No date or language restriction will be applied to electronic database searching.

Interventional imaging will be excluded. Review articles, editorials, letters and protocols will be excluded.

Search protocol

A systematic review of the following electronic databases will be conducted by one author (KTB): Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane, Scopus, ESCBO CINAHL and PubMed. The search strategy will combine the subject headings and keywords of cancer (neoplasm* or cancer* or malignan* or tum??r* or oncolog* or carcinoma*), imaging (diagnostic imaging or imaging or scan* or tomograpy or ultraso* or radionucl*) and anxiety (anxi* or fear* or worr* or distress*). Hand searching of reference lists of included articles will be undertaken.

All references will be imported into Endnote V9. After removal of duplicates, two authors (KTB and RL) will independently review and screen publication titles and abstracts for eligibility. Of the articles deemed potentially eligible, the full text of the article will be evaluated for final inclusion. Discrepancies will be decided by discussion between the two authors (KTB and RL), and will be escalated to all authors if a consensus cannot be reached.

Data extraction and analysis

Standardised data collection forms will be developed. Relevant data will be independently extracted from by two authors (KTB and RL) into an electronic data extraction form (Table 1).

Table 1. Included data items on the electronic data extraction form

Publication details	Study name/Title of article Study authors Date of publication (year) Country the study was held
Study details	Study aims Population including age, gender, type of cancer Study design Measurement tool used for scanxiety
Results/outcomes	Sample size Demographics – gender, age Cancer factors – type of cancers included Incidence of scanxiety

	Severity of scanxiety Contributing and exacerbating determinants of scanxiety Experiences of scanxiety for patients and other stakeholders If intervention: efficacy

Data will analysed depending on the population who underwent imaging (eg for screening, for early cancer or for advanced cancer) and the type of study (eg observational or intervention). Quantitative findings will be synthesised using summary statistics including the mean and range.

Consultation

Health care professionals with clinical experience in oncology and psychology will be consulted for content expertise and to discuss preliminary findings.

References

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Supplementary File 3. Protocol amendments

Scanxiety: A scoping review about scan-associated anxiety

The original protocol dated 10/04/2019 was amended as per the following statements:

1) The objective 'to explore the experiences of scanxiety for patients and other stakeholders' was abandoned due to feasibility of conducting qualitative and quantitative data analysis with the volume of literature identified
2) Inclusion criteria were updated to reflect changes in Amendment 1: experiences of patients with scanxiety were not included; only studies that quantitatively assessed prevalence and severity of scanxiety or met one of the other objectives were included
3) As per recommendations on scoping review methodology, exclusion criteria were updated *post hoc* and were expanded to also exclude studies involving follow-up scans for a positive screening result, because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attribute to scanxiety itself.
4) Exclusion criteria were also updated to reflect changes in Amendment 1, where studies that only qualitatively assessed scanxiety were excluded

Research checklist

Scanxiety: A scoping review about scan-associated anxiety

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3-4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Figure 1
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	4

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 2
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	5-10, including Tables 1 and 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	11-18, including Tables 3,4, 5 and 6
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-19
Limitations	20	Discuss the limitations of the scoping review process.	19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

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Scanxiety: A scoping review about scan-associated anxiety

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Primary Subject Heading:	Oncology
Secondary Subject Heading:	Radiology and imaging
Keywords:	Adult oncology < ONCOLOGY, Diagnostic radiology < RADIOLOGY & IMAGING, Anxiety disorders < PSYCHIATRY

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Title

Scanxiety: A scoping review about scan-associated anxiety

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Presentations

Bui, K.T., Liang, R., Kiely, B.E., Brown, C., Dhillon, H.M. & Blinman, P. What is scanxiety? A systematic scoping review [Poster]. Proceedings of the 2020 MOGA Abstract and Poster Program for Medical Oncology Advanced Trainees and Young Oncologists, 2020 August 14-21; Asia Pac J Clin Oncol, 16(2), 30-31.

Abstract

Objectives: To identify the available literature on the prevalence, severity and contributing factors of scan-associated anxiety ('scanxiety'), and interventions to reduce it.

Design: Systematic scoping review.

Data sources: Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane Central Register of Controlled Trials, Scopus, EBSCO CINAHL and PubMed up to July 2020.

Study selection: Eligible studies recruited people having a cancer-related non-invasive scan (including screening) and contained a quantitative assessment of scanxiety.

Data extraction: Demographics and scanxiety outcomes were recorded for each study and the data summarised by descriptive statistics.

Results: Of 26,693 citations, 57 studies were eligible for inclusion across a range of scan types (mammogram 26/57, 46%; positron-emission tomography 14/57, 25%; computed tomography 14/57, 25%) and designs (observation 47/57, 82%; intervention 10/57, 18%). Eighty-one measurement tools were used to quantify the prevalence and/or severity of scanxiety, including purpose-designed Likert scales (17/81, 21%); the State Trait Anxiety Inventory (14/81, 17%) and the Hospital Anxiety and Depression Scale (9/81, 11%). Scanxiety prevalence ranged from 0% to 83%. Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%). Moderate to severe scanxiety occurred in 4% to 28% of people in studies using descriptive measures. Nine of 20 studies assessing scanxiety pre- and post-scan reported a significant post-scan reduction in scanxiety. Lower education, smoking, higher levels of pain, higher perceived risk of cancer and diagnostic scans (v screening scans) consistently correlated with higher scanxiety severity, but not age, gender, ethnicity or marital status. Interventions included relaxation, distraction, education and psychological support. Six of the 10 interventions showed a reduction in scanxiety.

Conclusions: Prevalence and severity of scanxiety varied widely likely due to heterogeneous methods of measurement. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide interventions.

Strengths and limitations of this study

- This is the first scoping review on scanxiety
- A comprehensive search strategy and broad inclusion criteria have resulted in an extensive summary of all available literature
- Summary statistics for prevalence and severity of scanxiety were not possible due to heterogeneity in the type and timing of measurement tools between the studies**.**

INTRODUCTION

Anxiety may increase when people have scans to screen for, diagnose, or stage cancer, or to monitor cancer for recurrence or progression. Scan-associated anxiety, or the distress before, during or after a scan, was first dubbed 'scanxiety' by a patient writing for the Time Magazine in 2011[1].

Qualitative research on the experience of having a scan has shown some people experience dread in the weeks before a scan[2], perceive scans as dehumanising, unpleasant or causing claustrophobia[2-5], and find scans trigger fear of the unknown and fear of cancer recurrence[2, 3, 6]. Scanxiety is recognised as a common clinical concern on social media and public forums, and is acknowledged by international cancer institutions[7, 8] and cancer-specific support networks[9-11]. Despite this, scanxiety is not uniformly recognised or measured in published studies. We conducted a systematic scoping review to identify the available literature on scanxiety in people having cancer-related scans.

METHODS

We conducted a systematic scoping review based on the six-step methodological framework developed by Arskey & O'Malley[12] and modified by Levac *et al.*[13], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis protocols extension for Scoping Reviews (PRISMA-ScR) checklist[14]. The study protocol and amendments are available (**Supplementary File 1 & 2**).

Step 1: Research question

Our aim was to increase the understanding of scanxiety by: determining the prevalence and severity of scanxiety; identifying contributing factors to scanxiety; identifying interventions to reduce scanxiety in people having cancer-related scans; and, exploring patient experiences with scanxiety.

Step 2: Search strategy

Published studies were identified from seven electronic databases: Ovid MEDLINE (1946 onwards), Ovid EMBASE (1947 onwards), Ovid PsycINFO (1806 onwards), Ovid Cochrane Central Register of Controlled Trials (1991 onwards), Scopus (any year), EBSCO CINAHL (any year) and PubMed (any year). The search strategy combined the subject headings and keywords of cancer, imaging and anxiety. An example is provided in **Figure 1**. Reference lists of included articles were hand-searched for additional studies. All references were imported into Endnote V9.

The initial search was conducted on April 11, 2019, and updated on July 3, 2020.

Step 3: Study selection

Inclusion criteria were full-text original research studies that recruited adults (≥18 years old) who had a non-invasive scan for a cancer-related reason, and which quantitatively assessed the prevalence or severity of scanxiety, reported a statistical comparison between pre- and post-scan scanxiety, reported a

statistical comparison between scanxiety and possible contributing factors, or evaluated the impact of an intervention on scanxiety.

Cancer-related reasons included screening (detection of cancer in asymptomatic person), diagnosis (detection of cancer in symptomatic person), staging (determining extent of cancer in person with confirmed or suspected cancer), surveillance (detection of recurrence in person with cancer treated with curative intent) or monitoring (detection of progression in person with cancer treated with non-curative intent).

The measurement of scanxiety was defined as any measure of anxiety, distress or worry occurring around the time of a scan. This included any period before, during or after a scan where the scan was used as a reference point for the measurement of scanxiety. All non-invasive imaging modalities were accepted. No date restrictions were applied. Foreign language material was included if an English translation was available.

After initial review of citations and based on increasing familiarity with the literature, and in line with recommendations on scoping review methodology[12], exclusion criteria were developed *post hoc*. Exclusion criteria were: studies involving invasive scans (eg transvaginal ultrasound, ultrasound with fine needle aspirate, or endoscopic ultrasound) due to differences in scan preparation and risk of adverse events; and, studies of scans performed to investigate a positive initial screening result because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attributable to scanxiety. Due to feasibility of conducting quantitative and qualitative analysis with the volume of literature identified, studies reporting only a qualitative assessment of scanxiety were also excluded, and the objective to explore patient experiences was abandoned.

After removal of duplicate citations, two authors (KTB, RL) independently reviewed and screened publication titles and abstracts based on the eligibility criteria. Of the studies deemed potentially eligible, full texts were evaluated for final inclusion. Discrepancies were resolved by discussion between the two authors (KTB, RL) and were escalated to all authors if a consensus could not be reached.

Step 4: Charting the data

Relevant data were independently extracted by two authors (KTB, RL) into an electronic data extraction form in Microsoft Excel, which included study demographics and methodology, scanxiety measurement tools, and the outcome measures of prevalence and severity of scanxiety, contributing factors to scanxiety, and interventions to reduce scanxiety.

Step 5: Collating, summarizing and reporting the results

Study data was tabulated to assist with a descriptive numerical summary of the range of cancer types, imaging modalities, study methodology and scanxiety measurement tools. Associations between scanxiety and potential contributing factors were tabulated if three or more studies reported a statistical comparison.

The prevalence of scanxiety was identified in two ways:

- The percentage of people who scored above the pre-specified clinically important anxiety threshold, if reported; or,
- The percentage of people who scored any degree of anxiety, if no pre-specified threshold was reported.

Severity of scanxiety was defined in three ways:

- Any mean score of the anxiety measure above the pre-specified clinically important anxiety threshold, if reported;
- Any mean score of the anxiety measure that was at least half the total score, if an anxiety threshold was not reported; or
- At least 'moderate' anxiety (or its equivalent) on a descriptive range.

The definitions of prevalence and severity were purposed-designed to allow descriptive comparisons between the studies as we anticipated heterogeneity in scanxiety measurement would preclude meaningful summary statistics.

The components of intervention studies and their effect on scanxiety were summarised and reported descriptively.

Step 6: Consultation

Medical oncologists (PB, BK), a behavioural scientist (HD) and a statistician (CB) were consulted for content expertise to develop the study objectives and to improve clarity on clinically relevant interpretations of the data.

Patient and public involvement

This research did not directly involve patients and public. Our research was initiated by repeated observations of scanxiety in oncology patients.

RESULTS

The study search identified 26,693 citations. The selection process is outlined in **Figure 2**. After removal of duplicates, abstract and title screening, and full-text review, 57 eligible studies involving 21,352 people were included.

Demographics and study details

Observational studies

There were 47 observational studies (**Table 1**) involving 19,498 people[15-61]. Participants most commonly had scans for breast cancer (22 studies, *n*=14,338 women[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56, 58]), the most common scans were mammograms (21 studies[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56]), and most studies used self-report surveys to assess scanxiety (40 studies[15, 16, 18-36, 38, 40-54, 56, 58, 59]).

Table 1. Demographics and study details for the 47 observational studies

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Methods
Andolf[15]	1990	275	Sweden	Ovarian	NR	100	NR	NR	NR	Abdominal ultrasound	Screening	Cross-sectional survey
Bull[b,c][16]	1991	541	UK	Breast	50 to 54: 23% 55 to 59s 29% 60 to 64: 34% 65 to 70: 7% Unknown: 7%	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Peteet[17]	1992	79	USA	Any	NR	NR	NR	NR	4	CT	Any (except screening)	Cross-sectional interview
Cockburn[c][18]	1994	200	Australia	Breast	NR	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Ellman[c][19]	1995	331	UK	Breast	50 to 64: 52% 65 to 78: 48%	100	NR	NR	NR	Mammogram	Screening or surveillance	Cross-sectional survey
Sutton[c,d][20]	1995	306	UK	Breast	58	100	76	50	NR	Mammogram	Screening	Longitudinal surveys
Bakker[21]	1998	315	Canada	Breast	61	100	71	76	50	Mammogram	Screening	Longitudinal surveys
Gupta[22]	1999	167	Kuwait	Breast	Range 14 to 63	100	NR	82	NR	Mammogram ± ultrasound	Screening or diagnosis	Cross-sectional survey
Hafslund[23]	2000	170	Norway	Breast	NR	100	NR	NR	NR	Mammogram	Diagnosis	Longitudinal surveys
Meystre-Agustoni[24]	2001	887	Switzerland	Breast	50 to 54: 36% 55 to 59: 22% 60 to 64: 20% 65 to 69: 22%	100	77	62	27	Mammogram	Screening	Longitudinal surveys
Drossaert[25]	2002	2657	Netherlands	Breast	58	100	78	32	NR	Mammogram	Screening	Longitudinal surveys
Sandin[c,d][26]	2002	598	Spain	Breast	51	100	77	41	NR	Mammogram	Screening	Longitudinal surveys
Brunton[27]	2005	584	New Zealand	Breast	50 to 54: 38% 55 to 59: 35% 60 to 64: 27%	100	NR	74	<20%	Mammogram	Screening	Cross-sectional survey
Geurts[28]	2006	106	Netherlands	Head and neck	56	36	NR	29	NR	Chest X-ray	Surveillance	Cross-sectional survey
Tyndel[c][29]	2007	1174	UK	Breast	43	100	83	33	87	Mammogram	Screening	Longitudinal surveys
Bunge[b][30]	2008	324	Netherlands, Belgium	Lung	60	49	NR	NR	NR	CT	Screening	Longitudinal surveys
Brown Sofair[b][31]	2008	47	USA	Breast	50	100	34	80	NR	Mammogram	Screening	Longitudinal surveys
van den Bergh[b][32]	2008	324	Netherlands, Belgium	Lung	60	49	64	82	66	CT	Screening	Longitudinal surveys
Westerterp[b][33]	2008	82	Netherlands	Oesophageal	64	18	NR	NR	NR	CT + PET	Diagnosis & staging	Cross-sectional survey
Bastiaannet[34]	2009	59	Netherlands	Melanoma	Median: 59	44	69	66	NR	CT, PET ± Chest X-ray	Staging	Cross-sectional survey
Vierikko[b][35]	2009	601	Finland	Lung	65	0	36	NR	NR	CT	Screening	Longitudinal surveys

Bolukbas[36]	2010	93	Turkey	Breast	48	100	97	10	45	Mammogram	Screening or diagnosis	Cross-sectional survey
Thompson[37]	2010	70	USA	Lymphoma	Median: 47	64	53	97	NR	CT	Surveillance	Cross-sectional interview
Hutton[b][38]	2011	527	UK	Breast	Median: 40	100	79	NR	75	Mammogram ± MRI	Screening	Longitudinal surveys
Pifarre[39]	2011	200	Spain	Any	52	51	NR	NR	67	PET/CT	Any (except screening)	Cross-sectional interview
Steinemann[40]	2011	227	USA	Breast	NR	100	NR	NR	NR	Mammogram	Screening or diagnosis	Cross-sectional survey
Yu[41]	2011	398	Brazil	Any	54	79	56	57	27	Any	Any (except screening)	Cross-sectional survey
Bredart[b][42]	2012	637	France	Breast	50	100	NR	87	NR	Mammogram ± ultrasound ± MRI	Screening or surveillance	Longitudinal surveys
Hafslund[c][43]	2012	4249	Norway	Breast	58	100	NR	52	NR	Mammogram	Screening	Cross-sectional survey
Adams[e][44]	2014	36	Netherlands	Lymphoma	50	42	NR	NR	NR	CT & MRI	Staging	Cross-sectional survey
Baena-Canada[45]	2014	434	Spain	Breast	54	100	72	43	18	Mammogram	Screening	Cross-sectional survey
Andersson[46]	2015	169	Sweden	Any	64	47	62	62	100	PET/CT	Any (except screening)	Cross-sectional survey
Elboga[47]	2015	144	Turkey	Any	63	46	83	52	NR	PET/CT	Any (except screening)	Cross-sectional survey
Hobbs[48]	2015	49	Australia	Breast	55	100	79	NR	75	Mammogram ± MRI	Diagnosis	Longitudinal surveys
Bauml[49]	2016	103	USA	Lung	Median: 67	61	73	53	NR	CT, PET ± MRI	Monitoring	Cross-sectional survey
Abreu[50]	2017	232	Portugal	Any	61	51	NR	73	71	PET/CT	Any (except screening)	Longitudinal surveys
Grilo[51]	2017	81	Spain, Portugal	Any	55	53	NR	41	47	PET/CT	Any (except screening)	Longitudinal surveys
Evans[52]	2018	115	UK	Colorectal or Lung	66	33	NR	NR	NR	Whole body MRI, PET + CT	Staging	Longitudinal surveys
Goense[53]	2018	27	Netherlands	Oesophageal	64	15	NR	NR	NR	MRI + PET/CT	Staging & monitoring	Cross-sectional survey
Hall[54]	2018	169	USA	Lung	64	51	58	96	NR	Low dose CT	Screening	Cross-sectional survey
Derry[55]	2019	94	USA	Any	61	72	NR	69	0	Any	Monitoring	Longitudinal interview
Soriano[56]	2019	57	USA	Breast	58	100	93	NR	0	Mammogram	Surveillance	Longitudinal survey
Taghizadeh[57]	2019	1237	Canada	Lung	63	56	NR	85	NR	CT	Screening	Longitudinal interview
Bancroft[58]	2020	88	UK, Ireland	Breast	38	61	50	83	NR	MRI	Screening	Longitudinal survey
Grilo[59]	2020	94	Portugal	Any	61	54	NR	99	77	PET + bone scan	Staging, monitoring & surveillance	Longitudinal survey
Morreale[60]	2020	87	USA	Gastrointestinal and Lung	62	55	NR	92	NR	CT or MRI	Monitoring	Longitudinal interview
Paiella[61]	2020	54	Italy	Pancreatic	50	61	NR	NR	NR	MRI – MRCP	Screening	Cross-sectional interview

UK United Kingdom, USA United States of America, NR not reported, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging, MRCP Magnetic resonance cholangiopancreatography

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Demographic data is based on participants who completed the first survey

[c]These studies collected data from other groups who were not included in this review as they did not meet eligibility criteria. This included people having invasive procedures such as fine needle aspirate or open surgical biopsy[16, 33], people with abnormal screening results[18, 26, 29] and people who did not have a scan[18-20, 43]

[d]Demographics based on the entire population even if not all participants were eligible for this review.

[e]Four paediatric participants were included in this study.

Twenty-one studies were conducted in people having scans for screening[15, 16, 18, 20, 21, 24-27, 29-32, 35, 38, 43, 45, 54, 57, 58, 61]. In the remaining studies, reasons for scanning included diagnosis[23, 48], staging[34, 44, 52], monitoring[49, 55, 60], surveillance to detect recurrence[28, 37, 56] or a combination of reasons in people with known or suspected cancers (17 studies[17, 39, 41, 46, 47, 50, 51, 53, 59]). Five studies permitted scans for both screening and non-screening reasons (namely, diagnosis[22, 36, 40] or surveillance[19, 42])

The mean age of participants, reported by 33 studies, was 56.9 years (range 38 to 66 years)[20, 21, 25, 26, 28-33, 35, 36, 39, 41-48, 50-61]. The majority of participants were women (87%)[15, 16, 18-61]. When studies involving scans for breast cancer were excluded, there were similar proportions of men and women (women 49%, men 51%)[15, 27, 28, 30, 32-35, 37, 39, 41, 44, 46, 47, 49-55, 57, 59-61]. There was variation in the reporting and proportion of participants who were married (22 studies, range 34% to 97%[20, 21, 24-26, 29, 31, 32, 34-38, 41, 45-49, 54, 56, 58]), who received at least secondary education (29 studies, range 10% to 99%[20-22, 24-29, 31, 32, 34, 36, 37, 41-43, 45-47, 49-51, 54, 55, 57-60]) and who were attending their first scan (18 studies, range 0% to 100%[17, 21, 24, 27, 29, 32, 36, 38, 39, 41, 45, 46, 48, 50, 51, 55, 56, 59]).

Intervention studies

There were ten intervention studies (**Table 2**) involving 1,854 people[62-71]. This included people having scans for breast cancer (6 studies, *n*=1,449 people[62-65, 69, 70]) and lung cancer (1 study, *n*=16 people[68]). Scans included mammogram (5 studies[62-64, 69, 70]), positron emission tomography (PET) with computed tomography (CT; 3 studies[66, 67, 71]), magnetic resonance imaging (MRI)[65], CT[68] and ultrasound[70] (1 study each). Four studies involved scans for screening[63, 64, 68, 69], one for diagnosis[65], three for any reason in people with known or suspected cancers[66, 67, 71], and two where scans for screening, surveillance and/or diagnosis were permitted[62, 70].

The mean age of participants was reported by five studies and ranged from 47 to 65 years[63, 65, 68, 69, 71]. The majority were women (94%[62-66, 68-71]). There was variation in the reporting and proportion of participants who were married (2 studies, 73% and 75%[64, 65]), received at least secondary education (6 studies, range 28 to 100%[62-65, 68, 69]), and participants attending their first scan (5 studies, range 4% to 54%[62-64, 66, 71]).

Eight studies allocated participants to an intervention or control group[63-69, 71], one study compared two interventions[62] and one study delivered the intervention to all participants[70]. Two interventions were multifaceted[64, 65]. Types of interventions included: relaxation, distraction, and/or meditation (6 studies[62, 63, 66, 69-71]); education (4 studies[62, 64, 65, 68]); emotional or psychosocial support (2 studies[64, 65]); or, adjustments to routine logistics of the scan (1 study[67]).

Table 2. Demographics and study details for the 10 intervention studies to reduce scanxiety

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Allocation	Intervention and control groups
Mainiero[62]	2001	613	USA	Breast	< 40: 8% 50 to 50: 39% 50 to 60: 28% >70: 9%	100	NR	95	7	Mammogram	Screening or surveillance	Consecutive[b]	Educational or entertaining video in waiting room
Domar[63]	2005	143	USA	Breast	52	100	NR	81	8	Mammogram	Screening	Randomised	Relaxation, music or blank audiotape in waiting room and during scan
Fernandez-Feito[64]	2005	436	Spain	Breast	50 to 54: 24% 55 to 59: 30% 60 to 64: 23% 65 to 69: 22%	100	73	28	4	Mammogram	Screening	Randomised	Pre-scan nursing intervention or usual care
Caruso[65]	2006	44	Italy	Breast	47	100	75	89	NR	MRI	Diagnosis	Randomised	Pre-scan informative-emotive psychological support or routine information
Vogel[66]	2012	101	Netherlands	Any	Median: 58	51	NR	NR	41	PET/CT	Any (except screening)	Randomised	Audiovisual installation or usual care during FDG uptake
Acuff[67]	2014	180	USA	Any	NR	NR	NR	NR	NR	PET/CT	Any (except screening)	Unclear	Hand-held communication device or usual care during scan
Raz[68]	2014	16	USA	Lung	65	75	NR	100	NR	CT	Screening	Sequential[c]	Pre-scan multimedia education or usual care
Zavotsky[69]	2014	100	USA	Breast	54	100	NR	98	NR	Mammogram	Screening	Non-randomised[d]	Music or no music during scan
Ashton[70]	2019	113	USA	Breast	18 to 39: 3.6% 40 to 59: 51.8% 60 to 79: 39.3% > 80: 5.4%	100	NR	NR	NR	Mammogram ± ultrasound	Screening, surveillance or diagnosis	NA[e]	Shoulder & neck massage ± hand massage
Lorca[71]	2019	108	Spain	Any	59	57	NR	NR	54	PET/CT	Any (except screening)	Randomised	Mindfulness meditation or usual care during FDG uptake

USA United States of America, NR not reported, MRI magnetic resonance imaging, PET positron emission tomography, CT computed tomography, FDG fluorodeoxyglucose

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Each intervention was administered during one half of the study period

[c]Participants were enrolled into the control arm first, followed by the intervention arm

[d]Participants attending on Mondays, Wednesdays and Fridays were allocated to the intervention arm, and participants attending on Tuesdays and Thursdays were allocated to the control arm

[e]All participants received the intervention

Scanxiety measurement

Anxiety measurements varied across the studies, with different measurement tools, variants of the same tool, and different range and thresholds applied to tools.

Observational studies

The 47 observational studies (**Table 3**) used a total of 81 measures of anxiety, with 30 studies using one measure only[15-19, 21, 22, 25-28, 30, 33, 34, 36, 39, 40, 43, 44, 46, 48-51, 53, 55-57, 59, 61], and 17 studies using at least two measures[20, 23, 24, 29, 31, 32, 35, 37, 38, 41, 42, 45, 47, 52, 54, 58, 60].

The most common measures used were: purpose-designed Likert scales (17 studies); the State-Trait Anxiety Inventory (STAI) (14 studies); the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS) (9 studies); the Impact of Event Scale (IES) (6 studies); the Psychological Consequences Questionnaire (PCQ) (3 studies), the Cancer Worry Scale (3 studies), and; the Perceived Stress Scale (2 studies). There were 17 measures used by one study only[15, 20, 22, 26, 31, 32, 35, 52, 54, 56, 58, 60].

Likert scales were varied, with a numerical lower range limit of 0 or 1, and an upper range limit between 3 and 12[17, 20, 24, 25, 33, 40, 44, 46, 48, 50, 52, 53]. Seven studies used a descriptive range[21, 25, 27, 28, 33, 34, 55]. Two studies used both a numerical and a descriptive range[25, 33].

The STAI compromises State and Trait Anxiety subscales with a possible subscale range of 20 to 80. It has no validated anxiety threshold and is usually calculated as a sum of 4-point response options[72]. Included studies used and reported the STAI as a total score[37, 39], using one or both subscales[20, 23, 36, 37, 41, 42, 47, 51, 57, 59], or as a variant (e.g. STAI-6[32, 38, 58]). There were different ranges: none reported[47, 57]; no reported lower limit[41]; no reported upper limit[36]; 0 to 60[39, 51], or; based on a mean of individual item scores[20]. Some studies pre-specified an anxiety threshold of 39[57], 40[37, 41], 46[42], calculated based on the relationship between the anxiety and trait subscales[39], or based on investigator-determined categories[36]. One study used a different method to calculate scores (ie subtracting the points of reversed statements from direct statements, which were valued at 1, 2, 3 and 20, and then added to a constant of 50[36]).

The HADS Anxiety subscale has a range of 0 to 21 and a validated anxiety threshold of 11[73]. One study reported a range of 0 to 14[38], one study reported anxiety categories rather than a threshold[60], two studies reported an anxiety threshold of 8[41, 43] and one study reported an anxiety threshold of 10 (though there was overlap the 'tendency to anxiety' and 'anxiety' categories, classified as scores of 8 to 10 and 10 or more, respectively)[47].

The IES was used in its original form[30, 32, 38, 42, 58] or as a variant (IES-6[49]), and was reported as a total score[30, 32, 38, 49] or as Intrusion and Avoidance subscale scores[42, 58]. The two studies using subscale scores reported threshold levels of 20 or 21[42] and 8.5[58]. When using the PCQ, researchers used either the Emotional subscale[18] or the Negative Consequences subscale[24, 29]. The Cancer Worry Scale and the Perceived Stress Scale were used in original[45, 61] or variant[29, 54, 58] forms. The Symptom Checklist-90-Revised score could not be interpreted because the authors did not report a range[31], and a raw score or a transformed score could have been used[74].

Table 3. Prevalence and severity of scanxiety

Author	Year	Measurement of scanxiety			Results of scanxiety measurement		
		Name of tool	Range of tool (Anxiety threshold[a])	Timing of assessment	Prevalence (%)	Severity (Mean[b])	Pre- & post-scan comparison
Andolf[15]	1990	Visual analogue scale	0-100 (NA)	Post-scan: 1-3 years	81	Median 3.5	NA
Bull[16]	1991	HADS: Anxiety subscale	0-21 (≥11)[c]	Pre-scan: specific timing NR	4.9	4.97	Less severe post-scan scanxiety, p<0.001
				Post-scan: post-result, specific timing NR	4	4.43	
Peteet[17]	1992	10-point Likert scale	1-10 (NA)	Post-scan: specific timing NR	NR	First scan 5.5, Recent scan 3.5	NA
Cockburn[18]	1994	PCQ: Emotional subscale	0-15 (NA)	Pre-scan: day of scan	NR	<2	No difference
				Post-scan: pre-results, 1-week post-result & at 8 months	NR	<2	
Ellman[19]	1995	HADS: Anxiety subscale	0-21 (≥11)	Pre-scan: day of scan	6	NR	NA
Sutton[20]	1995	STAI: State Anxiety subscale	1-4 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		STAI: Trait Anxiety subscale	1-4 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences in scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		GHQ: Anxiety subscale	0-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<1	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<1	
		3-point Likert scale	1-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<2	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<2	
Bakker[21]	1998	5-point Likert scale	Descriptive range (NA)	Post-scan: immediate & at 3 weeks	39-40	Somewhat, very or extremely: 9 to 15%	NA
Gupta[22]	1999	HSCL-25	0-3 (NA)	Post-scan: specific timing NR	40	Moderate to severe: 25%	NA
Hafslund[23]	2000	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.5	No statistical comparison reported
				Post-scan: day of scan	NR	32.1	
		STAI: Trait Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.9	No statistical comparison reported
				Post-scan: day of scan	NR	NR	
Meystre-Agustoni[24]	2001	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: day of scan	NR	<1	No statistical comparison reported
				Post-scan: pre- result, 2 weeks post-result & 8 weeks post-result	NR	<2	
		6-point Likert scale	0-5 (NA)	Pre-scan: immediate	26	<1	
				Post-scan: pre-result, 2 weeks post-result & 8 weeks post-result	NR	<1	

Drossaert[25]	2002	Composite 7-item score of 4-point Likert scales	1-4 (NA)	Baseline: 8 weeks post-first scan	NR	1.6	No statistical comparison reported
				Pre-scan: 6 weeks (second & third scans)	NR	1.6 to 1.7	
				Post-scan: 6 weeks (second & third scans)	NR	1.5	
			Descriptive range (NA)	Baseline: 8 weeks post-first scan	NR	Moderate to severe: 10%	NA
Sandin[26]	2002	HSCL-90-R: Anxiety subscale	0-4 (NA)	Pre-scan: day of scan	NR	0.41	No statistical comparison reported
				Post-scan: 2 weeks	NR	0.28	
Brunton[27]	2005	4-point Likert scale, 3 items	Descriptive range (NA)	Post-scan: within 4 years	56-77	Quite or very: 11 to 28%	NA
Geurts[28]	2006	4-point Likert scale	1-4 (NA)	Peri-scan: specific timing NR	61	Moderate to severe: 21%	NA
Tyndel[29]	2007	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: 1 month	NR	5.1	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	3.8 to 4.2	
		Cancer Worry Scale - Revised	6-24 (NA)	Pre-scan: 1 month	NR	11.0	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	10.1 to 10.6	
Bunge[30]	2008	IES in low affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	5.6	Less severe post-scan scanxiety in both low and high affective risk groups, p<0.05
				Post-scan: 6 months	NR	4.3	
		IES in high affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	14.7	
				Post-scan: 6 months	NR	10.3	
Brown Sofair[31]	2008	Penn State Worry Questionnaire	16-80 (60)	Pre-scan: within 1 month	NR	50.18	No statistical comparison reported
				Post-scan: day of scan (post-result)	NR	NR	
		SCL-90-R: Anxiety subscale	NR (NA)	Pre-scan: within 1 month	NR	48.75	No difference
				Post-scan: day of scan (post-result)	NR	42.07	
		Individualized Questionnaire: Anxiety response	1-3 (2)	Pre-scan: within 1 month	35	NR	No statistical comparison reported
				Post-scan: day of scan (post-result)	24	NR	
van den Bergh[32]	2008	STAI-6	20-80 (NA)	Pre-scan: 1 day	NR	34.1	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	32.7 to 34.3	
		IES	0-75 (NA)	Pre-scan: 1 day	NR	6.9	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	5.1 to 5.6	
		EuroQol questionnaire: Anxiety subscale	1-3 (NA)	Pre-scan: 1 day	23	NR	No statistical comparison reported
				Post-scan: 6 months	NR	NR	
Westerterp[33]	2008	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): 2 weeks	NR	CT 1.2, PET 1.4	NA
			Descriptive range (NA)	Post-scan (after both scans): 2 weeks	CT 13, PET 23	Moderate to severe: CT 4%, PET 10%	NA
Bastiaannet[34]	2009	5-point Likert scale	1-5 (NA)	Post-scan: 2-6 weeks after lymph node dissection	Chest x-ray 20, CT 31, PET 36	Moderate to severe: Chest X-ray 13%, CT 5%, PET: 9%	NA
Vierikko[35]	2009	Health anxiety inventory	0-24 (NA)	Pre-scan: specific timing NR	NR	6.7	Less severe post-scan scanxiety, p<0.001
				Post-scan: 1 year	NR	5.8	
		Worry about lung cancer	0-8 (NA)	Pre-scan: specific timing NR	NR	3.0	No difference

				Post-scan: 1 year	NR	3.1	
Bolukbas[36]	2010	STAI: State Anxiety subscale	0-NR (20-39 mild, 40-59 moderate, 60-79 severe, ≥ 80 help needed)	Peri-scan: specific timing NR	NR	46.2	NA
Thompson[37]	2010	STAI	40-160 (NA)	Post-scan: specific timing NR	37	65.8	NA
		STAI: State Anxiety subscale	20-80 (≥40)	Post-scan: specific timing NR	NR	30.4	NA
		STAI: Trait Anxiety subscale	20-80 (≥40)	Post-scan: specific timing NR	NR	35.4	NA
Hutton[38]	2011	HADS: Anxiety subscale	0-14 (≥11)	Baseline: 4 weeks pre-first scan	20	6.9	No difference
				Pre-scan: day of each scan (for 5 scans)	MRI 17, Mammogram 20	MRI 5.2 to 6.5, Mammogram 5.0 to 6.5	
				Post-scan: 6 weeks (for 5 scans)	10 to 13	5.1 to 5.9	
		STAI-6	20-80 (NA)	Pre-scan: day of scan (for 5 scans)	NR	MRI 10.8 to 12.1, Mammogram 10.1 to 11.3	Less severe post-scan scanxiety for MRI (p<0.0005) & mammogram (p=0.002)
				Post-scan: day of scan (for 5 scans)	NR	MRI 9.6 to 10.7, Mammogram 9.7 to 10.5	
		IES	0-75 (NA)	Post-scan: 6 weeks (for 5 scans)	NR	MRI 17.8 to 19.3, Mammogram 17.2 to 18.6	NA
Pifarre[39]	2011	STAI	0-60 for each subscale (state more than 10 than trait)	Pre-scan: day of scan	68	NR	NA
Steinemann[40]	2011	7-point Likert scale	1-7 (NA)	Pre-scan: day of scan	NR	4.1	NA
Yu[41]	2011	HADS: Anxiety subscale	0-21 (≥8)	Pre-scan: day of scan	38	NR	NA
		STAI: State Anxiety subscale	NR-80 (≥40)	Pre-scan: day of scan	46	39.4	NA
		STAI: Trait Anxiety subscale	NR-80 (≥40)	Pre-scan: day of scan	46	39.9	NA
		Dichotomous reporting[d]	Yes/No (NA)	Pre-scan: day of scan	41	NR	NA
Bredart[42]	2012	STAI: State Anxiety subscale	20-80 (≥46)	Pre-scan: 1 week	NR	MRI 42.1, Mammogram 41.1	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 34.9, 40.8, Mammogram 34.3, 38.8	
		IES: Intrusion subscale	0-35 (≥20)	Pre-scan: 1 week	NR	MRI 8.9, Mammogram 8.4	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 8.5, Mammogram 7.7	
		IES: Avoidance subscale	0-40 (≥21)	Pre-scan: 1 week	NR	MRI 12.1, Mammogram 9.8	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 11.8, Mammogram 8.9	
Hafslund[43]	2012	HADS: Anxiety subscale	0-21 (≥8)	Pre-scan: within 2 weeks	15	4.1	NA
Adams[44]	2014	4-point Likert scale	1-4 (NA)	Post-scan: day of scan (after each scan)	NR	MRI 1.5, CT 1.8	NA
Baena-Canada[45]	2014	HADS: Anxiety subscale	0-21 (≥11)	Post-scan: specific timing NR	4	1.86	NA
		Cancer Worry Scale	6-24 (NA)	Post-scan: specific timing NR	NR	9.4	NA

Andersson[46]	2015	Sum of 3 items on 5-point Likert scale	0-12 (NA)	Post-scan: within four weeks	NR	4	NA
Elboga[47]	2015	HADS: Anxiety subscale	0-21 (≥10)	Pre-scan: day of scan	NR	9.2	NA
		STAI: State Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	40.4	NA
		STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	46.6	NA
Hobbs[48]	2015	5-point Likert scale	1-5 (NA)	Post-scan (after both scans), specific timing NR	Mammogram 17, MRI 44	NR	NA
Bauml[49]	2016	IES-6	0-24 (NA)	Post-scan: specific timing NR	83	6.4	NA
Abreu[50]	2017	10-point Likert scale	1-10 (NA)	Pre-scan: day of scan	NR	6.4	Less severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	5.7	
Grilo[51]	2017	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: day of scan	NR	31.1	More severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	33.0	
Evans[52]	2018	GHQ-12	0-12 (≥4)	Peri-scans: specific timing NR	42	NR	NA
		7-point Likert scale	1-7 (NA)	Post-scan: 1 month	NR	MRI 2.5, CT or PET/CT 2.2	NA
Goense[53]	2018	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): day of scan	NR	MRI 1.0, PET 1.0	NA
Hall[54]	2018	Generalized Anxiety Disorder 2-item	0-6 (≥3)	Peri-scan: specific timing NR	26	1.62	NA
		Perceived Stress Scale 4	0-16 (NA)	Peri-scan: specific timing NR	NR	5.14	NA
Derry[55]	2019	4-point Likert scale	Descriptive range (NA)	Peri-scan: pre-result	NR	'A great deal' or 'completely': 23%	NA
Soriano[56]	2019	PROMIS Anxiety Short Form	1-5 (NA)	Pre-scan: two weeks	NR	1.55	NA
Taghizadeh[57]	2019	STAI: State Anxiety subscale	NR (39)	Baseline	NR	30.9	More severe post-scan scanxiety, p<0.001
				Post-scan: one-month post-result & at 12 months	NR	33.1, 31.7	
Bancroft[58]	2020	HADS: Anxiety subscale	0-21 (11)	Baseline	Carriers[e]: 14 Controls: 7	Carriers: 6.2 Controls: 4.9	No difference in prevalence Less severe post-scan in carriers (p=0.04)
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 5 to 14 Controls: 2 to 7	Carriers: 5.3 to 5.9 Controls: 4.1 to 4.6	
		Cancer Worry Scale – Revised	8-32 (NA)	Baseline	NR	Carriers: 14.4 Controls: 12.2	No difference
				Post-scan: at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 13.6 to 14.7 Controls: 11.9 to 12.1	
		IES-cancer: Intrusion subscale	0-35 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 35 to 58 Controls: 5 to 13	Carriers: 8.3 to 11.4 Controls: 1.7 to 3.0	NA
		IES-cancer: Avoidance subscale	0-40 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 55 to 64 Controls: 12 to 37	Carriers: 9.9 to 13.3 Controls: 2.6 to 7.0	NA
		IES-MRI: Intrusion subscale	0-35 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 4 to 7 Controls: 0 to 3	Carriers: 1.2 to 3.1 Controls: 0.1 to 0.5	NA
		IES-MRI: Avoidance subscale	0-40 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 14 Controls: 8	Carriers: 1.8 Controls: 2.8	NA
		STAI-6	6-24 (NA)	Pre-scan: day of scan	NR	Carriers: 7.2 Controls: 7.3	NA

		Health Questionnaire	0-14 (NA)	Baseline	NR	Carriers: 7.0 Controls: 6.8	No difference
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 7.1 to 8.1 Controls: 6.9, to 7.7	
Grilo[59]	2020	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	Bone scan: 51.75 PET/CT: 44.76	Less severe post-scan scanxiety for both: Bone scan. p=0.02 PET/CT, p<0.001
				Post-scan: day of scan	NR	Bone scan: 36.70 PET/CT: 38.82	
Morreale[60]	2020	Distress thermometer	0-10 (4)	Peri-scan: day of scan	NR	3.73	No statistical comparison
				Post-scan: one-week post-result	NR	3.91	
		HADS: Anxiety subscale	0-21 (0-7 none, 8-10 mild, 11-14 moderate, 15-21 high)	Peri-scan: day of scan	NR	6.12	No statistical comparison
				Post-scan: one-week post-result	NR	5.32	
Paiella[61]	2020	Perceived Stress Scale	0-40 (15-18 moderate, ≥ 19 high)	Post-scan: pre-result	NR	14.8	NA

NA not applicable, NR not reported, HADS Hospital Anxiety and Depression Scale, PCQ Psychological Consequences Questionnaire, STAI State-Trait Anxiety Inventory, GHQ General Health Questionnaire, HSCL Hopkins Symptom Checklist, IES Impact of Event Scale, SCL-90-R Symptom Checklist-90-Revised, HSCL-90-R Hopkins Symptom Checklist 90-Revised, PROMIS Patient-Reported Outcomes Measurement Information System, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging

All percentages were rounded to the nearest whole number

[a]NA is listed as the anxiety threshold when the study did not state a pre-specified threshold. In these cases, the definition of scanxiety prevalence was the percentage of people who reported any degree of anxiety, and the definition of scanxiety severity was at least half the total instrument score

[b]Unless otherwise described

[c]This study did not specify an anxiety threshold; however, the Anxiety subscale of the Hospital Anxiety and Depression Scale has validated thresholds. These thresholds were included in this table

[d]Dichotomous reporting assumed given description of question (self-perception of anxiety) and results "40.5% of the patients considered themselves to be anxious"[41]

[e]This study included participants who were *TP53* mutation carriers, and population controls

Intervention studies

The ten intervention studies (**Table 4**) used 19 measures of anxiety, with five studies using one measure only[62, 66, 67, 69, 70], and five studies at least two[63-65, 68, 71]. The measures included subscales of the STAI (7 studies), Likert scales (5 studies), a variant of the Psychological Consequences Questionnaire (1 study[68]) and the Crown Crisp Experimental Index (1 study[65]).

Likert scales were varied, with a lower range limit of 0 or 1, and an upper range limit between 5 and 10[62, 63, 69-71]. The STAI was used and reported using one or both subscales[63-65, 67, 68, 71], or as a variant (8-item STAI[66]). There was variation from the usual STAI parameters, with studies using a different range (i.e. not reported[63, 65], 0 to 60[64], or 18 to 32[66]) or pre-specified anxiety thresholds of 40[68] or 16[66].

Scanxiety outcomes

Prevalence and severity of scanxiety for each study are provided in **Table 3**. Summary statistics for prevalence and severity were not calculated due to heterogeneity in the type and timing of measurement between the studies.

Prevalence of scanxiety

Twenty-four of the 47 studies reported the prevalence of scanxiety. The prevalence of scanxiety ranged between 0% and 64% across the 16 measures with pre-specified anxiety thresholds[16, 19, 31, 38, 41, 43, 45, 52, 54, 58], though eight of these measures came from only two studies[41, 58]. The prevalence of scanxiety ranged between 13% and 83% using the 14 measures without pre-specified anxiety thresholds[15, 21, 22, 24, 27, 28, 32-34, 37, 39, 41, 48, 49].

There were insufficient numbers to compare the prevalence of scanxiety using measures with pre-specified anxiety thresholds of people having scans for screening (11 measures[16, 31, 38, 43, 45, 54, 58]), reasons other than screening (four measures[41, 52]) and for screening or non-screening reasons (1 measure[19]). When no threshold was reported, the prevalence of scanxiety had a similar range (screening 23% to 81%, five measures[15, 21, 24, 27, 32]; reasons other than screening 14% to 83%, eight measures[28, 33, 34, 37, 39, 41, 48, 49]; either screening or reasons other than screening (40%, one measure[22]).

Severity of scanxiety

Severity of scanxiety was reported in 44 of 47 observational studies. Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%).

Table 4. Effect of interventions to reducing scanxiety

First author	Year	Intervention	Measurement of scanxiety			Impact of intervention on scanxiety	
			Name of tool	Range of tool (Anxiety threshold)	Timing of assessment	Description of results	P-value
Mainiero[62]	2001	Arm A: an educational video about breast cancer and mammography Arm B: an entertaining movie (from the 1940s to 1960s)	6-point Likert score	0-5 (NA)	Pre-scan: immediate Post-scan: immediate	No difference	NR
Domar[63]	2005	Arm A: relaxation audiotape, or; Arm B: music audiotape, or; Arm C: control (blank audiotape)	STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 34.8 v 33.6 v 33.2	0.18
					Post-scan: immediate	No difference Arm A v Arm B v Arm C: 30.4 v 30.9 v 33.2	0.78
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 32.6 v 32.7 v 32.5	0.99
			11-point Likert scale	1-10 (NA)	Post-scan	No difference Arm A v Arm B v Arm C: 2.6 v 3.2 v 2.8	0.43
					Post-scan: immediate	NR	NR
Fernandez-Feito[64]	2005	Arm A: A protocolised nursing intervention (information and emotional support) and usual care, or; Arm B: Usual care alone	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	Less severe	<0.001
						Less severe if fear of cancer present	0.002
						Less severe if no fear of cancer present	0.003
						No difference if fear of cancer outcome present	0.09
						Less severe if no fear of scan outcome	<0.001
			STAI: Trait Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	No difference	0.34
Caruso[65]	2006	Arm A: routine information and 45 minutes of informative-emotive psychological support with a psychologist, or; Arm B: routine information	Crown Crisp Experimental Index	NR (0-96)	Pre-scan: immediate (post-intervention)	Less severe Arm A v Arm B: 39.4 v 42.3	0.03
			STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	No difference Arm A v Arm B: 57.7 v 58.6	0.77
					Post-scan: immediate	Less severe	0.048
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	NR	NR
Vogel[66]	2012	Arm A: Uptake room with an audio-visual installation involving a video of nature scenes on a 119cm television, dynamic lighting & ambient electronic music Arm B: Uptake room without the audio-visual installation	8-item STAI	18-32 (≥16)	Pre-scan: immediately before & immediately after fluorodeoxyglucose uptake period	Less severe Arm A v Arm B: reduction by 2.39 v 1.02	0.04
Acuff[67]	2014	Arm A: Receive a hand-held device to contact imaging staff during the scan Arm B: No device	STAI: State Anxiety subscale	20-80 (NA)	During scan: immediately before completion of the scan	Less severe Arm A v Arm B: 22.87 v 26.45	0.014
						Less severe if previous PET/CT Arm A v Arm B: 20.78 v 24.64	0.023

						No difference if first time PET/CT Arm A v Arm B: 23.09 v 27.25, p=0.249	0.249
Raz[68]	2014	Arm A: multimedia education session and usual care, or; Arm B: Usual care	STAI: State Anxiety subscale	20-80 (≥40)	Pre-scan: within 2 weeks Post-scan: immediate, at 1 week & 3-7 months post-scan	No difference at any time point	NR
			STAI: Trait Anxiety subscale	20-80 (≥40)		No difference at any time point	NR
			PCQ: Lung Cancer adaptation, Anxiety subscale	0-18 (NR)		No difference at any time point	0.11 to 0.76
Zavotsky[69]	2014	Arm A: music of their choice played via dock during the scan Arm B: no music	11-point Likert scale	0-10 (NA)	Post-scan: immediate	No difference Arm A v Arm B: 2.36 v 2.98	0.21
Ashton[70]	2019	All participants: 10-minute shoulder & neck massage and/or hand massage before, during or after imaging, or between two imaging tests	11-pointLikert scale	0-10 (NA)	Post-intervention (pre- or post- scan)	81% had a reduction in anxiety following massage[a]	<0.01
Lorca[71]	2019	Arm A: mindfulness meditation Arm B: routine care	STAI: State Anxiety subscale	NR (NA)	Post-scan: immediate	Less severe Arm A v Arm B: 10.47 v 29.07	0.000
			STAI: Trait Anxiety subscale	NR (NA)		No difference	NS
			11-item Likert scale	0-10 (NA)		Less severe Arm A v Arm B, 1.07 v 5.70	0.000

NA not applicable, NR not reported, STAI State-Trait Anxiety Inventory, PCQ Psychological Consequences Questionnaire

[a]Mean scores for overall study population not provided

The mean severity scores were below pre-specified anxiety thresholds on 17 of the 19 measures where a threshold was reported[16, 31, 37, 38, 41-43, 45, 47, 54, 57, 58]. The two exceptions were observed in a study comparing people with *TP53* mutations ('carriers') to controls, with all participants undergoing screening scans. In carriers, mean scores were maximally 11.4 (IES Intrusion subscale, threshold 8.5), and 13.3 (IES Avoidance subscale, threshold 8.5). Mean severity scores for controls were below the thresholds[58].

Of the 43 measures without a pre-specified threshold, the majority had mean scores that were less than half the total scores[15, 18, 20, 23-26, 29, 30, 32, 33, 35, 37, 38, 44-46, 49, 52-54, 56, 58, 60, 61]. There were six exceptions, which reported maximal mean severity scores of: 5.5 out of 10 (Likert scale)[17]; 6.4 out of 10 (Likert scale)[50]; 4.1 out of 7 (Likert scale)[40], 33 out of 60 (STAI State Anxiety subscale)[51], 8.1 out of 14 (Health Questionnaire)[58], and; 51.75 out of 80 (STAI)[59]. Four of these scores occurred in studies where scans were performed for reasons other than screening[17, 50, 51, 59], one allowed scans for diagnosis or screening[40], and one allowed scans for screening only[58].

Eight measures used a descriptive range of severity, with more severe levels of scanxiety in 4% to 28% of participants[21, 22, 25, 27, 28, 33, 34, 55].

Four measures could not be interpreted because they failed to report a range and anxiety threshold[31, 36, 47].

Scanxiety before and after a scan

Of the 20 studies that reported a pre- and post-scan scanxiety measurement, 14 studies reported a statistical comparison[16, 18, 20, 29-32, 35, 38, 50, 51, 57-59] and six did not[23-26, 42, 60](**Table 3**). There was variation in the timing of scanxiety measurement before a scan from four weeks before the scan until immediately before the scan, and after a scan from immediately after the scan until one year after the scan. Five studies reported a post-scan reduction in scanxiety severity compared to pre-scan levels[16, 29, 30, 32, 50, 59]. Two studies reported an increase in post-scan scanxiety severity[51, 57], and two studies no difference in pre- and post-scan scanxiety severity[18, 31].

Four studies reported mixed findings on the change in scanxiety severity across different measures (**Table 5**).

Table 5. Studies with discrepant results on pre- and post-scan scanxiety severity using different measures

First author	Measurement tool	
	Post-scan reduction in scanxiety	**No difference in pre- or post-scan scanxiety**
Sutton[20]	General Health Questionnaire: Anxiety subscale 3-point Likert scale	STAI: State Anxiety subscale STAI: Trait Anxiety subscale
Vierikko[35]	Health Anxiety Inventory	Worry about lung cancer
Hutton[38]	6-item STAI	HADS: Anxiety subscale
Bancroft[58]	HADS: Anxiety subscale	Cancer Worry Scale – Revised Health Questionnaire

STAI: State Trait Anxiety Inventory, HADS: Hospital Anxiety and Depression Scale

Although Bancroft *et al.*[58] reported a reduction in scanxiety severity using HADS (anxiety subscale), there was no difference in scanxiety prevalence.

Contributing factors to scanxiety

Multiple comparisons were made between scanxiety and possible contributing factors across the included studies (**Table 6**).

Table 6. Contributing factors to scanxiety

Variable	Comparison	Effect on scanxiety	Studies	*n*	*P*-value[a]
Age	Younger v older	More prevalent	1	398	0.008[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	5	1883	0.005[45], <0.01[20], <0.01 (for screening)[70], 0.01[24], NR[63]
		No difference in severity	11	6804	NS[22, 27, 36, 37, 42, 43, 49, 51, 59, 62], NS (for surveillance)[70]
Gender	Men v women	More prevalent	1	200	<0.001[39]
		Less prevalent	1	298	0.021[41]
		No difference in prevalence	1	106	NS[28]
		More severe	1	232	0.033 (post-scan)[50]
		Less severe	2	1381	0.000[47], <0.05[57]
		No difference in severity	5	580	NS[37, 49, 51, 59], NS (pre-scan)[50]
Ethnicity	White v other races	More severe	1	143	NR[63]
	Maori & Pacific Islanders v New Zealand European or Asian	More severe	1	584	<0.001[27]
	Any	No difference in severity	5	1454	NS[22, 24, 37, 40, 49]
Education	Lower v higher	More prevalent	1	398	<0.001[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	8	7400	0.003[62], 0.007[36], <0.01[22], ≤0.01[42], 0.012[24], 0.018[27], 0.04[43], <0.05[23]
		No difference in severity	6	591	NS[37, 49, 51, 59, 63, 69]
Employment	Unemployed v employed	More prevalent	1	398	0.046[41]
		More severe	3	5056	0.01[43], 0.05[23], ≤0.05[42]
		No difference in severity	2	654	NS[27, 37]
Income	Higher v lower	No difference in severity	3	757	NS[27, 37, 49]
Marital status	Married or de facto v single	More severe	1	637	≤0.01 (using IES - Intrusion subscale)[42]
		No difference in severity	5	1790	NS[24, 36, 37, 49], NS (using STAI - State anxiety subscale)[42]
Children	Children v no children	No difference in severity	3	5206	NS[24, 37, 43]
Smoking status	Current v non-smoking[b]	More severe	3	4562	<0.001[43, 54], 0.031[47]
		No difference in severity	2	330	NS[40, 49]
Reason for scan	Diagnostic v screening	More severe	3	1104	0.007[41], 0.047[36], NR[62]
	Staging or surveillance v monitoring	More severe	1	200	<0.001[39]
	Lower v higher referral clarity	More severe	1	169	0.048[54]
Type of scan	MRI v mammogram	More severe	1	49	0.009[48]
		Less severe	1	637	NR[42]
	CT v MRI	More severe	1	36	0.007[44]
		Less severe	1	115	NR[52]
	PET v CT	More severe	1	82	0.01[33]
	Nuclear medicine scan v non-nuclear medicine scan	More severe	1	398	0.004[41]
	MRI v PET/CT	No difference in severity	2	142	NS[52, 53]
	CT v PET v chest X-ray	No difference in severity	1	59	NS[34]

	Bone scan v PET scan	More severe	1	94	<0.001 (post-scan)[59]
		No difference in severity	1	94	NS (pre-scan)[59]
Scan-naïve	First v subsequent scans	More prevalent	1	398	0.001[41]
		No difference in prevalence	1	200	NS[39]
		More severe	5	3796	<0.0005[38], <0.01[25], <0.02[19], <0.05[67], NR[66]
		Less severe	1	93	0.038[36]
		No difference in severity	6	2491	NS[24, 27, 50, 51, 59, 62]
Pain	Pain v no pain during scan	More severe	6	4291	<0.0001[25], <0.001[27], 0.001[62], <0.01[23, 69] <0.05[22]
Risk of cancer	Past history v no past history of cancer	More severe	2	864	≤0.001[42], <0.05[40]
		Less severe	1	434	0.013[45]
		No difference in severity	3	1206	NS[15, 24, 58]
	Family history v no family history of cancer	More severe	1	584	0.002[27]
		No difference in severity	3	1255	NS[15, 24, 36]
	Mutation carrier v not a carrier	More severe	1	88	<0.05 (three comparisons, using IES cancer – Intrusion and Avoidance subscales, and post-scan Health Questionnaire)[58]
		No difference	1	88	NS (five comparisons, using HADS- Anxiety subscale, Cancer Worry Scale – Revised, IES MRI – Intrusion and Avoidance subscales, and pre-scan Health Questionnaire)[58]
	Higher, not otherwise specified v lower	More severe	1	70	<0.05[37]
Perceived risk of cancer	Higher v lower	More severe	3	1545	<0.001[27], ≤0.001[42], <0.01[30]

NS not significant, NR not reported, IES Impact of Event Scale, STAI State Trait Anxiety Inventory, HADS Hospital Anxiety and Depression Scale, MRI Magnetic Resonance Imaging

[a]The P-values listed in this table were reported by individual studies based on their own datasets. This scoping review has not performed additional analysis or attempted quantitative comparisons between studies.

[b]One study compared current smokers v former smokers[54], and one study compared current and former smokers v never smokers[49]

In summary, higher scanxiety severity was associated with people with:

- Lower education (compared to higher education, eight of 14 studies[22-24, 27, 36, 37, 42, 43, 49, 51, 59, 62, 63, 69]);
- A history of smoking (compared to non-smoking, three of five studies[40, 43, 47, 49, 54]);
- Higher pain levels during the scan (compared to no pain, all six studies[22, 23, 25, 27, 62, 69]);
- Higher perceived risk of cancer (compared to lower perceived risk of cancer, all three studies[27, 30, 42]), and;
- Diagnostic scans (compared to screening scans, all three studies[36, 41, 62])

The prevalence or severity of scanxiety was not consistently affected by age (13 of 19 comparisons[20, 22, 24, 27, 28, 36, 37, 41-43, 45, 49-51, 59, 62, 63, 70]), gender (six of 11 comparisons[28, 37, 39, 41, 47, 49-51, 57, 59]), ethnicity (five of seven comparisons[22, 24, 27, 37, 40, 49, 63]), income (all three comparisons[27, 37, 49]), marital status (five of six comparisons[24, 36, 37, 42, 49]) or having children (all three comparisons[24, 37, 43]).

Inconclusive results occurred in the following comparisons:

- Employment (unemployed compared to employed, four of six comparisons[23, 27, 37, 41-43])

- Scan-naivety (first scan compared to subsequent scans, six of 13 comparisons[19, 24, 25, 27, 36, 38, 39, 41, 50, 51, 62, 66, 67])
- Risk of cancer (higher compared to lower risk of cancer, seven of 19 comparisons[15, 24, 27, 36, 37, 40, 42, 45, 58])

Although nine studies reported differences in scanxiety between different imaging modalities, the number of comparisons between specific scans were insufficient to draw conclusions[33, 34, 41, 42, 44, 48, 52, 53, 59].

Interventions that reduce scanxiety

Five of the 10 intervention studies showed a reduction in scanxiety compared to controls[64-67, 71]. Four studies reported no difference in scanxiety between the intervention arms[62, 63, 68, 69]. The study where all participants received the same intervention showed a reduction in anxiety[70]. Details of these results are listed in **Table 4**.

Both multi-faceted interventions studies incorporating education and emotional or psychological support showed a reduction in scanxiety[64, 65].

Of the six studies with relaxation, distraction and/or meditation components, three studies showed a reduction in scanxiety[66, 70, 71], while three studies did not[62, 63, 69].

Interventions with only educational components did not show a reduction in scanxiety[62, 68].

A reduction in scanxiety severity was also observed when a hand-held device was available to communicate with radiology staff. This reduction was observed in the subgroup of participants who had had a previous scan, but not in participants having their first scan[67].

DISCUSSION

This is the first systematic scoping review aimed at quantifying the phenomenon of scanxiety in people having cancer-related scans. Scanxiety is a common and important clinical problem, as supported by the large number of studies identified by our search. There is a wide range of reported scanxiety prevalence (0 to 83%), and scanxiety is generally not severe. Severity of scanxiety may be lower after a scan and is higher in people who have a lower education, currently smoke, experience pain during a scan, have higher perceived risk of cancer, and who are having diagnostic (rather than screening) scans. Interventions may be more likely to reduce scanxiety if they involve active participation (eg psychological and emotional support, meditation or a hand-held communication device) rather than passive participation (listening to music or education only).

Firm conclusions about prevalence and severity could not be drawn due to considerable methodological heterogeneity of the included studies, especially in relation to scanxiety measurement tools. None were designed and validated for scanxiety, and some tools and their thresholds were not designed and/or validated for anxiety. This review did use purpose-designed definitions of prevalence and severity to allow some comparison between studies; however, the lack of a universal definition or specific measurement tool for scanxiety limits confidence in the interpretation of the results and interstudy

comparisons. This highlights the need for a universally accepted measure to quantify scanxiety and evaluate scanxiety interventions in the future. A recent literature review by Al-Dibouni[75] provided a narrative overview of scanxiety in people having scans for any reason, and also recognised the lack of a specific measurement tool for scanxiety and variable scanxiety prevalence among studies[75].

Given the STAI and Likert scales were the most common tools used, we propose that future studies use the state anxiety subscale of the STAI, with a range of 20-80 and no specific anxiety threshold[72] (or variants, such as the STAI-6[76]), and/or the distress thermometer, with a range of 0-10 and a clinically significant threshold of ≥4[77], to measure scanxiety. These tools can be combined with other validated anxiety measures, such as the HADS, to further refine the relationship between tools. Using existing measures rather than developing a scanxiety specific tool allows scanxiety assessment to occur immediately and broadly in clinical research.

Strengths of this scoping review include the rigorous methodology using a published framework[12, 13], two independent researchers for study selection and data extraction, and the implementation of a comprehensive search strategy and broad inclusion criteria to achieve an exhaustive review of the available literature. Limitations include the use of purpose-designed definitions of prevalence and severity and the limited generalisability of the results due to heterogeneity in cancer type, reason for scan, imaging modality and timing of scanxiety measurement between the studies, and because the search strategy was restricted to English language databases. Finally, scanxiety in people who were recalled after an abnormal screening result were excluded from this review due to confounding and feasibility. These populations may be at higher risk of scanxiety, and further research may provide further insight about the scanxiety experience in this population.

Additional research implications of our review include the need for research into high-risk populations for scanxiety, including people with advanced cancer. This population was included in only three studies [49, 55, 60]; however, people with cancer have higher rates of anxiety compared to the general population[78]. As they may be more likely to develop scanxiety, experience more severe scanxiety, or have higher post-scan scanxiety while waiting for scan results, longitudinal assessment of scanxiety is required. Further research into effective and feasible interventions is also required, though these will face implementation challenges due to variations in health systems and available resources.

CONCLUSIONS

Prevalence and severity of scanxiety varied widely, although heterogeneity in scanxiety measurement interpretation. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide the development of interventions to high-risk populations.

FOOTNOTES

Contributions: KTB, PB, BK, HD and CB contributed to the concept and design of this review. KTB developed and implemented the search strategy. KTB and RL independently screened and reviewed titles, abstracts and full-text articles for inclusion. KTB and RL independently extracted data from the included studies. PB, BK, HD and CB contributed content expertise to ensure clinically relevant

interpretation of the data. KTB drafted the initial manuscript, and RL, PB, BK, HD and CB reviewed and approved the manuscript prior to submission.

Ethical approval: This study was not submitted for ethics approval because it is a review article and does not directly recruit participants.

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Data availability: All data relevant to the study are included in the article or uploaded as supplementary information. Data are available upon reasonable request. The additional data are the data extraction forms for each study.

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FIGURE CAPTIONS

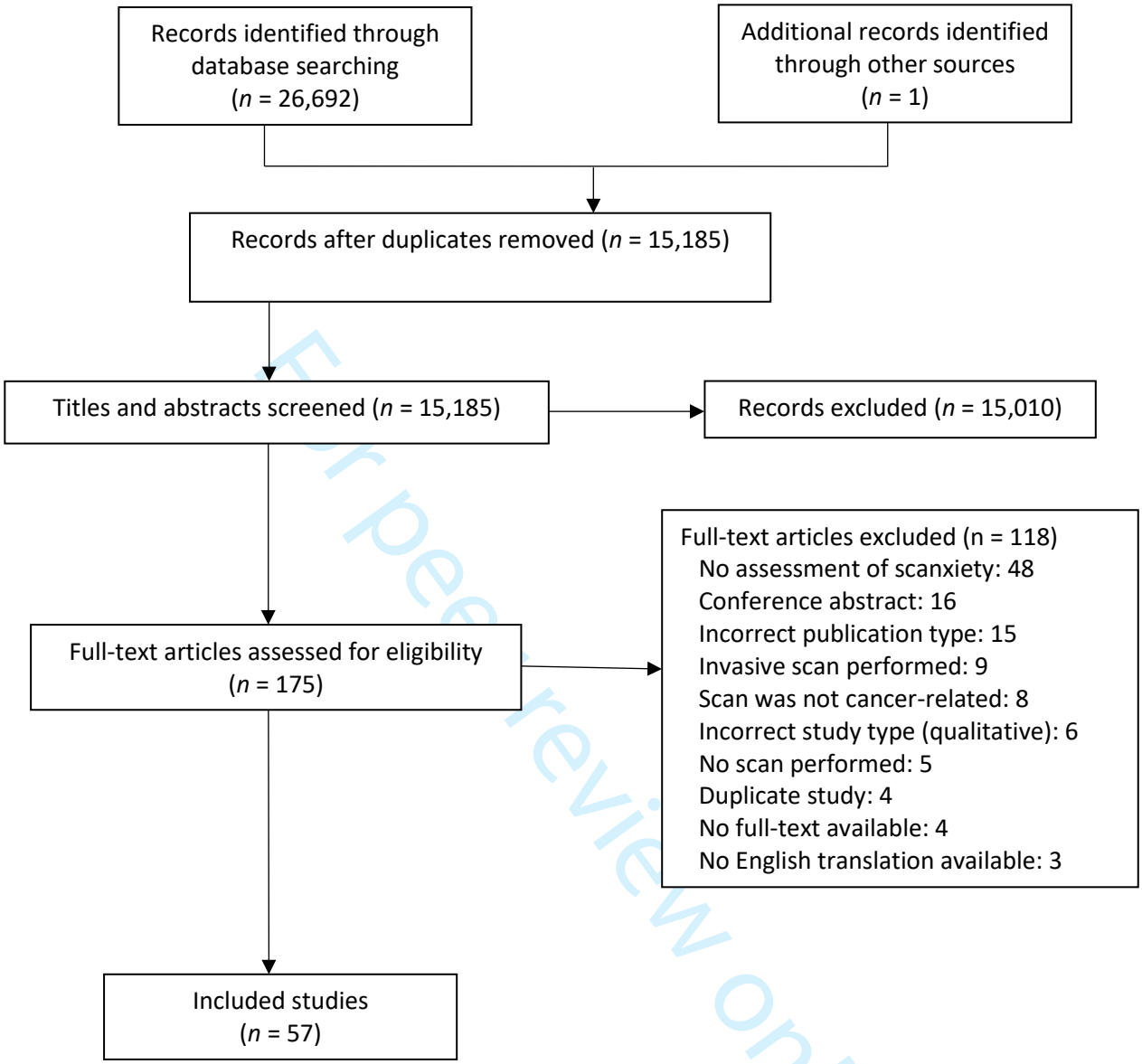
Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

Figure 2. Study search and selection flow diagram

Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

#	Search	#	Search	#	Search	#	Search
1	Exp Neoplasms/	10	Exp Diagnostic Imaging/	15	exp Anxiety/	22	or/1-9
2	Exp Medical oncology/	11	imaging.ti,ab	16	exp Anxiety Disorders/	23	or/10-14
3	neoplasm*.ti,ab	12	scan.ti,ab	17	exp Fear/	24	or/15-21
4	cancer*.ti,ab	13	tomography.ti,ab	18	anxi*.ti,ab	25	22 and 23 and 24
5	neoplasm*.ti,ab	14	ultraso*.ti,ab	19	fear.ti,ab		
6	malignan*.ti,ab			20	worr*.ti,ab		
7	tum??r*.ti,ab			21	distress*.ti,ab		
8	oncolog*.ti,ab						
9	carcinoma*.ti,ab						

Figure 2. Study search and selection flow diagram



Supplementary File 1. Protocol

Scanxiety: A scoping review about scan-associated anxiety

Protocol

Version 1.0, 10/04/2019

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Introduction

Radiological scans are necessary to diagnose and stage cancers, to monitor for cancer recurrence or progression or to investigate new cancer- or treatment-related problems. Imaging modalities include plain X-rays, computed tomography (CT) scans, positron-emission tomography (PET) scans, magnetic resonance imaging (MRI), ultrasound and nuclear medicine bone scans.

Distress before, during or after a scan has been dubbed "scanxiety" by a patient writing for the Time Magazine in 2011[1]. This is a common clinical problem that is widely discussed on social media and patient forms, but there is a paucity in the literature about this topic. This systematic scoping study aims to increase the understanding about scanxiety.

Objectives

The objectives of this study are to:

- determine the incidence and severity of scanxiety in adults who have scans for cancer-related reasons;
- compare tools that measure scanxiety;
- identify contributing and exacerbating determinants of scanxiety;
- identify strategies or interventions that reduce scanxiety; and,
- explore the experiences of scanxiety for patients and other stakeholders

Methods

This protocol is based on the six-step methodological framework developed by Arskey & O'Malley[2] and modified by Levac *et al.*[3], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols extension for Scoping Reviews (PRISMA-ScR) checklist[4].

Inclusion and exclusion criteria

Publications will be included if they were original full-text research articles that addressed scanxiety in adults over 18 years of age who had a scan for a cancer-related reason. Outcome measures have to include at least one of the following: the incidence of scanxiety; severity of scanxiety; contributing or exacerbating factors of scanxiety; intervention to improve scanxiety, or; experiences of patients with scanxiety. All types of non-interventional imaging modalities are acceptable. Any type or stage of cancer is acceptable, including populations undergoing cancer screening. No date or language restriction will be applied to electronic database searching.

Interventional imaging will be excluded. Review articles, editorials, letters and protocols will be excluded.

Search protocol

A systematic review of the following electronic databases will be conducted by one author (KTB): Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane, Scopus, ESCBO CINAHL and PubMed. The search strategy will combine the subject headings and keywords of cancer (neoplasm* or cancer* or malignan* or tum??r* or oncolog* or carcinoma*), imaging (diagnostic imaging or imaging or scan* or tomograpy or ultraso* or radionucl*) and anxiety (anxi* or fear* or worr* or distress*). Hand searching of reference lists of included articles will be undertaken.

All references will be imported into Endnote V9. After removal of duplicates, two authors (KTB and RL) will independently review and screen publication titles and abstracts for eligibility. Of the articles deemed potentially eligible, the full text of the article will be evaluated for final inclusion. Discrepancies will be decided by discussion between the two authors (KTB and RL), and will be escalated to all authors if a consensus cannot be reached.

Data extraction and analysis

Standardised data collection forms will be developed. Relevant data will be independently extracted from by two authors (KTB and RL) into an electronic data extraction form (Table 1).

Table 1. Included data items on the electronic data extraction form

Publication details	Study name/Title of article Study authors Date of publication (year) Country the study was held
Study details	Study aims Population including age, gender, type of cancer Study design Measurement tool used for scanxiety
Results/outcomes	Sample size Demographics – gender, age Cancer factors – type of cancers included Incidence of scanxiety

	Severity of scanxiety Contributing and exacerbating determinants of scanxiety Experiences of scanxiety for patients and other stakeholders If intervention: efficacy

Data will analysed depending on the population who underwent imaging (eg for screening, for early cancer or for advanced cancer) and the type of study (eg observational or intervention). Quantitative findings will be synthesised using summary statistics including the mean and range.

Consultation

Health care professionals with clinical experience in oncology and psychology will be consulted for content expertise and to discuss preliminary findings.

References

1. Feiler B. Scanxiety. Fear of a postcancer ritual. Time. 2011;177(24):56.
2. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. International Journal of Social Research Methodology. 2005;8(1):19-32.
3. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. Implement Sci. 2010;5:69.
4. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. 2018;169(7):467-73.

Supplementary File 2. Protocol amendments

Scanxiety: A scoping review about scan-associated anxiety

The original protocol dated 10/04/2019 was amended as per the following statements:

1) The objective 'to explore the experiences of scanxiety for patients and other stakeholders' was abandoned due to feasibility of conducting qualitative and quantitative data analysis with the volume of literature identified
2) Inclusion criteria were updated to reflect changes in Amendment 1: experiences of patients with scanxiety were not included; only studies that quantitatively assessed prevalence and severity of scanxiety or met one of the other objectives were included
3) As per recommendations on scoping review methodology, exclusion criteria were updated *post hoc* and were expanded to also exclude studies involving follow-up scans for a positive screening result, because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attribute to scanxiety itself.
4) Exclusion criteria were also updated to reflect changes in Amendment 1, where studies that only qualitatively assessed scanxiety were excluded

Research checklist

Scanxiety: A scoping review about scan-associated anxiety

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3-4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Figure 1
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	4

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 2
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	5-10, including Tables 1 and 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	11-18, including Tables 3,4, 5 and 6
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-19
Limitations	20	Discuss the limitations of the scoping review process.	19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

BMJ Open

Scanxiety: A scoping review about scan-associated anxiety

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-043215.R3
Article Type:	Original research
Date Submitted by the Author:	19-Apr-2021
Complete List of Authors:	Bui, Kim Tam; Concord Repatriation General Hospital, Medical Oncology; The University of Sydney Sydney Medical School Liang, Roger; Concord Repatriation General Hospital, Medical Oncology Kiely, Belinda; Concord Repatriation General Hospital, Medical Oncology; The University of Sydney Sydney Medical School Brown, Chris; NHMRC Clinical Trials Centre Dhillon, Haryana; The University of Sydney, Psycho-Oncology Cooperative Research Group; CEMPED Blinman, Prunella; Concord Repatriation General Hospital, Medical Oncology
Primary Subject Heading:	Oncology
Secondary Subject Heading:	Radiology and imaging
Keywords:	Adult oncology < ONCOLOGY, Diagnostic radiology < RADIOLOGY & IMAGING, Anxiety disorders < PSYCHIATRY

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Title

Scanxiety: A scoping review about scan-associated anxiety

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Keywords: scanxiety, imaging, scans, cancer, anxiety

Presentations

Bui, K.T., Liang, R., Kiely, B.E., Brown, C., Dhillon, H.M. & Blinman, P. What is scanxiety? A systematic scoping review [Poster]. Proceedings of the 2020 MOGA Abstract and Poster Program for Medical Oncology Advanced Trainees and Young Oncologists, 2020 August 14-21; Asia Pac J Clin Oncol, 16(2), 30-31.

Abstract

Objectives: To identify available literature on prevalence, severity and contributing factors of scan-associated anxiety ('scanxiety'), and interventions to reduce it.

Design: Systematic scoping review.

Data sources: Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane Central Register of Controlled Trials, Scopus, EBSCO CINAHL and PubMed up to July 2020.

Study selection: Eligible studies recruited people having cancer-related non-invasive scans (including screening) and contained a quantitative assessment of scanxiety.

Data extraction: Demographics and scanxiety outcomes were recorded and data summarised by descriptive statistics.

Results: Of 26,693 citations, 57 studies were included across a range of scan types (mammogram 26/57, 46%; positron-emission tomography 14/57, 25%; computed tomography 14/57, 25%) and designs (observation 47/57, 82%; intervention 10/57, 18%). Eighty-one measurement tools were used to quantify prevalence and/or severity of scanxiety, including purpose-designed Likert scales (17/81, 21%); the State Trait Anxiety Inventory (14/81, 17%) and the Hospital Anxiety and Depression Scale (9/81, 11%). Scanxiety prevalence ranged from 0% to 64% (above pre-specified thresholds) or 13% to 83% ('any' anxiety, if no threshold). Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%), regardless of whether anxiety thresholds were pre-specified. Moderate to severe scanxiety occurred in 4% to 28% of people in studies using descriptive measures. Nine of 20 studies assessing scanxiety pre- and post-scan reported significant post-scan reduction in scanxiety. Lower education, smoking, higher levels of pain, higher perceived risk of cancer and diagnostic scans (v screening scans) consistently correlated with higher scanxiety severity, but not age, gender, ethnicity or marital status. Interventions included relaxation, distraction, education and psychological support. Six of 10 interventions showed a reduction in scanxiety.

Conclusions: Prevalence and severity of scanxiety varied widely likely due to heterogeneous methods of measurement. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide interventions.

Strengths and limitations of this study

- This is the first scoping review on scanxiety
- A comprehensive search strategy and broad inclusion criteria have resulted in an extensive summary of all available literature
- Summary statistics for prevalence and severity of scanxiety were not possible due to heterogeneity in the type and timing of measurement tools between the studies**.**

INTRODUCTION

Anxiety may increase when people have scans to screen for, diagnose, or stage cancer, or to monitor cancer for recurrence or progression. Scan-associated anxiety, or the distress before, during or after a scan, was first dubbed 'scanxiety' by a patient writing for the Time Magazine in 2011[1].

Qualitative research on the experience of having a scan has shown some people experience dread in the weeks before a scan[2], perceive scans as dehumanising, unpleasant or causing claustrophobia[2-5], and find scans trigger fear of the unknown and fear of cancer recurrence[2, 3, 6]. Scanxiety is recognised as a common clinical concern on social media and public forums, and is acknowledged by international cancer institutions[7, 8] and cancer-specific support networks[9-11]. Despite this, scanxiety is not uniformly recognised or measured in published studies. We conducted a systematic scoping review to identify the available literature on scanxiety in people having cancer-related scans.

METHODS

We conducted a systematic scoping review based on the six-step methodological framework developed by Arskey & O'Malley[12] and modified by Levac *et al.*[13], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis protocols extension for Scoping Reviews (PRISMA-ScR) checklist[14]. The study protocol and amendments are available (**Supplementary File 1 & 2**).

Step 1: Research question

Our aim was to increase the understanding of scanxiety by: determining the prevalence and severity of scanxiety; identifying contributing factors to scanxiety; identifying interventions to reduce scanxiety in people having cancer-related scans; and, exploring patient experiences with scanxiety.

Step 2: Search strategy

Published studies were identified from seven electronic databases: Ovid MEDLINE (1946 onwards), Ovid EMBASE (1947 onwards), Ovid PsycINFO (1806 onwards), Ovid Cochrane Central Register of Controlled Trials (1991 onwards), Scopus (any year), EBSCO CINAHL (any year) and PubMed (any year). The search strategy combined the subject headings and keywords of cancer, imaging and anxiety. An example is provided in **Figure 1**. Reference lists of included articles were hand-searched for additional studies. All references were imported into Endnote V9.

The initial search was conducted on April 11, 2019, and updated on July 3, 2020.

Step 3: Study selection

Inclusion criteria were full-text original research studies that recruited adults (≥18 years old) who had a non-invasive scan for a cancer-related reason, and which quantitatively assessed the prevalence or severity of scanxiety, reported a statistical comparison between pre- and post-scan scanxiety, reported a

statistical comparison between scanxiety and possible contributing factors, or evaluated the impact of an intervention on scanxiety.

Cancer-related reasons included screening (detection of cancer in asymptomatic person), diagnosis (detection of cancer in symptomatic person), staging (determining extent of cancer in person with confirmed or suspected cancer), surveillance (detection of recurrence in person with cancer treated with curative intent) or monitoring (detection of progression in person with cancer treated with non-curative intent).

The measurement of scanxiety was defined as any measure of anxiety, distress or worry occurring around the time of a scan. This included any period before, during or after a scan where the scan was used as a reference point for the measurement of scanxiety. All non-invasive imaging modalities were accepted. No date restrictions were applied. Foreign language material was included if an English translation was available.

After initial review of citations and based on increasing familiarity with the literature, and in line with recommendations on scoping review methodology[12], exclusion criteria were developed *post hoc*. Exclusion criteria were: studies involving invasive scans (eg transvaginal ultrasound, ultrasound with fine needle aspirate, or endoscopic ultrasound) due to differences in scan preparation and risk of adverse events; and, studies of scans performed to investigate a positive initial screening result because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attributable to scanxiety. Due to feasibility of conducting quantitative and qualitative analysis with the volume of literature identified, studies reporting only a qualitative assessment of scanxiety were also excluded, and the objective to explore patient experiences was abandoned.

After removal of duplicate citations, two authors (KTB, RL) independently reviewed and screened publication titles and abstracts based on the eligibility criteria. Of the studies deemed potentially eligible, full texts were evaluated for final inclusion. Discrepancies were resolved by discussion between the two authors (KTB, RL) and were escalated to all authors if a consensus could not be reached.

Step 4: Charting the data

Relevant data were independently extracted by two authors (KTB, RL) into an electronic data extraction form in Microsoft Excel, which included study demographics and methodology, scanxiety measurement tools, and the outcome measures of prevalence and severity of scanxiety, contributing factors to scanxiety, and interventions to reduce scanxiety.

Step 5: Collating, summarizing and reporting the results

Study data was tabulated to assist with a descriptive numerical summary of the range of cancer types, imaging modalities, study methodology and scanxiety measurement tools. Associations between scanxiety and potential contributing factors were tabulated if three or more studies reported a statistical comparison.

The prevalence of scanxiety was identified in two ways:

- The percentage of people who scored above the pre-specified clinically important anxiety threshold, if reported; or,
- The percentage of people who scored any degree of anxiety, if no pre-specified threshold was reported.

Severity of scanxiety was defined in three ways:

- Any mean score of the anxiety measure above the pre-specified clinically important anxiety threshold, if reported;
- Any mean score of the anxiety measure that was at least half the total score, if an anxiety threshold was not reported; or
- At least 'moderate' anxiety (or its equivalent) on a descriptive range.

The definitions of prevalence and severity were purposed-designed to allow descriptive comparisons between the studies as we anticipated heterogeneity in scanxiety measurement would preclude meaningful summary statistics.

The components of intervention studies and their effect on scanxiety were summarised and reported descriptively.

Step 6: Consultation

Medical oncologists (PB, BK), a behavioural scientist (HD) and a statistician (CB) were consulted for content expertise to develop the study objectives and to improve clarity on clinically relevant interpretations of the data.

Patient and public involvement

This research did not directly involve patients and public. Our research was initiated by repeated observations of scanxiety in oncology patients.

RESULTS

The study search identified 26,693 citations. The selection process is outlined in **Figure 2**. After removal of duplicates, abstract and title screening, and full-text review, 57 eligible studies involving 21,352 people were included.

Demographics and study details

Observational studies

There were 47 observational studies (**Table 1**) involving 19,498 people[15-61]. Participants most commonly had scans for breast cancer (22 studies, *n*=14,338 women[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56, 58]), the most common scans were mammograms (21 studies[16, 18-27, 29, 31, 36, 38, 40, 42, 43, 45, 48, 56]), and most studies used self-report surveys to assess scanxiety (40 studies[15, 16, 18-36, 38, 40-54, 56, 58, 59]).

Table 1. Demographics and study details for the 47 observational studies

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Methods
Andolf[15]	1990	275	Sweden	Ovarian	NR	100	NR	NR	NR	Abdominal ultrasound	Screening	Cross-sectional survey
Bull[b,c][16]	1991	541	UK	Breast	50 to 54: 23% 55 to 59s 29% 60 to 64: 34% 65 to 70: 7% Unknown: 7%	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Peteet[17]	1992	79	USA	Any	NR	NR	NR	NR	4	CT	Any (except screening)	Cross-sectional interview
Cockburn[c][18]	1994	200	Australia	Breast	NR	100	NR	NR	NR	Mammogram	Screening	Longitudinal surveys
Ellman[c][19]	1995	331	UK	Breast	50 to 64: 52% 65 to 78: 48%	100	NR	NR	NR	Mammogram	Screening or surveillance	Cross-sectional survey
Sutton[c,d][20]	1995	306	UK	Breast	58	100	76	50	NR	Mammogram	Screening	Longitudinal surveys
Bakker[21]	1998	315	Canada	Breast	61	100	71	76	50	Mammogram	Screening	Longitudinal surveys
Gupta[22]	1999	167	Kuwait	Breast	Range 14 to 63	100	NR	82	NR	Mammogram ± ultrasound	Screening or diagnosis	Cross-sectional survey
Hafslund[23]	2000	170	Norway	Breast	NR	100	NR	NR	NR	Mammogram	Diagnosis	Longitudinal surveys
Meystre-Agustoni[24]	2001	887	Switzerland	Breast	50 to 54: 36% 55 to 59: 22% 60 to 64: 20% 65 to 69: 22%	100	77	62	27	Mammogram	Screening	Longitudinal surveys
Drossaert[25]	2002	2657	Netherlands	Breast	58	100	78	32	NR	Mammogram	Screening	Longitudinal surveys
Sandin[c,d][26]	2002	598	Spain	Breast	51	100	77	41	NR	Mammogram	Screening	Longitudinal surveys
Brunton[27]	2005	584	New Zealand	Breast	50 to 54: 38% 55 to 59: 35% 60 to 64: 27%	100	NR	74	<20%	Mammogram	Screening	Cross-sectional survey
Geurts[28]	2006	106	Netherlands	Head and neck	56	36	NR	29	NR	Chest X-ray	Surveillance	Cross-sectional survey
Tyndel[c][29]	2007	1174	UK	Breast	43	100	83	33	87	Mammogram	Screening	Longitudinal surveys
Bunge[b][30]	2008	324	Netherlands, Belgium	Lung	60	49	NR	NR	NR	CT	Screening	Longitudinal surveys
Brown Sofair[b][31]	2008	47	USA	Breast	50	100	34	80	NR	Mammogram	Screening	Longitudinal surveys
van den Bergh[b][32]	2008	324	Netherlands, Belgium	Lung	60	49	64	82	66	CT	Screening	Longitudinal surveys
Westerterp[b][33]	2008	82	Netherlands	Oesophageal	64	18	NR	NR	NR	CT + PET	Diagnosis & staging	Cross-sectional survey
Bastiaannet[34]	2009	59	Netherlands	Melanoma	Median: 59	44	69	66	NR	CT, PET ± Chest X-ray	Staging	Cross-sectional survey
Vierikko[b][35]	2009	601	Finland	Lung	65	0	36	NR	NR	CT	Screening	Longitudinal surveys

Bolukbas[36]	2010	93	Turkey	Breast	48	100	97	10	45	Mammogram	Screening or diagnosis	Cross-sectional survey
Thompson[37]	2010	70	USA	Lymphoma	Median: 47	64	53	97	NR	CT	Surveillance	Cross-sectional interview
Hutton[b][38]	2011	527	UK	Breast	Median: 40	100	79	NR	75	Mammogram ± MRI	Screening	Longitudinal surveys
Pifarre[39]	2011	200	Spain	Any	52	51	NR	NR	67	PET/CT	Any (except screening)	Cross-sectional interview
Steinemann[40]	2011	227	USA	Breast	NR	100	NR	NR	NR	Mammogram	Screening or diagnosis	Cross-sectional survey
Yu[41]	2011	398	Brazil	Any	54	79	56	57	27	Any	Any (except screening)	Cross-sectional survey
Bredart[b][42]	2012	637	France	Breast	50	100	NR	87	NR	Mammogram ± ultrasound ± MRI	Screening or surveillance	Longitudinal surveys
Hafslund[c][43]	2012	4249	Norway	Breast	58	100	NR	52	NR	Mammogram	Screening	Cross-sectional survey
Adams[e][44]	2014	36	Netherlands	Lymphoma	50	42	NR	NR	NR	CT & MRI	Staging	Cross-sectional survey
Baena-Canada[45]	2014	434	Spain	Breast	54	100	72	43	18	Mammogram	Screening	Cross-sectional survey
Andersson[46]	2015	169	Sweden	Any	64	47	62	62	100	PET/CT	Any (except screening)	Cross-sectional survey
Elboga[47]	2015	144	Turkey	Any	63	46	83	52	NR	PET/CT	Any (except screening)	Cross-sectional survey
Hobbs[48]	2015	49	Australia	Breast	55	100	79	NR	75	Mammogram ± MRI	Diagnosis	Longitudinal surveys
Bauml[49]	2016	103	USA	Lung	Median: 67	61	73	53	NR	CT, PET ± MRI	Monitoring	Cross-sectional survey
Abreu[50]	2017	232	Portugal	Any	61	51	NR	73	71	PET/CT	Any (except screening)	Longitudinal surveys
Grilo[51]	2017	81	Spain, Portugal	Any	55	53	NR	41	47	PET/CT	Any (except screening)	Longitudinal surveys
Evans[52]	2018	115	UK	Colorectal or Lung	66	33	NR	NR	NR	Whole body MRI, PET + CT	Staging	Longitudinal surveys
Goense[53]	2018	27	Netherlands	Oesophageal	64	15	NR	NR	NR	MRI + PET/CT	Staging & monitoring	Cross-sectional survey
Hall[54]	2018	169	USA	Lung	64	51	58	96	NR	Low dose CT	Screening	Cross-sectional survey
Derry[55]	2019	94	USA	Any	61	72	NR	69	0	Any	Monitoring	Longitudinal interview
Soriano[56]	2019	57	USA	Breast	58	100	93	NR	0	Mammogram	Surveillance	Longitudinal survey
Taghizadeh[57]	2019	1237	Canada	Lung	63	56	NR	85	NR	CT	Screening	Longitudinal interview
Bancroft[58]	2020	88	UK, Ireland	Breast	38	61	50	83	NR	MRI	Screening	Longitudinal survey
Grilo[59]	2020	94	Portugal	Any	61	54	NR	99	77	PET + bone scan	Staging, monitoring & surveillance	Longitudinal survey
Morreale[60]	2020	87	USA	Gastrointestinal and Lung	62	55	NR	92	NR	CT or MRI	Monitoring	Longitudinal interview
Paiella[61]	2020	54	Italy	Pancreatic	50	61	NR	NR	NR	MRI – MRCP	Screening	Cross-sectional interview

UK United Kingdom, USA United States of America, NR not reported, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging, MRCP Magnetic resonance cholangiopancreatography

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Demographic data is based on participants who completed the first survey

[c]These studies collected data from other groups who were not included in this review as they did not meet eligibility criteria. This included people having invasive procedures such as fine needle aspirate or open surgical biopsy[16, 33], people with abnormal screening results[18, 26, 29] and people who did not have a scan[18-20, 43]

[d]Demographics based on the entire population even if not all participants were eligible for this review.

[e]Four paediatric participants were included in this study.

Twenty-one studies were conducted in people having scans for screening[15, 16, 18, 20, 21, 24-27, 29-32, 35, 38, 43, 45, 54, 57, 58, 61]. In the remaining studies, reasons for scanning included diagnosis[23, 48], staging[34, 44, 52], monitoring[49, 55, 60], surveillance to detect recurrence[28, 37, 56] or a combination of reasons in people with known or suspected cancers (17 studies[17, 39, 41, 46, 47, 50, 51, 53, 59]). Five studies permitted scans for both screening and non-screening reasons (namely, diagnosis[22, 36, 40] or surveillance[19, 42])

The mean age of participants, reported by 33 studies, was 56.9 years (range 38 to 66 years)[20, 21, 25, 26, 28-33, 35, 36, 39, 41-48, 50-61]. The majority of participants were women (87%)[15, 16, 18-61]. When studies involving scans for breast cancer were excluded, there were similar proportions of men and women (women 49%, men 51%)[15, 27, 28, 30, 32-35, 37, 39, 41, 44, 46, 47, 49-55, 57, 59-61]. There was variation in the reporting and proportion of participants who were married (22 studies, range 34% to 97%[20, 21, 24-26, 29, 31, 32, 34-38, 41, 45-49, 54, 56, 58]), who received at least secondary education (29 studies, range 10% to 99%[20-22, 24-29, 31, 32, 34, 36, 37, 41-43, 45-47, 49-51, 54, 55, 57-60]) and who were attending their first scan (18 studies, range 0% to 100%[17, 21, 24, 27, 29, 32, 36, 38, 39, 41, 45, 46, 48, 50, 51, 55, 56, 59]).

Intervention studies

There were ten intervention studies (**Table 2**) involving 1,854 people[62-71]. This included people having scans for breast cancer (6 studies, *n*=1,449 people[62-65, 69, 70]) and lung cancer (1 study, *n*=16 people[68]). Scans included mammogram (5 studies[62-64, 69, 70]), positron emission tomography (PET) with computed tomography (CT; 3 studies[66, 67, 71]), magnetic resonance imaging (MRI)[65], CT[68] and ultrasound[70] (1 study each). Four studies involved scans for screening[63, 64, 68, 69], one for diagnosis[65], three for any reason in people with known or suspected cancers[66, 67, 71], and two where scans for screening, surveillance and/or diagnosis were permitted[62, 70].

The mean age of participants was reported by five studies and ranged from 47 to 65 years[63, 65, 68, 69, 71]. The majority were women (94%[62-66, 68-71]). There was variation in the reporting and proportion of participants who were married (2 studies, 73% and 75%[64, 65]), received at least secondary education (6 studies, range 28 to 100%[62-65, 68, 69]), and participants attending their first scan (5 studies, range 4% to 54%[62-64, 66, 71]).

Eight studies allocated participants to an intervention or control group[63-69, 71], one study compared two interventions[62] and one study delivered the intervention to all participants[70]. Two interventions were multifaceted[64, 65]. Types of interventions included: relaxation, distraction, and/or meditation (6 studies[62, 63, 66, 69-71]); education (4 studies[62, 64, 65, 68]); emotional or psychosocial support (2 studies[64, 65]); or, adjustments to routine logistics of the scan (1 study[67]).

Table 2. Demographics and study details for the 10 intervention studies to reduce scanxiety

First author	Year	*n*	Country of study	Cancer type	Age (years) (Mean[a])	Female (%)	Married or de facto (%)	At least secondary education (%)	First scan (%)	Scan type	Reason for scan	Allocation	Intervention and control groups
Mainiero[62]	2001	613	USA	Breast	< 40: 8% 50 to 50: 39% 50 to 60: 28% >70: 9%	100	NR	95	7	Mammogram	Screening or surveillance	Consecutive[b]	Educational or entertaining video in waiting room
Domar[63]	2005	143	USA	Breast	52	100	NR	81	8	Mammogram	Screening	Randomised	Relaxation, music or blank audiotape in waiting room and during scan
Fernandez-Feito[64]	2005	436	Spain	Breast	50 to 54: 24% 55 to 59: 30% 60 to 64: 23% 65 to 69: 22%	100	73	28	4	Mammogram	Screening	Randomised	Pre-scan nursing intervention or usual care
Caruso[65]	2006	44	Italy	Breast	47	100	75	89	NR	MRI	Diagnosis	Randomised	Pre-scan informative-emotive psychological support or routine information
Vogel[66]	2012	101	Netherlands	Any	Median: 58	51	NR	NR	41	PET/CT	Any (except screening)	Randomised	Audiovisual installation or usual care during FDG uptake
Acuff[67]	2014	180	USA	Any	NR	NR	NR	NR	NR	PET/CT	Any (except screening)	Unclear	Hand-held communication device or usual care during scan
Raz[68]	2014	16	USA	Lung	65	75	NR	100	NR	CT	Screening	Sequential[c]	Pre-scan multimedia education or usual care
Zavotsky[69]	2014	100	USA	Breast	54	100	NR	98	NR	Mammogram	Screening	Non-randomised[d]	Music or no music during scan
Ashton[70]	2019	113	USA	Breast	18 to 39: 3.6% 40 to 59: 51.8% 60 to 79: 39.3% > 80: 5.4%	100	NR	NR	NR	Mammogram ± ultrasound	Screening, surveillance or diagnosis	NA[e]	Shoulder & neck massage ± hand massage
Lorca[71]	2019	108	Spain	Any	59	57	NR	NR	54	PET/CT	Any (except screening)	Randomised	Mindfulness meditation or usual care during FDG uptake

USA United States of America, NR not reported, MRI magnetic resonance imaging, PET positron emission tomography, CT computed tomography, FDG fluorodeoxyglucose

All percentages were rounded to the nearest whole number

[a]Unless otherwise stated

[b]Each intervention was administered during one half of the study period

[c]Participants were enrolled into the control arm first, followed by the intervention arm

[d]Participants attending on Mondays, Wednesdays and Fridays were allocated to the intervention arm, and participants attending on Tuesdays and Thursdays were allocated to the control arm

[e]All participants received the intervention

Scanxiety measurement

Anxiety measurements varied across the studies, with different measurement tools, variants of the same tool, and different range and thresholds applied to tools.

Observational studies

The 47 observational studies (**Table 3**) used a total of 81 measures of anxiety, with 30 studies using one measure only[15-19, 21, 22, 25-28, 30, 33, 34, 36, 39, 40, 43, 44, 46, 48-51, 53, 55-57, 59, 61], and 17 studies using at least two measures[20, 23, 24, 29, 31, 32, 35, 37, 38, 41, 42, 45, 47, 52, 54, 58, 60].

The most common measures used were: purpose-designed Likert scales (17 studies); the State-Trait Anxiety Inventory (STAI) (14 studies); the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS) (9 studies); the Impact of Event Scale (IES) (6 studies); the Psychological Consequences Questionnaire (PCQ) (3 studies), the Cancer Worry Scale (3 studies), and; the Perceived Stress Scale (2 studies). There were 17 measures used by one study only[15, 20, 22, 26, 31, 32, 35, 52, 54, 56, 58, 60].

Likert scales were varied, with a numerical lower range limit of 0 or 1, and an upper range limit between 3 and 12[17, 20, 24, 25, 33, 40, 44, 46, 48, 50, 52, 53]. Seven studies used a descriptive range[21, 25, 27, 28, 33, 34, 55]. Two studies used both a numerical and a descriptive range[25, 33].

The STAI compromises State and Trait Anxiety subscales with a possible subscale range of 20 to 80. It has no validated anxiety threshold and is usually calculated as a sum of 4-point response options[72]. Included studies used and reported the STAI as a total score[37, 39], using one or both subscales[20, 23, 36, 37, 41, 42, 47, 51, 57, 59], or as a variant (e.g. STAI-6[32, 38, 58]). There were different ranges: none reported[47, 57]; no reported lower limit[41]; no reported upper limit[36]; 0 to 60[39, 51], or; based on a mean of individual item scores[20]. Some studies pre-specified an anxiety threshold of 39[57], 40[37, 41], 46[42], calculated based on the relationship between the anxiety and trait subscales[39], or based on investigator-determined categories[36]. One study used a different method to calculate scores (ie subtracting the points of reversed statements from direct statements, which were valued at 1, 2, 3 and 20, and then added to a constant of 50[36]).

The HADS Anxiety subscale has a range of 0 to 21 and a validated anxiety threshold of 11[73]. One study reported a range of 0 to 14[38], one study reported anxiety categories rather than a threshold[60], two studies reported an anxiety threshold of 8[41, 43] and one study reported an anxiety threshold of 10 (though there was overlap the 'tendency to anxiety' and 'anxiety' categories, classified as scores of 8 to 10 and 10 or more, respectively)[47].

The IES was used in its original form[30, 32, 38, 42, 58] or as a variant (IES-6[49]), and was reported as a total score[30, 32, 38, 49] or as Intrusion and Avoidance subscale scores[42, 58]. The two studies using subscale scores reported threshold levels of 20 or 21[42] and 8.5[58]. When using the PCQ, researchers used either the Emotional subscale[18] or the Negative Consequences subscale[24, 29]. The Cancer Worry Scale and the Perceived Stress Scale were used in original[45, 61] or variant[29, 54, 58] forms. The Symptom Checklist-90-Revised score could not be interpreted because the authors did not report a range[31], and a raw score or a transformed score could have been used[74].

Table 3. Prevalence and severity of scanxiety

Author	Year	Measurement of scanxiety			Results of scanxiety measurement		
		Name of tool	Range of tool (Anxiety threshold[a])	Timing of assessment	Prevalence (%)	Severity (Mean ±SD[b])	Pre- & post-scan comparison
Andolf[15]	1990	Visual analogue scale	0-100 (NA)	Post-scan: 1-3 years	81	Median 3.5 (range 0-100)	NA
Bull[16]	1991	HADS: Anxiety subscale	0-21 (≥11)[c]	Pre-scan: specific timing NR	4.9	4.97 (range 0-20)	Less severe post-scan scanxiety, p<0.001
				Post-scan: post-result, specific timing NR	4	4.43 (range 0-17)	
Peteet[17]	1992	10-point Likert scale	1-10 (NA)	Post-scan: specific timing NR	NR	First scan 5.5, Recent scan 3.5	NA
Cockburn[18]	1994	PCQ: Emotional subscale	0-15 (NA)	Pre-scan: day of scan	NR	<2	No difference
				Post-scan: pre-results, 1-week post-result & at 8 months	NR	<2	
Ellman[19]	1995	HADS: Anxiety subscale	0-21 (≥11)	Pre-scan: day of scan	6	NR	NA
Sutton[20]	1995	STAI: State Anxiety subscale	1-4 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		STAI: Trait Anxiety subscale	1-4 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	Between 1.65 and 1.95	No significant differences in scanxiety at any time point
				Peri-scan: day of scan	NR		
				Post-scan: 9 months	NR		
		GHQ: Anxiety subscale	0-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<1	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<1	
		3-point Likert scale	1-3 (NA)	Pre-scan: at invitation to screening, specific timing NR	NR	<2	Less severe post-scan scanxiety, p<0.001
				Post-scan: 9 months	NR	<2	
Bakker[21]	1998	5-point Likert scale	Descriptive range (NA)	Post-scan: immediate & at 3 weeks	39-40	Somewhat, very or extremely: 9 to 15%	NA
Gupta[22]	1999	HSCL-25	0-3 (NA)	Post-scan: specific timing NR	40	Moderate to severe: 25%	NA
Hafslund[23]	2000	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.5 ±11.0	No statistical comparison reported
				Post-scan: day of scan	NR	32.1 ±10.9	
		STAI: Trait Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	35.9 ±9.1	No statistical comparison reported
				Post-scan: day of scan	NR	NR	
Meystre-Agustoni[24]	2001	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: day of scan	NR	<1	No statistical comparison reported
				Post-scan: pre- result, 2 weeks post-result & 8 weeks post-result	NR	<2	
		6-point Likert scale	0-5 (NA)	Pre-scan: immediate	26	<1	
				Post-scan: pre-result, 2 weeks post-result & 8 weeks post-result	NR	<1	

Drossaert[25]	2002	Composite 7-item score of 4-point Likert scales	1-4 (NA)	Baseline: 8 weeks post-first scan	NR	1.6	No statistical comparison reported
				Pre-scan: 6 weeks (second & third scans)	NR	1.6 to 1.7	
				Post-scan: 6 weeks (second & third scans)	NR	1.5	
			Descriptive range (NA)	Baseline: 8 weeks post-first scan	NR	Moderate to severe: 10%	NA
Sandin[26]	2002	HSCL-90-R: Anxiety subscale	0-4 (NA)	Pre-scan: day of scan	NR	0.41 ±0.33	No statistical comparison reported
				Post-scan: 2 weeks	NR	0.28 ±0.30	
Brunton[27]	2005	4-point Likert scale, 3 items	Descriptive range (NA)	Post-scan: within 4 years	56-77	Quite or very: 11 to 28%	NA
Geurts[28]	2006	4-point Likert scale	1-4 (NA)	Peri-scan: specific timing NR	61	Moderate to severe: 21%	NA
Tyndel[29]	2007	PCQ: Negative consequences subscale	0-36 (NA)	Pre-scan: 1 month	NR	5.1 ±6.7	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	3.8 ±6.0 to 4.2 ±6.2	
		Cancer Worry Scale - Revised	6-24 (NA)	Pre-scan: 1 month	NR	11.0 ±2.9	Less severe post-scan scanxiety, p=0.000
				Post-scan: 1-month post- result & 6-months post-result	NR	10.1 ±2.5 to 10.6 ±2.6	
Bunge[30]	2008	IES in low affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	5.6 ±7.9	Less severe post-scan scanxiety in both low and high affective risk groups, p<0.05
				Post-scan: 6 months	NR	4.3 ±7.2	
		IES in high affective risk people	0-75 (NA)	Pre-scan: 1 day	NR	14.7 ±14.4	
				Post-scan: 6 months	NR	10.3 ±11.0	
Brown Sofair[31]	2008	Penn State Worry Questionnaire	16-80 (60)	Pre-scan: within 1 month	NR	50.18 (range 40-60)	No statistical comparison reported
				Post-scan: day of scan (post-result)	NR	NR	
		SCL-90-R: Anxiety subscale	NR (NA)	Pre-scan: within 1 month	NR	48.75	No difference
				Post-scan: day of scan (post-result)	NR	42.07	
		Individualized Questionnaire: Anxiety response	1-3 (2)	Pre-scan: within 1 month	35	NR	No statistical comparison reported
				Post-scan: day of scan (post-result)	24	NR	
van den Bergh[32]	2008	STAI-6	20-80 (NA)	Pre-scan: 1 day	NR	34.1 ±7.7	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	32.7 ±8.4 to 34.3 ±9.1	
		IES	0-75 (NA)	Pre-scan: 1 day	NR	6.9 ±9.6	Less severe post-scan scanxiety, p<0.01
				Post-scan: within 1 week & at 6 months	NR	5.1 ±8.0 to 5.6 ±8.8	
		EuroQol questionnaire: Anxiety subscale	1-3 (NA)	Pre-scan: 1 day	23	NR	No statistical comparison reported
				Post-scan: 6 months	NR	NR	
Westerterp[33]	2008	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): 2 weeks	NR	CT 1.2 ±0.6, PET 1.4 ±1.0	NA
			Descriptive range (NA)	Post-scan (after both scans): 2 weeks	CT 13, PET 23	Moderate to severe: CT 4%, PET 10%	NA
Bastiaannet[34]	2009	5-point Likert scale	1-5 (NA)	Post-scan: 2-6 weeks after lymph node dissection	Chest x-ray 20, CT 31, PET 36	Moderate to severe: Chest X-ray 13%, CT 5%, PET: 9%	NA
Vierikko[35]	2009	Health anxiety inventory	0-24 (NA)	Pre-scan: specific timing NR	NR	6.7 ±4.7	Less severe post-

				Post-scan: 1 year	NR	5.8 ±4.6	scan scanxiety, p<0.001
		Worry about lung cancer	0-8 (NA)	Pre-scan: specific timing NR	NR	3.0 ±2.4	No difference
				Post-scan: 1 year	NR	3.1 ±2.3	
Bolukbas[36]	2010	STAI: State Anxiety subscale	0-NR (20-39 mild, 40-59 moderate, 60-79 severe, ≥ 80 help needed)	Peri-scan: specific timing NR	NR	46.2 ±4.9	NA
Thompson[37]	2010	STAI	40-160 (NA)	Post-scan: specific timing NR	37	65.8 ±21.0	NA
		STAI: State Anxiety subscale	20-80 (≥40)	Post-scan: specific timing NR	NR	30.4 ±10.9	NA
		STAI: Trait Anxiety subscale	20-80 (≥40)	Post-scan: specific timing NR	NR	35.4 ±11.3	NA
Hutton[38]	2011	HADS: Anxiety subscale	0-14 (≥11)	Baseline: 4 weeks pre-first scan	20	6.9 ±4.2	No difference
				Pre-scan: day of each scan (for 5 scans)	MRI 17, Mammogram 20	MRI 5.2 ±4.0 to 6.5 ±4.2, Mammogram 5.0 ±3.9 to 6.5 ±4.1	
				Post-scan: 6 weeks (for 5 scans)	10 to 13	5.1 ±4.2 to 5.9 ±4.1	
		STAI-6	20-80 (NA)	Pre-scan: day of scan (for 5 scans)	NR	MRI 10.8 ±3.8 to 12.1 ±4.0, Mammogram 10.1 ±3.9 to 11.3 ±4.1	Less severe post-scan scanxiety for MRI (p<0.0005) & mammogram (p=0.002)
				Post-scan: day of scan (for 5 scans)	NR	MRI 9.6 ±3.2 to 10.7 ±3.8, Mammogram 9.7 ±3.1 to 10.5 ±3.9	
		IES	0-75 (NA)	Post-scan: 6 weeks (for 5 scans)	NR	MRI 17.8 ±5.8 to 19.3 ±7.0, Mammogram 17.2 ±4.4 to 18.6 ±5.2	NA
Pifarre[39]	2011	STAI	0-60 for each subscale (state more than 10 than trait)	Pre-scan: day of scan	68	NR	NA
Steinemann[40]	2011	7-point Likert scale	1-7 (NA)	Pre-scan: day of scan	NR	4.1	NA
Yu[41]	2011	HADS: Anxiety subscale	0-21 (≥8)	Pre-scan: day of scan	38	NR	NA
		STAI: State Anxiety subscale	NR-80 (≥40)	Pre-scan: day of scan	46	39.4 ±12.2	NA
		STAI: Trait Anxiety subscale	NR-80 (≥40)	Pre-scan: day of scan	46	39.9 ±12.2	NA
		Dichotomous reporting[d]	Yes/No (NA)	Pre-scan: day of scan	41	NR	NA
Bredart[42]	2012	STAI: State Anxiety subscale	20-80 (≥46)	Pre-scan: 1 week	NR	MRI 42.1, Mammogram 41.1	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 34.9, 40.8, Mammogram 34.3, 38.8	
		IES: Intrusion subscale	0-35 (≥20)	Pre-scan: 1 week	NR	MRI 8.9, Mammogram 8.4	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 8.5, Mammogram 7.7	

		IES: Avoidance subscale	0-40 (≥21)	Pre-scan: 1 week	NR	MRI 12.1, Mammogram 9.8	No statistical comparison reported
				Post-scan: day of scan & between 15 days to 3 months	NR	MRI 11.8, Mammogram 8.9	
Hafslund[43]	2012	HADS: Anxiety subscale	0-21 (≥8)	Pre-scan: within 2 weeks	15	4.1 ±3.3	NA
Adams[44]	2014	4-point Likert scale	1-4 (NA)	Post-scan: day of scan (after each scan)	NR	MRI 1.5 ±0.7, CT 1.8 ±0.8	NA
Baena-Canada[45]	2014	HADS: Anxiety subscale	0-21 (≥11)	Post-scan: specific timing NR	4	1.86 ±3.26	NA
		Cancer Worry Scale	6-24 (NA)	Post-scan: specific timing NR	NR	9.4 ±3.0	NA
Andersson[46]	2015	Sum of 3 items on 5-point Likert scale	0-12 (NA)	Post-scan: within four weeks	NR	4 (range 0-10)	NA
Elboga[47]	2015	HADS: Anxiety subscale	0-21 (≥10)	Pre-scan: day of scan	NR	9.2 ±3.8	NA
		STAI: State Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	40.4 ±8.5	NA
		STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: day of scan	NR	46.6 ±7.8	NA
Hobbs[48]	2015	5-point Likert scale	1-5 (NA)	Post-scan (after both scans), specific timing NR	Mammogram 17, MRI 44	NR	NA
Bauml[49]	2016	IES-6	0-24 (NA)	Post-scan: specific timing NR	83	6.4 ±5.3	NA
Abreu[50]	2017	10-point Likert scale	1-10 (NA)	Pre-scan: day of scan	NR	6.4 ±2.7	Less severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	5.7 ±2.6	
Grilo[51]	2017	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: day of scan	NR	31.1 ±5.2	More severe post-scan scanxiety, p=0.000
				Post-scan: day of scan	NR	33.9 ±4	
Evans[52]	2018	GHQ-12	0-12 (≥4)	Peri-scans: specific timing NR	42	NR	NA
		7-point Likert scale	1-7 (NA)	Post-scan: 1 month	NR	MRI 2.5 ±1.3, CT or PET/CT 2.2 ±1.2	NA
Goense[53]	2018	5-point Likert scale	1-5 (NA)	Post-scan (after both scans): day of scan	NR	MRI 1.0 ±0.2, PET 1.0 ±0.2	NA
Hall[54]	2018	Generalized Anxiety Disorder 2-item	0-6 (≥3)	Peri-scan: specific timing NR	26	1.62 ±1.78	NA
		Perceived Stress Scale 4	0-16 (NA)	Peri-scan: specific timing NR	NR	5.14 ±3.35	NA
Derry[55]	2019	4-point Likert scale	Descriptive range (NA)	Peri-scan: pre-result	NR	'A great deal' or 'completely': 23%	NA
Soriano[56]	2019	PROMIS Anxiety Short Form	1-5 (NA)	Pre-scan: two weeks	NR	1.55 ±0.64	NA
Taghizadeh[57]	2019	STAI: State Anxiety subscale	NR (39)	Baseline	NR	30.9	More severe post-scan scanxiety, p<0.001
				Post-scan: one-month post-result & at 12 months	NR	33.1, 31.7	
Bancroft[58]	2020	HADS: Anxiety subscale	0-21 (11)	Baseline	Carriers[e]: 14 Controls: 7	Carriers: 6.2 ±3.9 Controls: 4.9 ±3.3	No difference in prevalence Less severe post-scan in carriers (p=0.04)
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 5 to 14 Controls: 2 to 7	Carriers: 5.3 ±3.9 to 5.9 ±4.1 Controls: 4.1 ±3.1 to 4.6 ±3.3	

		Cancer Worry Scale – Revised	8-32 (NA)	Baseline	NR	Carriers: 14.4 ±3.6 Controls: 12.2 ±1.7	No difference
				Post-scan: at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 13.6 ±4.4 to 14.7 ±4.2 Controls: 11.9 ±1.4 to 12.1 ±1.9	
		IES-cancer: Intrusion subscale	0-35 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 35 to 58 Controls: 5 to 13	Carriers: 8.3 ±9.1 to 11.4 ±9.1 Controls: 1.7 ±3.5 to 3.0 ±4.9	NA
		IES-cancer: Avoidance subscale	0-40 (8.5)	Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	Carriers: 55 to 64 Controls: 12 to 37	Carriers: 9.9 ±9.0 to 13.3 ±10.5 Controls: 2.6 ±4.6 to 7.0 ±8.2	NA
		IES-MRI: Intrusion subscale	0-35 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 4 to 7 Controls: 0 to 3	Carriers: 1.2 ±3.2 to 3.1 ±8.8 Controls: 0.1 ±0.3 to 0.5 ±1.8	NA
		IES-MRI: Avoidance subscale	0-40 (8.5)	Post-scan: at 12 weeks, 26 weeks & 52 weeks	Carriers: 14 Controls: 8	Carriers: 1.8 ±3.4 to 4.1 ±9.3 Controls: 0.8 ±1.4 to 2.8 ± 1.8	NA
		STAI-6	6-24 (NA)	Pre-scan: day of scan	NR	Carriers: 7.2 ±3.3 Controls: 7.3 ±3.2	NA
		Health Questionnaire	0-14 (NA)	Baseline	NR	Carriers: 7.0 ±2.6 Controls: 6.8 ±2.2	No difference
				Post-scan: pre-results, at 12 weeks, 26 weeks & 52 weeks	NR	Carriers: 7.1 ±2.5 to 8.1 ±2.8 Controls: 6.9 ±2.2 to 7.7 ±2.1	
Grilo[59]	2020	STAI: State Anxiety subscale	20-80 (NA)	Pre-scan: day of scan	NR	Bone scan: 51.75 ±3.77 PET/CT: 44.76 ±10.0	Less severe post-scan scanxiety for both: Bone scan. p=0.02 PET/CT, p<0.001
				Post-scan: day of scan	NR	Bone scan: 36.70 ±12.12 PET/CT: 38.82 ±11.33	
Morreale[60]	2020	Distress thermometer	0-10 (4)	Peri-scan: day of scan	NR	3.73 ±2.60	No statistical comparison
				Post-scan: one-week post-result	NR	3.91 ±2.69	
		HADS: Anxiety subscale	0-21 (0-7 none, 8-10 mild, 11-14 moderate, 15-21 high)	Peri-scan: day of scan	NR	6.12 ±3.98	No statistical comparison
				Post-scan: one-week post-result	NR	5.32 ±4.31	
Paiella[61]	2020	Perceived Stress Scale	0-40 (15-18 moderate, ≥ 19 high)	Post-scan: pre-result	NR	14.8	NA

SD standard deviation NA not applicable, NR not reported, HADS Hospital Anxiety and Depression Scale, PCQ Psychological Consequences Questionnaire, STAI State-Trait Anxiety Inventory, GHQ General Health Questionnaire, HSCL Hopkins Symptom Checklist, IES Impact of Event Scale, SCL-90-R Symptom Checklist-90-Revised, HSCL-90-R Hopkins Symptom Checklist 90-Revised, PROMIS Patient-Reported Outcomes Measurement Information System, CT computed tomography, PET positron emission tomography, MRI magnetic resonance imaging

All percentages were rounded to the nearest whole number

[a]NA is listed as the anxiety threshold when the study did not state a pre-specified threshold. In these cases, the definition of scanxiety prevalence was the percentage of people who reported any degree of anxiety

[b]Mean listed unless otherwise described; standard deviation listed only when available

[c]This study did not specify an anxiety threshold; however, the Anxiety subscale of the Hospital Anxiety and Depression Scale has validated thresholds. These thresholds were included in this table

[d]Dichotomous reporting assumed given description of question (self-perception of anxiety) and results "40.5% of the patients considered themselves to be anxious"[41]

[e]This study included participants who were *TP53* mutation carriers, and population controls

Intervention studies

The ten intervention studies (**Table 4**) used 19 measures of anxiety, with five studies using one measure only[62, 66, 67, 69, 70], and five studies at least two[63-65, 68, 71]. The measures included subscales of the STAI (7 studies), Likert scales (5 studies), a variant of the Psychological Consequences Questionnaire (1 study[68]) and the Crown Crisp Experimental Index (1 study[65]).

Likert scales were varied, with a lower range limit of 0 or 1, and an upper range limit between 5 and 10[62, 63, 69-71]. The STAI was used and reported using one or both subscales[63-65, 67, 68, 71], or as a variant (8-item STAI[66]). There was variation from the usual STAI parameters, with studies using a different range (i.e. not reported[63, 65], 0 to 60[64], or 18 to 32[66]) or pre-specified anxiety thresholds of 40[68] or 16[66].

Scanxiety outcomes

Prevalence and severity of scanxiety for each study are provided in **Table 3**. Summary statistics for prevalence and severity were not calculated due to heterogeneity in the type and timing of measurement between the studies.

Prevalence of scanxiety

Twenty-four of the 47 studies reported the prevalence of scanxiety. The prevalence of scanxiety above pre-specified anxiety thresholds ranged between 0% and 64% across the 16 measures[16, 19, 31, 38, 41, 43, 45, 52, 54, 58], though eight of these measures came from only two studies[41, 58]. In the 14 measures without a pre-specified anxiety threshold, the prevalence of any degree of scanxiety ranged between 13% and 83% [15, 21, 22, 24, 27, 28, 32-34, 37, 39, 41, 48, 49].

There were insufficient numbers to compare the prevalence of scanxiety using measures with pre-specified anxiety thresholds of people having scans for screening (11 measures[16, 31, 38, 43, 45, 54, 58]), reasons other than screening (four measures[41, 52]) and for screening or non-screening reasons (1 measure[19]). When no threshold was reported, the prevalence of scanxiety had a similar range (screening 23% to 81%, five measures[15, 21, 24, 27, 32]; reasons other than screening 14% to 83%, eight measures[28, 33, 34, 37, 39, 41, 48, 49]; either screening or reasons other than screening (40%, one measure[22]).

Severity of scanxiety

Severity of scanxiety was reported in 44 of 47 observational studies. Mean severity scores appeared low in almost all measures which quantitatively measured scanxiety (54/62, 87%).

Table 4. Effect of interventions to reducing scanxiety

First author	Year	Intervention	Measurement of scanxiety			Impact of intervention on scanxiety	
			Name of tool	Range of tool (Anxiety threshold)	Timing of assessment	Description of results	P-value
Mainiero[62]	2001	Arm A: an educational video about breast cancer and mammography Arm B: an entertaining movie (from the 1940s to 1960s)	6-point Likert score	0-5 (NA)	Pre-scan: immediate Post-scan: immediate	No difference	NR
Domar[63]	2005	Arm A: relaxation audiotape, or; Arm B: music audiotape, or; Arm C: control (blank audiotape)	STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 34.8 v 33.6 v 33.2	0.18
					Post-scan: immediate	No difference Arm A v Arm B v Arm C: 30.4 v 30.9 v 33.2	0.78
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate	No difference Arm A v Arm B v Arm C: 32.6 v 32.7 v 32.5	0.99
			11-point Likert scale	1-10 (NA)	Post-scan	No difference Arm A v Arm B v Arm C: 2.6 v 3.2 v 2.8	0.43
					Post-scan: immediate	NR	NR
Fernandez-Feito[64]	2005	Arm A: A protocolised nursing intervention (information and emotional support) and usual care, or; Arm B: Usual care alone	STAI: State Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	Less severe	<0.001
						Less severe if fear of cancer present	0.002
						Less severe if no fear of cancer present	0.003
						No difference if fear of cancer outcome present	0.09
						Less severe if no fear of scan outcome	<0.001
			STAI: Trait Anxiety subscale	0-60 (NA)	Pre-scan: immediate (post-intervention)	No difference	0.34
Caruso[65]	2006	Arm A: routine information and 45 minutes of informative-emotive psychological support with a psychologist, or; Arm B: routine information	Crown Crisp Experimental Index	NR (0-96)	Pre-scan: immediate (post-intervention)	Less severe Arm A v Arm B: 39.4 v 42.3	0.03
			STAI: State Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	No difference Arm A v Arm B: 57.7 v 58.6	0.77
					Post-scan: immediate	Less severe	0.048
			STAI: Trait Anxiety subscale	NR (NA)	Pre-scan: immediate (post-intervention)	NR	NR
Vogel[66]	2012	Arm A: Uptake room with an audio-visual installation involving a video of nature scenes on a 119cm television, dynamic lighting & ambient electronic music Arm B: Uptake room without the audio-visual installation	8-item STAI	18-32 (≥16)	Pre-scan: immediately before & immediately after fluorodeoxyglucose uptake period	Less severe Arm A v Arm B: reduction by 2.39 v 1.02	0.04
Acuff[67]	2014	Arm A: Receive a hand-held device to contact imaging staff during the scan Arm B: No device	STAI: State Anxiety subscale	20-80 (NA)	During scan: immediately before completion of the scan	Less severe Arm A v Arm B: 22.87 v 26.45	0.014
						Less severe if previous PET/CT Arm A v Arm B: 20.78 v 24.64	0.023

						No difference if first time PET/CT Arm A v Arm B: 23.09 v 27.25, p=0.249	0.249
Raz[68]	2014	Arm A: multimedia education session and usual care, or; Arm B: Usual care	STAI: State Anxiety subscale	20-80 (≥40)	Pre-scan: within 2 weeks Post-scan: immediate, at 1 week & 3-7 months post-scan	No difference at any time point	NR
			STAI: Trait Anxiety subscale	20-80 (≥40)		No difference at any time point	NR
			PCQ: Lung Cancer adaptation, Anxiety subscale	0-18 (NR)		No difference at any time point	0.11 to 0.76
Zavotsky[69]	2014	Arm A: music of their choice played via dock during the scan Arm B: no music	11-point Likert scale	0-10 (NA)	Post-scan: immediate	No difference Arm A v Arm B: 2.36 v 2.98	0.21
Ashton[70]	2019	All participants: 10-minute shoulder & neck massage and/or hand massage before, during or after imaging, or between two imaging tests	11-pointLikert scale	0-10 (NA)	Post-intervention (pre- or post- scan)	81% had a reduction in anxiety following massage[a]	<0.01
Lorca[71]	2019	Arm A: mindfulness meditation Arm B: routine care	STAI: State Anxiety subscale	NR (NA)	Post-scan: immediate	Less severe Arm A v Arm B: 10.47 v 29.07	0.000
			STAI: Trait Anxiety subscale	NR (NA)		No difference	NS
			11-item Likert scale	0-10 (NA)		Less severe Arm A v Arm B, 1.07 v 5.70	0.000

NA not applicable, NR not reported, STAI State-Trait Anxiety Inventory, PCQ Psychological Consequences Questionnaire

[a]Mean scores for overall study population not provided

The mean severity scores were below pre-specified anxiety thresholds on 17 of the 19 measures where a threshold was reported[16, 31, 37, 38, 41-43, 45, 47, 54, 57, 58]. The two exceptions were observed in a study comparing people with *TP53* mutations ('carriers') to controls, with all participants undergoing screening scans. In carriers, mean scores were maximally 11.4 (IES Intrusion subscale, threshold 8.5), and 13.3 (IES Avoidance subscale, threshold 8.5). Mean severity scores for controls were below the thresholds[58].

Of the 43 measures without a pre-specified threshold, the majority had mean scores that were less than half the total scores[15, 18, 20, 23-26, 29, 30, 32, 33, 35, 37, 38, 44-46, 49, 52-54, 56, 58, 60, 61]. There were six exceptions, which reported maximal mean severity scores of: 5.5 out of 10 (Likert scale)[17]; 6.4 out of 10 (Likert scale)[50]; 4.1 out of 7 (Likert scale)[40], 33 out of 60 (STAI State Anxiety subscale)[51], 8.1 out of 14 (Health Questionnaire)[58], and; 51.75 out of 80 (STAI)[59]. Four of these scores occurred in studies where scans were performed for reasons other than screening[17, 50, 51, 59], one allowed scans for diagnosis or screening[40], and one allowed scans for screening only[58].

Eight measures used a descriptive range of severity, with more severe levels of scanxiety in 4% to 28% of participants[21, 22, 25, 27, 28, 33, 34, 55].

Four measures could not be interpreted because they failed to report a range and anxiety threshold[31, 36, 47].

Scanxiety before and after a scan

Of the 20 studies that reported a pre- and post-scan scanxiety measurement, 14 studies reported a statistical comparison[16, 18, 20, 29-32, 35, 38, 50, 51, 57-59] and six did not[23-26, 42, 60](**Table 3**). There was variation in the timing of scanxiety measurement before a scan from four weeks before the scan until immediately before the scan, and after a scan from immediately after the scan until one year after the scan. Five studies reported a post-scan reduction in scanxiety severity compared to pre-scan levels[16, 29, 30, 32, 50, 59]. Two studies reported an increase in post-scan scanxiety severity[51, 57], and two studies no difference in pre- and post-scan scanxiety severity[18, 31].

Four studies reported mixed findings on the change in scanxiety severity across different measures (**Table 5**).

Table 5. Studies with discrepant results on pre- and post-scan scanxiety severity using different measures

First author	Measurement tool	
	Post-scan reduction in scanxiety	**No difference in pre- or post-scan scanxiety**
Sutton[20]	General Health Questionnaire: Anxiety subscale 3-point Likert scale	STAI: State Anxiety subscale STAI: Trait Anxiety subscale
Vierikko[35]	Health Anxiety Inventory	Worry about lung cancer
Hutton[38]	6-item STAI	HADS: Anxiety subscale
Bancroft[58]	HADS: Anxiety subscale	Cancer Worry Scale – Revised Health Questionnaire

STAI: State Trait Anxiety Inventory, HADS: Hospital Anxiety and Depression Scale

Although Bancroft *et al.*[58] reported a reduction in scanxiety severity using HADS (anxiety subscale), there was no difference in scanxiety prevalence.

Contributing factors to scanxiety

Multiple comparisons were made between scanxiety and possible contributing factors across the included studies (**Table 6**).

Table 6. Contributing factors to scanxiety

Variable	Comparison	Effect on scanxiety	Studies	*n*	*P*-value[a]
Age	Younger v older	More prevalent	1	398	0.008[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	5	1883	0.005[45], <0.01[20], <0.01 (for screening)[70], 0.01[24], NR[63]
		No difference in severity	11	6804	NS[22, 27, 36, 37, 42, 43, 49, 51, 59, 62], NS (for surveillance)[70]
Gender	Men v women	More prevalent	1	200	<0.001[39]
		Less prevalent	1	298	0.021[41]
		No difference in prevalence	1	106	NS[28]
		More severe	1	232	0.033 (post-scan)[50]
		Less severe	2	1381	0.000[47], <0.05[57]
		No difference in severity	5	580	NS[37, 49, 51, 59], NS (pre-scan)[50]
Ethnicity	White v other races	More severe	1	143	NR[63]
	Maori & Pacific Islanders v New Zealand European or Asian	More severe	1	584	<0.001[27]
	Any	No difference in severity	5	1454	NS[22, 24, 37, 40, 49]
Education	Lower v higher	More prevalent	1	398	<0.001[41]
		No difference in prevalence	2	338	NS[28, 50]
		More severe	8	7400	0.003[62], 0.007[36], <0.01[22], ≤0.01[42], 0.012[24], 0.018[27], 0.04[43], <0.05[23]
		No difference in severity	6	591	NS[37, 49, 51, 59, 63, 69]
Employment	Unemployed v employed	More prevalent	1	398	0.046[41]
		More severe	3	5056	0.01[43], 0.05[23], ≤0.05[42]
		No difference in severity	2	654	NS[27, 37]
Income	Higher v lower	No difference in severity	3	757	NS[27, 37, 49]
Marital status	Married or de facto v single	More severe	1	637	≤0.01 (using IES - Intrusion subscale)[42]
		No difference in severity	5	1790	NS[24, 36, 37, 49], NS (using STAI - State anxiety subscale)[42]
Children	Children v no children	No difference in severity	3	5206	NS[24, 37, 43]
Smoking status	Current v non-smoking[b]	More severe	3	4562	<0.001[43, 54], 0.031[47]
		No difference in severity	2	330	NS[40, 49]
Reason for scan	Diagnostic v screening	More severe	3	1104	0.007[41], 0.047[36], NR[62]
	Staging or surveillance v monitoring	More severe	1	200	<0.001[39]
	Lower v higher referral clarity	More severe	1	169	0.048[54]
Type of scan	MRI v mammogram	More severe	1	49	0.009[48]
		Less severe	1	637	NR[42]
	CT v MRI	More severe	1	36	0.007[44]
		Less severe	1	115	NR[52]
	PET v CT	More severe	1	82	0.01[33]
	Nuclear medicine scan v non-nuclear medicine scan	More severe	1	398	0.004[41]
	MRI v PET/CT	No difference in severity	2	142	NS[52, 53]
	CT v PET v chest X-ray	No difference in severity	1	59	NS[34]

	Bone scan v PET scan	More severe	1	94	<0.001 (post-scan)[59]
		No difference in severity	1	94	NS (pre-scan)[59]
Scan-naïve	First v subsequent scans	More prevalent	1	398	0.001[41]
		No difference in prevalence	1	200	NS[39]
		More severe	5	3796	<0.0005[38], <0.01[25], <0.02[19], <0.05[67], NR[66]
		Less severe	1	93	0.038[36]
		No difference in severity	6	2491	NS[24, 27, 50, 51, 59, 62]
Pain	Pain v no pain during scan	More severe	6	4291	<0.0001[25], <0.001[27], 0.001[62], <0.01[23, 69] <0.05[22]
Risk of cancer	Past history v no past history of cancer	More severe	2	864	≤0.001[42], <0.05[40]
		Less severe	1	434	0.013[45]
		No difference in severity	3	1206	NS[15, 24, 58]
	Family history v no family history of cancer	More severe	1	584	0.002[27]
		No difference in severity	3	1255	NS[15, 24, 36]
	Mutation carrier v not a carrier	More severe	1	88	<0.05 (three comparisons, using IES cancer – Intrusion and Avoidance subscales, and post-scan Health Questionnaire)[58]
		No difference	1	88	NS (five comparisons, using HADS- Anxiety subscale, Cancer Worry Scale – Revised, IES MRI – Intrusion and Avoidance subscales, and pre-scan Health Questionnaire)[58]
	Higher, not otherwise specified v lower	More severe	1	70	<0.05[37]
Perceived risk of cancer	Higher v lower	More severe	3	1545	<0.001[27], ≤0.001[42], <0.01[30]

NS not significant, NR not reported, IES Impact of Event Scale, STAI State Trait Anxiety Inventory, HADS Hospital Anxiety and Depression Scale, MRI Magnetic Resonance Imaging

[a]The P-values listed in this table were reported by individual studies based on their own datasets. This scoping review has not performed additional analysis or attempted quantitative comparisons between studies.

[b]One study compared current smokers v former smokers[54], and one study compared current and former smokers v never smokers[49]

In summary, higher scanxiety severity was associated with people with:

- Lower education (compared to higher education, eight of 14 studies[22-24, 27, 36, 37, 42, 43, 49, 51, 59, 62, 63, 69]);
- A history of smoking (compared to non-smoking, three of five studies[40, 43, 47, 49, 54]);
- Higher pain levels during the scan (compared to no pain, all six studies[22, 23, 25, 27, 62, 69]);
- Higher perceived risk of cancer (compared to lower perceived risk of cancer, all three studies[27, 30, 42]), and;
- Diagnostic scans (compared to screening scans, all three studies[36, 41, 62])

The prevalence or severity of scanxiety was not consistently affected by age (13 of 19 comparisons[20, 22, 24, 27, 28, 36, 37, 41-43, 45, 49-51, 59, 62, 63, 70]), gender (six of 11 comparisons[28, 37, 39, 41, 47, 49-51, 57, 59]), ethnicity (five of seven comparisons[22, 24, 27, 37, 40, 49, 63]), income (all three comparisons[27, 37, 49]), marital status (five of six comparisons[24, 36, 37, 42, 49]) or having children (all three comparisons[24, 37, 43]).

Inconclusive results occurred in the following comparisons:

- Employment (unemployed compared to employed, four of six comparisons[23, 27, 37, 41-43])

- Scan-naivety (first scan compared to subsequent scans, six of 13 comparisons[19, 24, 25, 27, 36, 38, 39, 41, 50, 51, 62, 66, 67])
- Risk of cancer (higher compared to lower risk of cancer, seven of 19 comparisons[15, 24, 27, 36, 37, 40, 42, 45, 58])

Although nine studies reported differences in scanxiety between different imaging modalities, the number of comparisons between specific scans were insufficient to draw conclusions[33, 34, 41, 42, 44, 48, 52, 53, 59].

Interventions that reduce scanxiety

Five of the 10 intervention studies showed a reduction in scanxiety compared to controls[64-67, 71]. Four studies reported no difference in scanxiety between the intervention arms[62, 63, 68, 69]. The study where all participants received the same intervention showed a reduction in anxiety[70]. Details of these results are listed in **Table 4**.

Both multi-faceted interventions studies incorporating education and emotional or psychological support showed a reduction in scanxiety[64, 65].

Of the six studies with relaxation, distraction and/or meditation components, three studies showed a reduction in scanxiety[66, 70, 71], while three studies did not[62, 63, 69].

Interventions with only educational components did not show a reduction in scanxiety[62, 68].

A reduction in scanxiety severity was also observed when a hand-held device was available to communicate with radiology staff. This reduction was observed in the subgroup of participants who had had a previous scan, but not in participants having their first scan[67].

DISCUSSION

This is the first systematic scoping review aimed at quantifying the phenomenon of scanxiety in people having cancer-related scans. Scanxiety is a common and important clinical problem, as supported by the large number of studies identified by our search. There is a wide range of reported scanxiety prevalence (0 to 83%), and scanxiety is generally not severe. Severity of scanxiety may be lower after a scan and is higher in people who have a lower education, currently smoke, experience pain during a scan, have higher perceived risk of cancer, and who are having diagnostic (rather than screening) scans. Interventions may be more likely to reduce scanxiety if they involve active participation (eg psychological and emotional support, meditation or a hand-held communication device) rather than passive participation (listening to music or education only).

Firm conclusions about prevalence and severity could not be drawn due to considerable methodological heterogeneity of the included studies, especially in relation to scanxiety measurement tools. None were designed and validated for scanxiety, and some tools and their thresholds were not designed and/or validated for anxiety. This review did use purpose-designed definitions of prevalence and severity to allow some comparison between studies; however, the lack of a universal definition or specific measurement tool for scanxiety limits confidence in the interpretation of the results and interstudy

comparisons. This highlights the need for a universally accepted measure to quantify scanxiety and evaluate scanxiety interventions in the future. A recent literature review by Al-Dibouni[75] provided a narrative overview of scanxiety in people having scans for any reason, and also recognised the lack of a specific measurement tool for scanxiety and variable scanxiety prevalence among studies[75].

Given the STAI and Likert scales were the most common tools used, we propose that future studies use the state anxiety subscale of the STAI, with a range of 20-80 and no specific anxiety threshold[72] (or variants, such as the STAI-6[76]), and/or the distress thermometer, with a range of 0-10 and a clinically significant threshold of ≥4[77], to measure scanxiety. These tools can be combined with other validated anxiety measures, such as the HADS, to further refine the relationship between tools. Using existing measures rather than developing a scanxiety specific tool allows scanxiety assessment to occur immediately and broadly in clinical research.

Strengths of this scoping review include the rigorous methodology using a published framework[12, 13], two independent researchers for study selection and data extraction, and the implementation of a comprehensive search strategy and broad inclusion criteria to achieve an exhaustive review of the available literature. Limitations include the use of purpose-designed definitions of prevalence and severity and the limited generalisability of the results due to heterogeneity in cancer type, reason for scan, imaging modality and timing of scanxiety measurement between the studies, and because the search strategy was restricted to English language databases. Finally, scanxiety in people who were recalled after an abnormal screening result were excluded from this review due to confounding and feasibility. These populations may be at higher risk of scanxiety, and further research may provide further insight about the scanxiety experience in this population.

Additional research implications of our review include the need for research into high-risk populations for scanxiety, including people with advanced cancer. This population was included in only three studies [49, 55, 60]; however, people with cancer have higher rates of anxiety compared to the general population[78]. As they may be more likely to develop scanxiety, experience more severe scanxiety, or have higher post-scan scanxiety while waiting for scan results, longitudinal assessment of scanxiety is required. Further research into effective and feasible interventions is also required, though these will face implementation challenges due to variations in health systems and available resources.

CONCLUSIONS

Prevalence and severity of scanxiety varied widely, although heterogeneity in scanxiety measurement interpretation. A uniform approach to evaluating scanxiety will improve understanding of the phenomenon and help guide the development of interventions to high-risk populations.

FOOTNOTES

Contributions: KTB, PB, BK, HD and CB contributed to the concept and design of this review. KTB developed and implemented the search strategy. KTB and RL independently screened and reviewed titles, abstracts and full-text articles for inclusion. KTB and RL independently extracted data from the included studies. PB, BK, HD and CB contributed content expertise to ensure clinically relevant

interpretation of the data. KTB drafted the initial manuscript, and RL, PB, BK, HD and CB reviewed and approved the manuscript prior to submission.

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FIGURE CAPTIONS

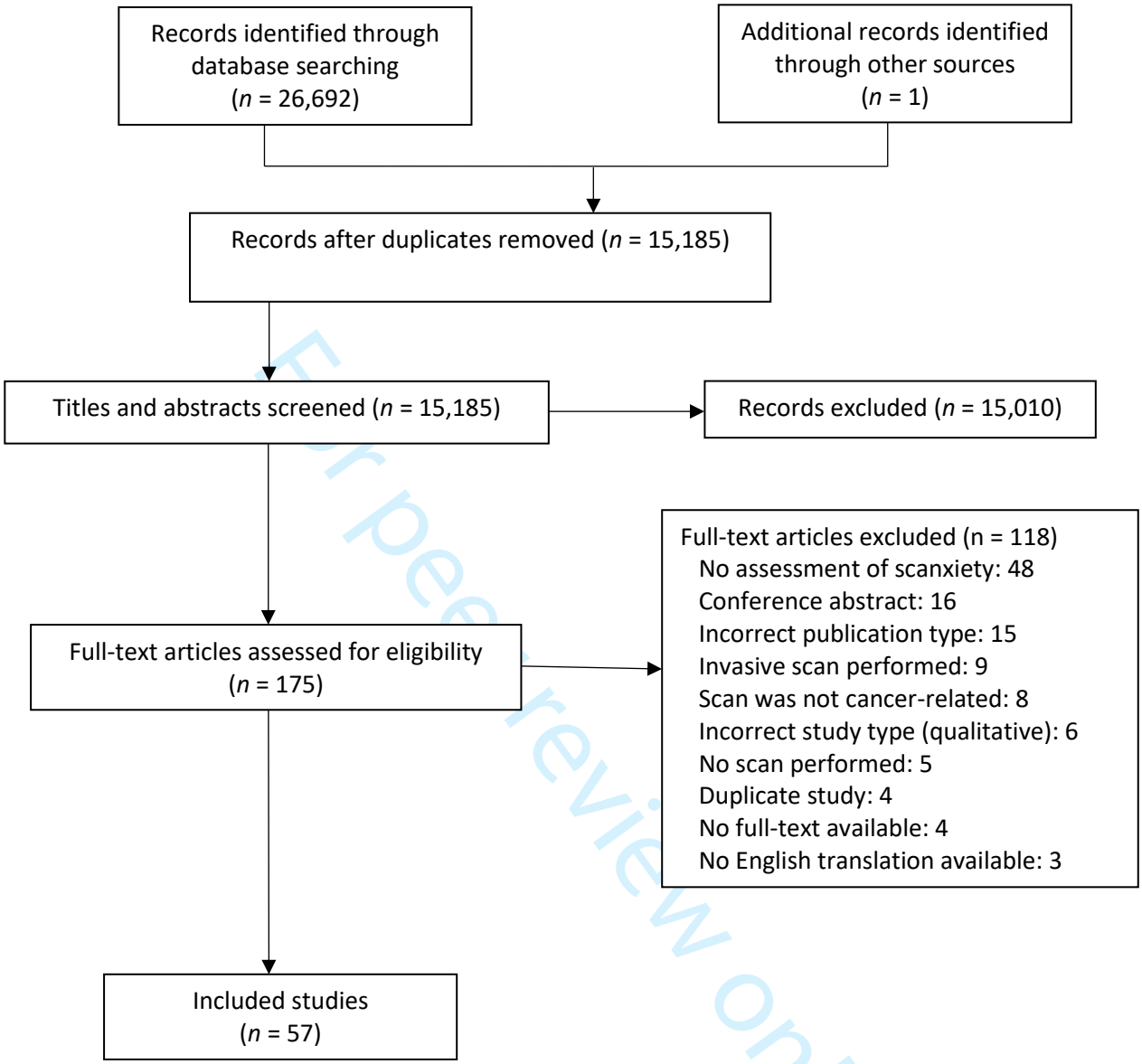
Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

Figure 2. Study search and selection flow diagram

Figure 1. Search strategy used for Ovid MEDLINE (1946 onwards)

#	Search	#	Search	#	Search	#	Search
1	Exp Neoplasms/	10	Exp Diagnostic Imaging/	15	exp Anxiety/	22	or/1-9
2	Exp Medical oncology/	11	imaging.ti,ab	16	exp Anxiety Disorders/	23	or/10-14
3	neoplasm*.ti,ab	12	scan.ti,ab	17	exp Fear/	24	or/15-21
4	cancer*.ti,ab	13	tomography.ti,ab	18	anxi*.ti,ab	25	22 and 23 and 24
5	neoplasm*.ti,ab	14	ultraso*.ti,ab	19	fear.ti,ab		
6	malignan*.ti,ab			20	worr*.ti,ab		
7	tum??r*.ti,ab			21	distress*.ti,ab		
8	oncolog*.ti,ab						
9	carcinoma*.ti,ab						

Figure 2. Study search and selection flow diagram



Supplementary File 1. Protocol

Scanxiety: A scoping review about scan-associated anxiety

Protocol

Version 1.0, 10/04/2019

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Introduction

Radiological scans are necessary to diagnose and stage cancers, to monitor for cancer recurrence or progression or to investigate new cancer- or treatment-related problems. Imaging modalities include plain X-rays, computed tomography (CT) scans, positron-emission tomography (PET) scans, magnetic resonance imaging (MRI), ultrasound and nuclear medicine bone scans.

Distress before, during or after a scan has been dubbed "scanxiety" by a patient writing for the Time Magazine in 2011[1]. This is a common clinical problem that is widely discussed on social media and patient forms, but there is a paucity in the literature about this topic. This systematic scoping study aims to increase the understanding about scanxiety.

Objectives

The objectives of this study are to:

- determine the incidence and severity of scanxiety in adults who have scans for cancer-related reasons;
- compare tools that measure scanxiety;
- identify contributing and exacerbating determinants of scanxiety;
- identify strategies or interventions that reduce scanxiety; and,
- explore the experiences of scanxiety for patients and other stakeholders

Methods

This protocol is based on the six-step methodological framework developed by Arskey & O'Malley[2] and modified by Levac *et al.*[3], and guided by the Preferred Reporting Items for Systematic review and Meta-Analysis Protocols extension for Scoping Reviews (PRISMA-ScR) checklist[4].

Inclusion and exclusion criteria

Publications will be included if they were original full-text research articles that addressed scanxiety in adults over 18 years of age who had a scan for a cancer-related reason. Outcome measures have to include at least one of the following: the incidence of scanxiety; severity of scanxiety; contributing or exacerbating factors of scanxiety; intervention to improve scanxiety, or; experiences of patients with scanxiety. All types of non-interventional imaging modalities are acceptable. Any type or stage of cancer is acceptable, including populations undergoing cancer screening. No date or language restriction will be applied to electronic database searching.

Interventional imaging will be excluded. Review articles, editorials, letters and protocols will be excluded.

Search protocol

A systematic review of the following electronic databases will be conducted by one author (KTB): Ovid MEDLINE, Ovid EMBASE, Ovid PsycINFO, Ovid Cochrane, Scopus, ESCBO CINAHL and PubMed. The search strategy will combine the subject headings and keywords of cancer (neoplasm* or cancer* or malignan* or tum??r* or oncolog* or carcinoma*), imaging (diagnostic imaging or imaging or scan* or tomograpy or ultraso* or radionucl*) and anxiety (anxi* or fear* or worr* or distress*). Hand searching of reference lists of included articles will be undertaken.

All references will be imported into Endnote V9. After removal of duplicates, two authors (KTB and RL) will independently review and screen publication titles and abstracts for eligibility. Of the articles deemed potentially eligible, the full text of the article will be evaluated for final inclusion. Discrepancies will be decided by discussion between the two authors (KTB and RL), and will be escalated to all authors if a consensus cannot be reached.

Data extraction and analysis

Standardised data collection forms will be developed. Relevant data will be independently extracted from by two authors (KTB and RL) into an electronic data extraction form (Table 1).

Table 1. Included data items on the electronic data extraction form

Publication details	Study name/Title of article Study authors Date of publication (year) Country the study was held
Study details	Study aims Population including age, gender, type of cancer Study design Measurement tool used for scanxiety
Results/outcomes	Sample size Demographics – gender, age Cancer factors – type of cancers included Incidence of scanxiety

	Severity of scanxiety Contributing and exacerbating determinants of scanxiety Experiences of scanxiety for patients and other stakeholders If intervention: efficacy

Data will analysed depending on the population who underwent imaging (eg for screening, for early cancer or for advanced cancer) and the type of study (eg observational or intervention). Quantitative findings will be synthesised using summary statistics including the mean and range.

Consultation

Health care professionals with clinical experience in oncology and psychology will be consulted for content expertise and to discuss preliminary findings.

References

1. Feiler B. Scanxiety. Fear of a postcancer ritual. Time. 2011;177(24):56.
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Supplementary File 2. Protocol amendments

Scanxiety: A scoping review about scan-associated anxiety

The original protocol dated 10/04/2019 was amended as per the following statements:

1) The objective 'to explore the experiences of scanxiety for patients and other stakeholders' was abandoned due to feasibility of conducting qualitative and quantitative data analysis with the volume of literature identified
2) Inclusion criteria were updated to reflect changes in Amendment 1: experiences of patients with scanxiety were not included; only studies that quantitatively assessed prevalence and severity of scanxiety or met one of the other objectives were included
3) As per recommendations on scoping review methodology, exclusion criteria were updated *post hoc* and were expanded to also exclude studies involving follow-up scans for a positive screening result, because the psychological experiences of asymptomatic persons facing a potential new cancer diagnosis may lead to higher anxiety than is attribute to scanxiety itself.
4) Exclusion criteria were also updated to reflect changes in Amendment 1, where studies that only qualitatively assessed scanxiety were excluded

Research checklist

Scanxiety: A scoping review about scan-associated anxiety

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	3
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	3
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	3
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	3-4
Information sources	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	3
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Figure 1
Selection of sources of evidence	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	4
Data charting process	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	4
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	4

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	4
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Figure 2
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	5-10, including Tables 1 and 2
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	11-18, including Tables 3,4, 5 and 6
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	11-18
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	18-19
Limitations	20	Discuss the limitations of the scoping review process.	19
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20