Are community-based health worker interventions an effective approach for early diagnosis of cancer?

DOI:

[10.1002/pon.4575](https://doi.org/10.1002/pon.4575)

Document Version

Accepted author manuscript

[Link to publication record in Manchester Research Explorer](#)

Citation for published version (APA):

Bellhouse, S., McWilliams, L., Firth, J., Yorke, J., & French, D. (2017). Are community-based health worker interventions an effective approach for early diagnosis of cancer? A systematic review and meta-analysis. *Psycho-oncology*. <https://doi.org/10.1002/pon.4575>

Published in:

Psycho-oncology

Citing this paper

Please note that where the full-text provided on Manchester Research Explorer is the Author Accepted Manuscript or Proof version this may differ from the final Published version. If citing, it is advised that you check and use the publisher's definitive version.

General rights

Copyright and moral rights for the publications made accessible in the Research Explorer are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Takedown policy

If you believe that this document breaches copyright please refer to the University of Manchester's Takedown Procedures [<http://man.ac.uk/04Y6Bo>] or contact uml.scholarlycommunications@manchester.ac.uk providing relevant details, so we can investigate your claim.

Psycho-Oncology

Are community-based lay health worker interventions an effective approach for early diagnosis of cancer? A systematic review and meta-analysis

Journal:	<i>Psycho-Oncology</i>
Manuscript ID	PON-17-0368.R1
Wiley - Manuscript type:	Review Article
Date Submitted by the Author:	n/a
Complete List of Authors:	<p>Bellhouse, Sarah; The Christie NHS Foundation Trust, Christie Patient Centred Research, School of Oncology</p> <p>McWilliams, Lorna; The Christie NHS Foundation Trust, Christie Patient Centred Research, School of Oncology</p> <p>Firth, Joseph; The University of Manchester, Division of Psychology and Mental Health, School of Health Sciences; Western Sydney University School of Science and Health, NICM</p> <p>Yorke, Janelle; University of Manchester, Division of Nursing, Midwifery and Social Work, School of Health Sciences; The Christie NHS Foundation Trust, Christie Patient Centred Research, School of Oncology</p> <p>French, David; The University of Manchester, Manchester Centre for Health Psychology, School of Health Sciences</p>
Keywords:	cancer, oncology, behavior change techniques, early diagnosis, meta-analysis, systematic review, community health worker

SCHOLARONE™
Manuscripts

Are community-based health worker interventions an effective approach for early diagnosis of cancer? A systematic review and meta-analysis

Sarah Bellhouse¹, Lorna McWilliams¹, Joseph Firth^{2,3}, Janelle Yorke^{1,4}, & David P. French⁵

Running title: CBHWs and Early Diagnosis of Cancer

Authors' affiliations:

¹Christie Patient Centred Research Group, School of Oncology, The Christie NHS Foundation Trust, UK

²Division of Psychology and Mental Health, School of Health Sciences, University of Manchester, UK

³NICM, School of Science and Health, University of Western Sydney, Australia

⁴Division of Nursing, Midwifery and Social Work, School of Health Sciences, University of Manchester UK

⁵Manchester Centre for Health Psychology, School of Health Sciences, University of Manchester, UK

Corresponding author:

Sarah Bellhouse, Christie Patient Centred Research Group, School of Oncology, The Christie NHS Foundation Trust, Wilmslow Road, Withington, Manchester, M20 4BX, UK. Phone: 0161 918 2451; E-mail: sarah.bellhouse@christie.nhs.uk

Word count: 6,259

Figures/tables: 4

Abstract

Objective: This systematic review aimed to assess the effectiveness of community-based health worker (CBHW) interventions for early detection of cancer. Secondary aims were to consider the extent that interventions were based on theory, and potential moderators including behaviour change techniques (BCTs).

Methods: Six databases were searched for randomized controlled trials. Random-effects meta-analyses were applied to 30 eligible studies with a cancer screening outcome.

Results: Participation in CBHW interventions was associated with increased receipt of screening (OR =1.901, 95% CI: 1.60-2.26, $p<0.001$) for breast, cervical and bowel cancer. Larger effect sizes were observed in participants previously non-adherent with recommended schedules of cancer screening. 25/30 studies were conducted with ethnic minority groups. Only 15 (45%) studies explicitly reported a theoretical foundation for intervention. The number of BCTs used by CBHWs had a trend level association with observed effect size ($p=0.08$). Study quality was generally poor and common limitations were inadequate blinding and reliance on self-reported outcomes.

Conclusions: CBHW interventions are an effective resource for increasing uptake of all three types of cancer screening in ethnic minority groups. Those previously non-adherent with recommended schedules of cancer screening benefitted the most from the CBHW approach. However, better quality studies based on more explicit evidence-based theory are needed to optimise the effectiveness of CBHW interventions on screening uptake. Further research is

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 needed to ascertain whether CBHWs can help promote symptom recognition and help-seeking
2 behaviour to facilitate early diagnosis of cancer.

3 **Keywords:** behaviour change techniques, cancer, early diagnosis, community health worker,
4 meta-analysis, oncology and systematic review

For Peer Review

1. Background

In 2013, The World Health Organization (WHO) published their global action plan for the prevention and control of non-communicable diseases, including cancer.¹ The WHO recognize that not all cancers are preventable and so health services are urged to focus on diagnosing cancer earlier in order to increase survival rates and reduce costs associated with treating the disease.² To facilitate this, more interventions aimed at ‘down-staging’ cancers such as increasing uptake of screening programmes are warranted.³

Even though recognition of cancer signs and symptoms are relatively high⁴, attendance rates for cancer screening have decreased in recent years in the UK and USA.⁵⁻⁷ Barriers to attending screening or raising a cancer-related health concern with healthcare professionals remain including; language/cultural barriers, embarrassment/fear and perceptions of wasting doctors’ time.⁸⁻¹⁰

One approach to overcoming barriers towards cancer screening and early diagnosis is using Lay Health Workers (LHWs) i.e., any health worker carrying out functions related to health care delivery who does not have any formal professional or paraprofessional qualifications.^{11, 12} LHW roles in a cancer context include providing education to raise cancer awareness and overcoming individual barriers to attending screening. Two LHW models have been proposed in the literature, differentiated by setting; community based and clinic/hospital based.¹³ Although there is overlap in tasks completed by both types of LHW, community-based health workers (CBHWs) act as a liaison facilitating initial access between individuals and healthcare settings.^{12, 14} In contrast, LHWs based in clinic and hospital settings, commonly referred to as patient navigators, offer guidance to persons with an abnormal cancer screening test or a cancer

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 diagnosis to access the cancer care system.^{15, 16} The present review will focus on CBHWs only as
2 they provide the earliest possible opportunity to promote early cancer diagnosis.

4 Several systematic reviews have examined the effects of CBHW interventions on cancer
5 outcomes, most commonly cancer screening uptake.^{13, 17-21} Two previous systematic reviews
6 which applied meta-analytic techniques found that CBHWs can improve breast cancer screening
7 uptake, with small effects of 1.05¹¹ and 1.06²² reported.

8 Although these previous systematic reviews are useful, they have four limitations that the present
9 research aims to address. Firstly, the searches in the previous systematic reviews were conducted
10 some time ago (2001 and 2008), so there is a need to update systematic review evidence in this
11 area. Secondly, previous reviews that have included quantitative estimates of effects on
12 screening attendance have only examined mammography uptake, one of several available
13 screening programmes in many countries. Since then, more recent studies have examined the
14 effects of CBHWs on other forms of screening²³⁻²⁵, potentially allowing quantitative estimates of
15 the effects of CBHW interventions on these other kinds of screening. Thirdly, previous reviews
16 have not considered the use of theory underpinning intervention development on effectiveness
17 beyond listing theories mentioned. Consequently, it is difficult to assess the extent to which
18 these theories are used in the design, analysis and interpretation of review results. Fourth,
19 previous reviews have not assessed how the use of behaviour change techniques (BCTs) may
20 enhance early detection outcomes. BCTs have been defined as “observable, replicable, and
21 irreducible component(s) of an intervention designed to alter or redirect causal processes that
22 regulate behaviour” (p82)²⁶, and have been shown to moderate the effects of interventions for

other behaviours.²⁷ Thus, previous reviews have not clearly described the active intervention ingredients that CBHW interventions include.

The aim of the present review was to systematically identify and critically review studies that investigate the effectiveness of CBHWs in promoting outcomes pertinent to early cancer diagnosis including screening, symptom recognition, early detection, and help-seeking behaviour. Specific objectives were to:

- a) determine the effectiveness of lay health led interventions in targeting outcomes related to early detection of cancer, with the expectation that screening uptake will be the likely focus considering previous reviews in this area.
- b) identify the extent to which risk of bias may affect intervention effectiveness.
- c) assess the extent to which CBHW interventions are underpinned by a theoretical foundation and determine the prevalence and types of BCTs included in interventions.
- d) examine potential moderators of intervention effectiveness, including type of screening programme, mode of delivery, intervention setting, and use of BCTs.

2. Methods

2.1. Search strategy

This systematic review followed the PRISMA statement, with no ethical approval required.²⁸

Electronic database searches were conducted of MEDLINE, Embase, BNI, CINAHL, PsycINFO & AMED in May 2016, and updated in April 2017. No date restrictions were applied for any

1 searches. A broad search strategy was used to identify relevant articles and variation of index
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 searches. A broad search strategy was used to identify relevant articles and variation of index
2 terms across databases was taken into account. For the full search strategy for each database,
3 refer to Appendix S1.

4
5 In addition to database searches, forward and backward citation searches were conducted.
6 Companion papers were retrieved where necessary to ascertain further information about
7 intervention development and content and CBHW selection/training.

8
9 *2.2. Eligibility criteria*

10 Only English-language research articles published in peer-reviewed journals were included in the
11 review. Studies were included if they met the following criteria:

- 12 (1) Participants: general population (≥ 18 years).
- 13 (2) Interventions were delivered by a CBHW who did not require formal professional or
14 paraprofessional education/qualifications to complete the role. The role of the CBHW
15 was to facilitate initial engagement with healthcare providers and access to services
16 related to early cancer diagnosis e.g. cancer screening or visiting the GP after identifying
17 a potential cancer symptom. Therefore studies delivered in primary care settings would
18 be eligible if the person was attending for a routine visit unrelated to cancer. Studies
19 whereby CBHWs were providing follow up support for those already engaged with
20 cancer related healthcare were excluded. Studies were excluded if CBHW input could not
21 be assessed where healthcare professionals were also involved. Interventions were
22 included whether the CBHW did or did not receive payment for their work.

(3) Controls: studies had to have at least one non CBHW comparator arm, with no other restriction placed upon the nature of the comparison with the intervention group.

(4) Outcomes: studies had to measure an outcome that promoted early diagnosis of cancer at baseline and post-intervention e.g. uptake/intention to complete cancer screening programmes or any measure of cancer symptom awareness/beliefs, knowledge of cancer risk factors, benefits of early detection and help seeking behaviour/confidence to detect a change that might be cancer. There had to be an explicit link between the targeted outcome and cancer.

(5) Studies: RCTs and cluster RCTs were included. Only randomized trials with at least one comparator arm were included in this review because these study designs provide the strongest evidence for evaluating effectiveness of interventions.²⁹

2.3. Study selection

All studies identified during the database search were assessed for relevance in a two-stage screening process; firstly the studies were assessed based on the information contained in the title and abstract. If at this stage the study appeared to meet the inclusion criteria, or if this was unclear, the full article was retrieved. Papers selected for retrieval were primarily assessed by one reviewer (SB) to determine inclusion given the clearly defined a-priori criteria. In ambiguous cases, additional reviewers were consulted (LM, JY, DF).

2.4. Data extraction

Detailed information on sample demographics, CBHW characteristics (including selection/training processes) and intervention characteristics was extracted and an example

1 extraction form is available in Appendix S2. Relevant information was also extracted to code
2 theory use, assess BCT prevalence and judge risk of bias, coded by one reviewer (SB). Five
3 articles were double coded by two reviewers (SB, LM) to establish agreement. During the double
4 coding process, advice was sought from a third reviewer (DF) regarding definitions of
5 terminology to ensure consistency and fairness in coding. Substantial agreement was indicated
6 for theory coding (chance-corrected $\kappa=.72$) and risk of bias judgements (chance-corrected $\kappa=.90$)
7 and moderate agreement for BCTs (chance-corrected $\kappa=.0.55$). However it is not recommended
8 to use the Kappa statistic when coding the BCT taxonomy due to the high likelihood of BCTs
9 being absent artificially lowering observed Kappa statistics.³⁰ Given this, reporting percentage
10 agreement is more appropriate; this was almost perfect at 97%. Due to high agreement, one
11 reviewer (SB) proceeded to code the remaining 30 articles and advice was sought from a third
12 reviewer (DF) on an adhoc basis.

13 **Theory application.** The Theory Coding Scheme³¹, a coding framework developed to
14 assess extent of behaviour change theory use was used to code reported theory application in
15 included articles. The framework consists of 33 questions which are rated “yes”, “no”, “don’t
16 know” or “n/a”. It has previously been used in systematic reviews to code theory use based on
17 intervention reports.³² The Theory Coding Scheme assesses the extent to which intervention
18 techniques are explicitly linked to theoretical constructs. A theoretical construct is defined as a
19 concept within a theory which predicts behaviour and is amenable to change e.g. perceived
20 susceptibility in the Health Belief Model.³³ Percentages were calculated to assess the number of
21 studies scoring “yes” to each question. An overall theory score (range 0-8) was calculated using
22 the answers to items 3 to 11.³²

Behaviour change technique use. A hierarchical taxonomy of 93 BCTs was used to code the content of the interventions.²⁶ The most recent hierarchical list was used, with published definitions guiding coding for each technique. The lead coder (SB) completed the online training resource for the BCT taxonomy. A BCT was not coded as present unless the text explicitly linked the technique to both the named target behaviour and the named population. For example, “CBHWs helped participants identify their barriers to cancer screening and generated possible solutions to help overcome the barriers” adequately describes the problem solving BCT whereas stating that “barriers to cancer screening were discussed” is insufficient. Percentages were calculated to assess the proportion of studies using each BCT.

Risk of bias. Using the Cochrane Collaboration’s tool for assessing risk of bias³⁴, a judgement of risk of bias was made for items related to randomization and blinding procedures, incomplete data assessment, selective reporting and any other sources of bias. The additional guidance provided by the Cochrane Collaboration was followed when deciding between low, unclear or high risk judgements.

2.5. Statistical analyses

Meta-analyses of screening attendance measures were performed in Comprehensive Meta-Analysis 2.0.³⁵ To account for the expected heterogeneity between studies, a random-effects model was applied.³⁶ First, ‘adherence to cancer screening’ was calculated as a pooled odds ratio (O.R.) comparing the total numbers of participants who had taken part in screening for breast cancer, colorectal cancer or cervical cancer following CBHW interventions versus control

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

conditions. Breast self-examination (BSE) and/or clinical breast examination (CBE) adherence data were not classified as forms of cancer screening in these analyses. Data from both medical records and self-report measures were used for analysis. Where studies had reported this separately, a mean O.R. was calculated for medical record and self-report data and used in the analysis. Similarly, where studies which had reported multiple cancer screening outcomes, a mean O.R. was calculated from all eligible measures within each respective study.

The secondary outcome was ‘Uptake of cancer screening amongst non-adherent samples’. “Non-adherent” refers to individuals, who at the time of participation in the study were non-compliant with age appropriate recommended schedules of cancer screening. Thus “uptake” refers to the total number of non-adherent individuals who attended cancer screening after receiving a CBHW intervention (or control condition). Data from those studies which included only non-adherent samples from the outset, and those studies which reported screening uptake among non-adherent sub-groups of standard samples were used.

Heterogeneity between studies was quantified as Cochran’s Q (with respective p-value) and I^2 values.³⁷ Funnel-plots were generated to assess the possibility of publication bias influencing the main analyses and Egger’s test³⁸ and Begg & Mazumdar’s test³⁹ were applied to quantify the risk of publication bias. Where either was significant, a trim-and-fill analysis was applied to recalculate the O.R. effect of CBHW interventions after removing all studies which could potentially be introducing publication bias.⁴⁰

Sensitivity analyses examined the size of main effects (i) only among trials with full outcome data or intention-to-treat analyses, and (ii) when using only medical record data or self-report measures alone.

Subgroup analyses were used to investigate four potential moderators of overall intervention effect. Firstly, the extent to which effects of CBHW interventions on attendance were found for specific cancer types was examined, specifically breast cancer (mammography), colorectal cancer (any measure due to small number of included studies), or cervical cancer (Pap test), individually. As the BSE and CBE data still related to an outcome of interest (early detection of cancer symptoms), it was also included in this analysis. Secondly, moderator analyses considered which settings may be most effective for delivering CBHW interventions to improve cancer screening adherence; comparing pooled effect sizes of interventions delivered in the home, community, and those delivered by telephone only. A third subgroup analysis explored modes of delivery to assess which may be most effective to improve cancer screening adherence; comparing pooled effect sizes of interventions delivered individually, in a group format and those delivered using a combination approach (individual and group).⁴¹ Finally, a mixed-effects meta-regression was performed to explore the relationship between two continuous moderators (number of BCTs applied and Theory Coding Scheme score) and intervention effect size.

3. Results

3.1. Search results

The searches identified 2493 results; 123 full text versions were retrieved and assessed, of which 33 articles were eligible for inclusion (screening process in Figure 1).

[Figure 1 insert here]

3.2. Included studies and participant details

Twenty individually randomized controlled trials and 13 cluster RCTs were included; 30 were conducted in the USA, two in a US-Mexico border region and one was conducted in Belgium. The majority of studies focused on female participants from ethnic minorities, with only nine of the eligible studies including participants who were male (mean = 31.3%, range 16.4-50.0). The mean age of participants was more than 50 years in 17 studies, 10 studies had a mean age less than 50 years, and six did not specify the average sample age. The average length of follow-up across all studies was six months, ranging from immediately post-intervention to 24 months. For more key study characteristics see Appendix S3.

3.2.1. Selection and training processes

A selection process for the CBHWs was described in k=7 (21%) studies⁴²⁻⁴⁸, which included assessment of desirable skills/experience⁴⁴⁻⁴⁶, personality characteristics^{42, 43, 45, 48} and practicalities such as availability.^{43, 45, 47} Gender concordance of CBHWs with the target population was reported in k=22 (67%) studies.^{23-25, 42-60} CBHWs from the same cultural background as the target audience were selected in k=18 (55%) studies.^{23-25, 42, 43, 48, 50, 52-54, 57-64} One study included personal experience of breast or cervical cancer as a selection criterion for CBHWs.⁵¹ Some discussion of the training CBHWs received was reported in k=27 (82%) studies.^{23, 24, 42-60, 62-67} The most commonly used pedagogic methodologies for training CBHWs were visual aids/flip charts, practice intervention sessions, and role-playing. A competency assessment measure was described in k=18 (55%) studies including; ongoing supervision throughout intervention period, practice sessions and a written examination.^{23, 24, 42, 44, 45, 47, 49, 52-55, 59, 60, 62-66} A form of research skills training including the principle of randomization and the importance of

1 protocol adherence was reported in k=12 (36%) studies.^{24, 42, 44, 45, 49, 50, 52, 53, 55, 62-64} The duration
2 of training was described in k=17 (52%) studies and the average duration was 11 hours (range: 4-
3 24 hours).^{24, 42, 44, 47-49, 51-55, 59, 60, 62, 64-66} For the majority of studies, training was conducted in one
4 session or a series of sessions before the intervention commenced with only k=3 (9%) reporting
5 booster, refresher sessions at least once throughout the intervention period.^{45, 55, 62}

6 3.2.2. Theory application

7 A theory base was explicitly reported (i.e., coded yes to item 5 of Theory Coding Scheme) in
8 k=15 (45%) interventions.^{23, 25, 43-45, 53-55, 59, 60, 62-64, 67, 68} Of these 15 studies, a combination of
9 theories was reported in k=8 (53%) (range 2-4).^{23, 25, 43, 45, 54, 60, 63, 64} The Transtheoretical Model
10 was applied in k=8 (53%) studies and the Health Belief Model was reported in k=7 (47%)
11 studies. At least one explicit link between an intervention technique and a theory-relevant
12 construct was reported in k=6 (40%) interventions.^{23, 25, 60, 62, 64, 68} At least one explicit link
13 between a theory-relevant construct and an intervention technique was reported in k=9 (60%)
14 interventions.^{23, 54, 55, 60, 62-64, 67, 68} Theoretically relevant constructs (self-efficacy and perceived
15 severity) were measured pre and post-intervention in k=2 (6%) studies.^{44, 55} Only one study
16 discussed the results in relation to the theoretical basis of the intervention.⁵⁵ Overall, the Theory
17 Coding Scheme illustrated poor theory application; of the 33 interventions, k=18 (55%) scored
18 zero and the highest score was four out of a possible eight. This pattern of results precluded
19 assessment of theory score as a moderator variable.

20 3.2.3. Behaviour change technique use

21 Overall, 21 of 93 possible BCTs were present in the interventions included in this review.
22 Interventions incorporated between zero and nine BCTs with a mean of four BCTs in each

1 intervention. Table 1 demonstrates that the most commonly observed techniques involved
2 providing practical social support, prompts and cues and problem solving. This remained the
3 case when results were limited to the BCTs delivered by the CBHW only and other components
4 such as videos and media campaigns were discounted.

5 **[Table 1 insert here]**

6 *3.2.4. Risk of bias*

7
8 Overall, study quality was poor (see Appendix S4). Only one study had a published protocol.^{67, 69}
9 Therefore the risk of bias for selective reporting was coded high for all remaining studies. Other
10 areas of common bias were reliance on self-reported outcomes, inadequate blinding of key
11 personnel and attrition bias. Attrition rates larger than 25% were reported in k=10 (30%)
12 studies.^{43, 44, 46, 51, 55, 58, 65, 68, 70, 71}

13 *3.3. Effects of lay health worker interventions on cancer screening adherence*

14 Results of all meta-analyses are displayed in Table 2. Adherence screening data for the primary
15 outcome was available from a total of 21,990 participants across 30 studies; 11,487 were
16 assigned to CBHW interventions, 10,503 to control conditions.^{23-25, 42-60, 62-68, 72} Random-effects
17 meta-analyses found that CBHW interventions resulted in significantly greater uptake of overall
18 cancer screening (see Figure 2) than control conditions (O.R.=1.90, 95% CI=1.60-2.26,
19 p<0.001), although there was considerable heterogeneity among study findings (Q=199.9,
20 p<0.01, I² = 85.5%).

21 **[Figure 2 insert here]**

3.4. Publication bias and sensitivity analyses

Although the risk of publication bias was not statistically significant according to Begg & Mazumdar's test (Kendall's $\tau=0.15$, $p=0.24$), Egger's test did indicate publication bias ($p=0.007$). Nonetheless, the Duval and Tweedies trim-and-fill analysis showed that, after removing 12 studies which may introduce publication bias, CBHW interventions still significantly improved screening adherence more than control conditions (O.R.=1.40, 95% C.I.=1.15-1.69).

A sensitivity analysis was performed on the 19 studies which used ITT analyses or complete outcome data, with 16,300 participants in total.^{23, 42, 45-47, 49-51, 53, 54, 56-58, 62, 63, 65-67, 72} This found that CBHW interventions also resulted in increased cancer screening adherence on an intention-to-treat basis (O.R.=1.98, 95% CI=1.57-2.49, $p<0.001$) again with significant heterogeneity between studies ($Q=146.2$, $p<0.01$, $I^2=87.7\%$).

Further sensitivity analyses showed that CBHW interventions resulted in significantly greater adherence to cancer screening than control conditions when using only medical records^{25, 47, 49, 50, 56, 58, 66, 72} (N=8, n=11658, O.R.=2.092, 95% CI=1.36- 3.21, $p=0.001$) or self-report data^{24, 25, 42, 43, 46, 48, 51, 52, 55-60, 62-64, 68} (N=18, n=8620, O.R.=1.686, 95% CI=1.40-2.03, $p<0.001$).

3.5. Effects of lay health worker interventions on cancer screening uptake in non-adherent samples

We also examined the effect of CBHW interventions on uptake of any cancer screening among non-adherent samples (see Appendix S5). Across 20 studies with 12,769 previously non-adherent individuals, LHW interventions resulted in significantly greater likelihood of receiving cancer screening at follow-up compared to control conditions^{23, 24, 42, 44-49, 51, 53-55, 57, 58, 65-68, 72}

(O.R.=2.40, 95% C.I.=1.85-3.11, $p<0.001$). However, there was statistical evidence of both between-study heterogeneity ($Q=149.1$, $p<0.01$, $I^2=87.3\%$) and publication bias (Egger's $t=2.33$, $p=0.03$). Nonetheless, the results still significantly favoured LHW interventions after applying the trim-and-fill analysis ($N=9$, O.R.=1.58, 95% C.I.=1.19- 2.09).

3.6. Factors associated with intervention efficacy

Further analyses were performed to examine effects of CBHW interventions on the primary outcome (i.e. adherence to cancer screening) when (i) focusing on specific cancer screening types, (ii) comparing different settings of delivery, (iii) comparing different modes of delivery, and (iv) number of BCTs used in interventions (see Table 2).

[Table 2 insert here]

Significant benefits of CBHW interventions were observed across each type of screening measure, including mammography ($k=13$, $n=9641$, O.R.=1.923, 95% CI=1.44-2.57, $p<0.001$), Pap testing ($k=15$, $n=5276$, O.R.=1.922, 95% CI=1.39-2.64, $p<0.001$) and colorectal cancer screening ($k=7$, $n=9425$, O.R.=1.983, 95% CI=1.31-3.01, $p<0.001$). Furthermore, the benefits of CBHW interventions were demonstrated for both BSE ($k=4$, $n=1493$, O.R.=1.554, 95% CI=1.17-2.07, $p=0.003$) and CBE ($N=5$, $n=2582$, O.R.=1.528, 95% CI=1.19-2.00, $p=0.001$).

Twenty-six studies used home or community settings, and found CBHW interventions were effective when delivered in the home ($k=13$, $n=5779$, O.R.=1.808, 95% CI=1.40-2.34, $p<0.001$) or the community ($k=13$, $n=5621$, O.R.=2.249, 95% CI=1.63-3.11, $p<0.001$). Four studies examined telephone-only interventions, which demonstrated an overall benefit for CBHWs ($k=4$, $n=10590$, O.R.=1.322, 95% CI=1.14-1.54, $p<0.001$).

Regarding mode of delivery, CBHW interventions were equally as effective when delivered individually ($k=16$, $n=15256$, $O.R.=1.680$, $95\% CI=1.40-2.02$, $p<0.001$) or in a group format ($k=5$, $n=2378$, $O.R.=1.633$, $95\% CI=1.36-1.96$, $p<0.001$). A combined delivery approach (individual and group elements present) was found to be most effective ($k=8$, $n=3636$, $O.R.=2.463$, $95\% CI=1.43-4.23$, $p=0.001$).

Mixed-effects meta-regression found that number of BCTs used in CBHW interventions held a trend-level association with observed effect size (see Appendix S6); as the O.R. for cancer screening adherence from CBHW interventions increased with the number of BCTs used ($B=0.061$, $S.E. = 0.036$, $Z = 1.71$, $p=0.088$). A post-hoc subgroup analysis was conducted to examine the effects of CBHW interventions which used a high number of BCTs (four or more) vs. those which used a low number of BCTs (three or less) (Table 2; see Appendix S7). These cut offs were selected in light of the average intervention containing four BCTs. CBHW interventions with a high number of BCTs increased cancer screening with an odds ratio of 2.27 ($k=13$, $n=6557$, $95\% C.I.=1.78- 2.89$, $p<0.001$), whereas those with low use of BCTs increased cancer screening by only $O.R.=1.66$ ($k=17$, $n=15433$, $95\% C.I. =1.34-2.05$, $p<0.001$), although the difference between High and Low BCT subgroups fell short of statistical significance ($Q=3.613$, $p=0.057$).

The finding of poor theory application precluded assessment of theory score as a moderator variable.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

4. Discussion

4.1. Summary of main findings

The results from this systematic review and meta-analysis indicate that CBHW interventions are associated with a statistically significant increase in cancer screening attendance, with a stronger effect size observed for participants previously non-adherent with recommended schedules of cancer screening. Similar odds ratios were found for screening for breast, cervical and colorectal cancer. The overall pattern of results was robust to sensitivity analyses, with similar effect sizes found irrespective of source of outcome measure (self-report or medical records), or whether intention-to-treat analyses were conducted or not. There was little use of theory in these interventions, making it difficult to identify the means by which the interventions changed screening attendance. The interventions generally did not use many BCTs, in line with the apparent lack of use of theory to develop interventions. Methodological quality of included studies was generally poor.

4.2. Strengths & limitations

The findings of this review build upon the results of previous smaller reviews examining mammography screening only.^{11, 22} This review has been the first to illustrate the effectiveness of CBHW interventions across all types of cancer screening and other measures of early detection (BSE and CBE). This allows the present review to draw conclusions relating to the efficacy of CBHW interventions across screening for breast, cervical and colorectal cancer. Further the present review has been the first to apply the BCT taxonomy and Theory Coding Scheme to cancer specific CBHW interventions.

1 A limitation of the present review was that, as many terms are used to describe CBHWs, it may
2 be possible that we did not extract all relevant articles in the existing literature. However, to
3 avoid this, a systematic, comprehensive electronic search was conducted using 45 different terms
4 for CBHW after a consultation with a trained health science librarian. The present review
5 identified many more studies than did previous systematic reviews, and included studies
6 identified by these previous reviews, indicating that this was not a major problem.

7
8 There were however, limitations of the primary evidence base that the present review has
9 identified, but which limit the conclusions that can be drawn. First, substantial heterogeneity
10 was found across the analyses. This between-study heterogeneity is unsurprising, given the clear
11 differences between CBHW interventions in terms of the intervention components used, cancers
12 screened for, guidelines in place at screening, populations studied and outcome measures
13 applied, all sources of heterogeneity which are typical to meta-analytic research. Although this
14 heterogeneity was statistically accounted for by the random-effects model applied, it is
15 acknowledged that the strength of the conclusions from this review are limited as a result.
16 Second, the research base itself was limited to cancer screening outcomes and heterogeneity
17 prevented the combination of secondary outcome data into meaningful categories to examine
18 effectiveness of CBHW interventions in other areas of early cancer diagnosis awareness (e.g.,
19 knowledge, intention, self-efficacy). It was also notable that all but one of the included studies
20 were implemented in the USA and therefore caution is needed to generalize and apply findings
21 to countries with different healthcare systems, cancer screening guidelines and ethnic
22 compositions.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 The review identified several methodological biases present in the primary studies; high rates of
2 attrition, reliance on self-reported outcomes, and failure to report blinding which could have
3 contributed to biased estimates of interventional efficacy. However it is important to note that
4 there is an inherent difficulty with blinding in trials assessing the effectiveness of CBHWs. In the
5 majority of cases CBHWs recruit participants from their own social networks/communities as
6 shared characteristics between the CBHW and the audience facilitate learning and increase the
7 likelihood that participants will model the desired behaviour.⁷³ Therefore blinding may interfere
8 with one of the presumed mechanisms of effectiveness. Nevertheless, sensitivity analyses
9 suggested that these methodological limitations did not unduly affect the overall conclusions.
10 Furthermore, publication bias was indicated but after removing studies with smaller sample
11 sizes, improvements in screening attendance in CBHW conditions remained significant.

12
13 *4.3. Interpretation of main findings*

14
15 This study has been the first to illustrate the effectiveness of CBHW interventions beyond
16 mammography screening. Furthermore this meta-analysis yielded higher odds ratios than
17 previous reviews (1.90-2.40), indicating larger effects of CBHW interventions than previous
18 reviews have suggested.^{11, 22} Subgroup analyses revealed similar effects for breast, cervical and
19 colorectal cancer screening.

20
21 The review provides an updated description of CBHW training characteristics, crucial to the
22 successful implementation of CBHW interventions.⁷⁴ Marked heterogeneity was present in the
23 reporting of selection and training processes in CBHW literature. A conceptual model has been

1 proposed to standardize the reporting of such processes in the future.⁷⁵ This transparency will
2 facilitate learning for future intervention development. However, how training content is selected
3 remains unclear, and the lack of readily reported information about components of training
4 hinders the development of evidence based training packages.

5
6 The present review explored potential moderators of effectiveness to provide practical
7 recommendations for future CBHW intervention development. Moderator analyses demonstrated
8 that CBHW interventions were equally as effective across all types of cancer screening.
9 Subgroup analyses revealed that interventions were effective when delivered in community and
10 home settings, over the telephone and when both individual and group modes of delivery were
11 used. Only one of the included interventions was delivered in a primary care setting.⁷⁰ However
12 as it measured knowledge changes only, there was no eligible data to include in the meta-
13 analysis of effects on screening behaviour. No beneficial effect of the CBHW was found when
14 compared to usual care but additional research is needed to establish whether delivering a
15 CBHW intervention in primary care settings has the potential to be effective.

16
17 An in-depth analysis with Theory Coding Scheme items³¹ revealed substantial evidence of
18 ‘theory inspired’ interventions, whereby theory is not used to identify methods to change
19 behaviour, as evidenced by poor linkage between BCTs and theoretical constructs.⁷⁶ This
20 absence of an explicit theoretical basis for interventions makes it difficult to identify why
21 interventions worked, and how future interventions could work better: it prevents an
22 accumulation of knowledge on what basis future CBHW interventions should be developed.^{77, 78}
23 Few BCTs were generally used: CBHWs were found to most frequently provide practical

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

support to participants, resolve barriers and prompt the desired behaviour. There was a trend (p=0.057) towards the use of BCTs being positively associated with intervention effectiveness; larger effect sizes were observed in studies using more than four BCTs (OR = 2.27) compared to those using three or fewer (OR = 1.66). Given that few BCTs were generally used, this would have reduced the association between BCTs and effectiveness, due to a lack of range. Given this, at the least the inclusion of more BCTs should be considered in future studies, to examine whether this results in increased intervention effectiveness.

Of note was the exclusive emphasis on cancer screening behaviour observed in this review. Half of the included studies measured secondary outcomes related to knowledge but this was limited to awareness of screening procedures, the benefits of early diagnosis, and cancer risk factors. International comparisons have reported greater endorsement of barriers to help-seeking in UK adults⁷⁹, in particular regarding the perception of not wanting to waste the doctor's time or cause a fuss.⁸⁰ Despite public awareness campaigns increasing cancer symptom awareness, GP approachability remains a barrier to early engagement with primary care⁸, and a lack of engagement is more pronounced in lower socioeconomic groups.⁸¹ This suggests that broadening the CBHW remit to increasing symptom recognition and promotion of help-seeking behaviour is a worthwhile avenue to pursue, particularly in a UK context where barriers to help-seeking remain high.

4.4. Implications and future research directions

This review has demonstrated that CBHW interventions are a promising approach to addressing cancer screening disparities in the US, particularly in ethnic minority groups. Notwithstanding

1 limitations in evidence base, the evidence and size of effect obtained in this review support the
2 implementation of CBHW interventions to increase cancer screening in ethnic minorities. Based
3 on the current evidence base, those previously non-adherent with recommended schedules of
4 cancer screening are most likely to benefit.

5 However substantial work is still needed to fully elucidate the conditions key to intervention
6 effectiveness using methodologically sound studies in different populations. As such, the
7 following recommendations for future research are made:

- 8 a) Guidelines such as the Template for intervention description and replication (TIDieR)⁸²
9 should be used more to increase transparency and facilitate learning between researchers.
10 This would contribute to the identification of key mechanisms of behaviour change, the
11 most effective components of training packages and reduce heterogeneity prevalent
12 across studies.
- 13 b) Use of explicit theory in the development and evaluation of interventions, to target
14 hypothetical mediators of behaviour change, such as knowledge and intent, to increase
15 intervention effectiveness. The use of theory in evaluation of such interventions should
16 clarify the processes of change initiated by CBHWs. This would help inform the need for
17 refinement in terms of intervention components and BCTs.
- 18 c) The use of a greater range of BCTs should be considered in future interventions, to allow
19 an assessment of whether this would result in greater intervention effectiveness,
20 compared to CBHW interventions conducted to date.

d) Further exploring the influence demographic factors such as participant gender has on CBHW intervention effectiveness across all cancer screening programmes. There is a clear need for more research using populations outside the US to assess whether such interventions are more or less effective in different settings.

e) Exploratory **work** should be conducted to assess the feasibility of using CBHWs to increase symptom awareness and promote help-seeking behaviour.

5. Conclusions

In conclusion, this review has found that CBHWs are an effective resource for increasing cancer screening uptake, particularly for those previously non-adherent with recommended schedules of cancer screening. It is yet unknown whether CBHW interventions are an effective approach for other areas of early diagnosis including symptom awareness and help-seeking behaviour. The number of explicitly described BCTs used was found to be positively associated with effect size, although this did not reach statistical significance. At present, these conclusions are almost entirely limited to the US healthcare context and ethnic composition and limited by poor methodological quality and substantial heterogeneity. As such it remains unknown whether the effectiveness of CBHW interventions would translate to different countries or other areas pertinent to early cancer diagnosis such as help-seeking behaviour.

Conflicts of interest

The authors declare no potential conflicts of interest.

References

References marked with an asterisk indicate studies included in the systematic review

1. World Health Organization. Global action plan for the prevention and control of NCDs 2013-2020 [Internet]. World Health Organization; 2013. Available from: http://apps.who.int/iris/bitstream/10665/94384/1/9789241506236_eng.pdf?ua=1
2. World Health Organization. Guide to cancer early diagnosis [Internet]. World Health Organization; 2017. Available from: <http://apps.who.int/iris/bitstream/10665/254500/1/9789241511940-eng.pdf?ua=1>
3. Ott JJ, Ullrich A, Miller AB. The importance of early symptom recognition in the context of early detection and cancer survival. *Eur J Cancer*. **2009**;45:2743-8
4. CRUK. Cancer Awareness Measure (CAM) Key Findings Report; 2014 & Trends Analysis (2008-2014) [Internet]. 2014. Available from: http://www.cancerresearchuk.org/sites/default/files/cam_key_findings_report_-_2014_trends_analysis_v5.pdf
5. Health and Social Care Information Centre. Cervical Screening Programme - England, 2014-15 [Internet]. National Statistics; 2015. Available from: <http://content.digital.nhs.uk/catalogue/PUB18932/nhs-cervical-stat-eng-2014-15-rep.pdf>
6. Health and Social Care Information Centre. Breast Screening Programme - England, 2014-15 [Internet]. National Statistics; 2016. Available from: <http://content.digital.nhs.uk/catalogue/PUB20018/bres-scre-prog-eng-2014-15-rep.pdf>
7. Smith RA, Manassaram-Baptiste D, Brooks D, Doroshenk M, Fedewa S, Saslow D, et al. Cancer screening in the United States, 2015: A review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin*. **2015**;65:30-54
8. Power E, Wardle J. Change in public awareness of symptoms and perceived barriers to seeing a doctor following Be Clear on Cancer campaigns in England. *Br J Cancer*. **2015**;112:S22-S6
9. Guessous I, Dash C, Lapin P, Doroshenk M, Smith RA, Klabunde CN. Colorectal cancer screening barriers and facilitators in older persons. *Prev Med*. **2010**;50:3-10
10. Smith LK, Pope C, Botha JL. Patients' help-seeking experiences and delay in cancer presentation: a qualitative synthesis. *The Lancet*. **2005**;366:825-31
11. Lewin SA, Dick J, Pond P, Zwarenstein M, Aja G, van Wyk B, et al. Lay health workers in primary and community health care. *The Cochrane database of systematic reviews*. **2005**. CD004015.
12. Witmer A, Seifer SD, Finocchio L, Leslie J, O'Neil EH. Community health workers: integral members of the health care work force. *Am J Public Health*. **1995**;85:1055-8
13. Hou S-I, Roberson K. A Systematic Review on US-Based Community Health Navigator (CHN) Interventions for Cancer Screening Promotion—Comparing Community- Versus Clinic-Based Navigator Models. *J Cancer Educ*. **2015**;30:173-86
14. Rhodes SD, Foley KL, Zometa CS, Bloom FR. Lay Health Advisor Interventions Among Hispanics/Latinos: A Qualitative Systematic Review. *Am J Prev Med*. **2007**;33:418-27
15. Freeman HP. A model patient navigation program. *Oncology Issues*. **2004**;19:44-6
16. Wells KJ, Battaglia TA, Dudley DJ, Garcia R, Greene A, Calhoun E, et al. Patient navigation: State of the art or is it science? *Cancer*. **2008**;113:1999-2010
17. Gibbons MC, Tyus NC. Systematic review of U.S.-based randomized controlled trials using community health workers. *Prog Community Health Partnersh*. **2007**;1:371-81

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

18. Islam NS, Zanowiak JM, Riley L, Nadkarni SK, Kwon SC, Trinh-Shevrin C. Characteristics of Asian American, Native Hawaiian, and Pacific Islander community health worker programs: a systematic review. *J Health Care Poor Underserved*. **2015**;26:238-68

19. Viswanathan M, Kraschnewski JL, Nishikawa B, Morgan LC, Honeycutt AA, Thieda P, et al. Outcomes and Costs of Community Health Worker Interventions: A Systematic Review. *Med Care*. **2010**;48:792-808

20. Wadler BM, Judge CM, Prout M, Allen JD, Geller AC. Improving Breast Cancer Control via the Use of Community Health Workers in South Africa: A Critical Review. *J Oncol*. **2011**;2011:H382-7

21. Kim K, Choi JS, Choi E, Nieman CL, Joo JH, Lin FR, et al. Effects of Community-Based Health Worker Interventions to Improve Chronic Disease Management and Care Among Vulnerable Populations: A Systematic Review. *Am J Public Health*. **2016**;106:e3-e28

22. Wells KJ, Luque JS, Miladinovic B, Vargas N, Asvat Y, Roetzheim RG, et al. Do Community Health Worker Interventions Improve Rates of Screening Mammography in the United States? A Systematic Review. *Cancer Epidemiol Biomarkers Prev*. **2011**;20:1580-98

23. *Byrd TL, Wilson KM, Smith JL, Coronado G, Vernon SW, Fernandez-Esquer ME, et al. AMIGAS: A multicity, multicomponent cervical cancer prevention trial among Mexican American women. *Cancer*. **2013**;119:1365-72

24. *Nguyen BH, Stewart SL, Nguyen TT, Bui-Tong N, McPhee SJ. Effectiveness of Lay Health Worker Outreach in Reducing Disparities in Colorectal Cancer Screening in Vietnamese Americans. *Am J Public Health*. **2015**;105:2083-9

25. *Paskett ED, McLaughlin JM, Lehman AM, Katz ML, Tatum CM, Oliveri JM. Evaluating the Efficacy of Lay Health Advisors for Increasing Risk-Appropriate Pap Test Screening: A Randomized Controlled Trial among Ohio Appalachian Women. *Cancer Epidemiol Biomarkers Prev*. **2011**;20:835-43

26. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Ann Behav Med*. **2013**;46:81-95

27. French DP, Olander EK, Chisholm A, Mc Sharry J. Which Behaviour Change Techniques Are Most Effective at Increasing Older Adults' Self-Efficacy and Physical Activity Behaviour? A Systematic Review. *Ann Behav Med*. **2014**;48:225-34

28. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. **2009**;6:e1000097

29. Evans D. Hierarchy of evidence: a framework for ranking evidence evaluating healthcare interventions. *J Clin Nurs*. **2003**;12:77-84

30. Wood CE, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. Applying the behaviour change technique (BCT) taxonomy v1: a study of coder training. *Transl Behav Med*. **2015**;5:134-48

31. Michie S, Prestwich A. Are interventions theory-based? Development of a theory coding scheme. *Health Psychol*. **2010**;29:1-8

32. Prestwich A, Sniehotta FF, Whittington C, Dombrowski SU, Rogers L, Michie S. Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychol*. **2014**;33:465-74

33. Janz NK, Becker MH. The Health Belief Model: A Decade Later. *Health Educ Q.* **1984**;11:1-47
34. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ.* **2011**;343:d5928
35. Borenstein M, Hedges L, Higgins J, Rothstein H. Comprehensive Meta Analysis. 2 ed. Englewood, NJ: Biostat; 2005.
36. DerSimonian R, Kacker R. Random-effects model for meta-analysis of clinical trials: An update. *Contemp Clin Trials.* **2007**;28:105-14
37. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med.* **2002**;21:1539-58
38. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ.* **1997**;315:629-34
39. Begg CB, Mazumdar M. Operating Characteristics of a Rank Correlation Test for Publication Bias. *Biometrics.* **1994**;50:1088-101
40. Duval S, Tweedie R. Trim and Fill: A Simple Funnel-Plot-Based Method of Testing and Adjusting for Publication Bias in Meta-Analysis. *Biometrics.* **2000**;56:455-63
41. Dombrowski SU, O'Carroll RE, Williams B. Form of delivery as a key 'active ingredient' in behaviour change interventions. *Br J Health Psychol.* **2016**;21:733-40
42. *Lam TK, Mc Phee SJ, Mock J, Wong C, Doan HT, Nguyen T, et al. Encouraging Vietnamese-American Women to Obtain Pap Tests Through Lay Health Worker Outreach and Media Education. *J Gen Intern Med.* **2003**;18:516-24
43. *Navarro AM, Senn KL, McNicholas LJ, Kaplan RM, Roppé B, Campo MC. Por La Vida model intervention enhances use of cancer screening tests among Latinas. *Am J Prev Med.* **1998**;15:32-41
44. *O'Brien MJ, Halbert CH, Bixby R, Pimentel S, Shea JA. Community Health Worker Intervention to Decrease Cervical Cancer Disparities in Hispanic Women. *J Gen Intern Med.* **2010**;25:1186-92
45. *Paskett E, Tatum C, Rushing J, Michielutte R, Bell R, Foley KL, et al. Randomized Trial of an Intervention to Improve Mammography Utilization Among a Triracial Rural Population of Women. *J Natl Cancer Inst.* **2006**;98:1226-37
46. *Sung JF, Blumenthal DS, Coates RJ, Williams JE, Alema-Mensah E, Liff JM. Effect of a cancer screening intervention conducted by lay health workers among inner-city women. *Am J Prev Med.* **1997**;13:51-7
47. *Han H-R, Song Y, Kim M, Hedlin HK, Kim K, Ben Lee H, et al. Breast and Cervical Cancer Screening Literacy Among Korean American Women: A Community Health Worker-Led Intervention. *Am J Public Health.* **2017**;107:159-65
48. *Mock J, McPhee SJ, Nguyen T, Wong C, Doan H, Lai KQ, et al. Effective Lay Health Worker Outreach and Media-Based Education for Promoting Cervical Cancer Screening Among Vietnamese American Women. *Am J Public Health.* **2007**;97:1693-700
49. *Goelen G, De Clercq G, Hanssens S. A community peer-volunteer telephone reminder call to increase breast cancer-screening attendance. *Oncol Nurs Forum.* **2010**;37:E312-7
50. *Hunter JB, de Zapien JG, Papenfuss M, Fernandez ML, Meister J, Giuliano AR. The Impact of a Promotora on Increasing Routine Chronic Disease Prevention among Women Aged 40 and Older at the U.S.-Mexico Border. *Health Educ Behav.* **2004**;31:18S-28S

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

51. *Jandorf L, Bursac Z, Pulley L, Trevino M, Castillo A, Erwin DO. Breast and cervical cancer screening among Latinas attending culturally specific educational programs. *Prog Community Health Partnersh.* **2008**;2:195-204

52. *Nguyen TT, Le G, Nguyen T, Le K, Lai K, Gildengorin G, et al. Breast Cancer Screening Among Vietnamese Americans: A Randomized Controlled Trial of Lay Health Worker Outreach. *Am J Prev Med.* **2009**;37:306-13

53. *Nuño T, Martinez ME, Harris R, García F. A Promotora-administered group education intervention to promote breast and cervical cancer screening in a rural community along the U.S.–Mexico border: a randomized controlled trial. *Cancer Causes Control.* **2011**;22:367-74

54. *Russell KM, Champion VL, Monahan PO, Millon-Underwood S, Zhao Q, Spacey N, et al. Randomized Trial of a Lay Health Advisor and Computer Intervention to Increase Mammography Screening in African American Women. *Cancer Epidemiol Biomarkers Prev.* **2010**;19:201-10

55. *Sadler GR, Ko CM, Wu P, Alisangco J, Castañeda SF, Kelly C. A Cluster Randomized Controlled Trial to Increase Breast Cancer Screening Among African American Women: The Black Cosmetologists Promoting Health Program. *J Natl Med Assoc.* **2011**;103:735-45

56. *Taylor VM, Carey Jackson J, Yasui Y, Kuniyuki A, Acorda E, Marchand A, et al. Evaluation of an outreach intervention to promote cervical cancer screening among Cambodian American women. *Cancer Detect Prev.* **2002a**;26:320-7

57. *Taylor VM, Hislop TG, Jackson JC, Tu S-P, Yasui Y, Schwartz SM, et al. A Randomized Controlled Trial of Interventions to Promote Cervical Cancer Screening Among Chinese Women in North America. *J Natl Cancer Inst.* **2002b**;94:670-7

58. *Taylor VM, Jackson JC, Yasui Y, Nguyen TT, Woodall E, Acorda E, et al. Evaluation of a Cervical Cancer Control Intervention Using Lay Health Workers for Vietnamese American Women. *Am J Public Health.* **2010**;100:1924-9

59. *Walsh JME, Salazar R, Nguyen TT, Kaplan C, Nguyen L, Hwang J, et al. Healthy Colon, Healthy Life: A Novel Colorectal Cancer Screening Intervention. *Am J Prev Med.* **2010**;39:1-14

60. *Zhu K, Hunter S, Bernard LJ, Payne-Wilks K, Roland CL, Elam LC, et al. An Intervention Study on Screening for Breast Cancer among Single African-American Women Aged 65 and Older. *Prev Med.* **2002**;34:536-45

61. *Carney PA, Lee-Lin F, Mongoue-Tchokote S, Mori M, Leung H, Lau C, et al. Improving colorectal cancer screening in Asian Americans: Results of a randomized intervention study. *Cancer.* **2014**;120:1702-12

62. *Nguyen TT, Tsoh JY, Woo K, Stewart SL, Le GM, Burke A, et al. Colorectal Cancer Screening and Chinese Americans: Efficacy of Lay Health Worker Outreach and Print Materials. *Am J Prev Med.* **2017**;52:e67-e76

63. *Tong EK, Nguyen TT, Lo P, Stewart SL, Gildengorin GL, Tsoh JY, et al. Lay health educators increase colorectal cancer screening among Hmong Americans: A cluster randomized controlled trial. *Cancer.* **2017**;123:98-106

64. *Jo AM, Nguyen TT, Stewart S, Sung MJ, Gildengorin G, Tsoh JY, et al. Lay health educators and print materials for the promotion of colorectal cancer screening among Korean Americans: A randomized comparative effectiveness study. *Cancer.* **2017**. Epub 2017 Apr 25

65. *Fernández ME, Gonzales A, Tortolero-Luna G, Williams J, Saavedra-Embesi M, Chan W, et al. Effectiveness of Cultivando La Salud: A Breast and Cervical Cancer Screening Promotion Program for Low-Income Hispanic Women. *Am J Public Health.* **2009**;99:936-43

66. *Percac-Lima S, Grant RW, Green AR, Ashburner JM, Gamba G, Oo S, et al. A Culturally Tailored Navigator Program for Colorectal Cancer Screening in a Community Health Center: A Randomized, Controlled Trial. *J Gen Intern Med.* **2009**;24:211-7
67. *Thompson B, Carosso EA, Jhingan E, Wang L, Holte SE, Byrd TL, et al. Results of a randomized controlled trial to increase cervical cancer screening among rural Latinas. *Cancer.* **2017**;123:666-74
68. *Duan N, Fox SA, Derosé KP, Carson S. Maintaining mammography adherence through telephone counseling in a church-based trial. *Am J Public Health.* **2000**;90:1468-71
69. Duggan C, Coronado G, Martinez J, Byrd TL, Carosso E, Lopez C, et al. Cervical cancer screening and adherence to follow-up among Hispanic women study protocol: a randomized controlled trial to increase the uptake of cervical cancer screening in Hispanic women. *BMC Cancer.* **2012**;12:170
70. *Castañeda SF, Xiong Y, Gallo LC, Yepes-Rios M, Ji M, Talavera AC, et al. Colorectal Cancer Educational Intervention Targeting Latino Patients Attending a Community Health Center. *J Prim Care Community Health.* **2012**;3:164-9
71. *Sadler GR, Beerman PR, Lee K, Hung J, Nguyen H, Cho J, et al. Promoting Breast Cancer Screening Among Asian American Women: the Asian Grocery Store-Based Cancer Education Program. *J Cancer Educ.* **2012**;27:612-7
72. *Potter MB, Namvargolian Y, Hwang J, Walsh JME. Improving Colorectal Cancer Screening: A Partnership Between Primary Care Practices and the American Cancer Society. *J Cancer Educ.* **2009**;24:22-7
73. Bandura. Social cognitive theory. *Annals of Child Development.* **1989**;6:1-66
74. Swider SM, Martin M, Lynas C, Rothschild S. Project MATCH. *Diabetes Educ.* **2010**;36:98-108
75. O'Brien MJ, Squires AP, Bixby RA, Larson SC. Role Development of Community Health Workers: An Examination of Selection and Training Processes in the Intervention Literature. *Am J Prev Med.* **2009**;37:S262-S9
76. Michie S, Johnston M, Francis J, Hardeman W, Eccles M. From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques. *Appl Psychol.* **2008**;57:660-80
77. Michie S, Johnston M. Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychol Rev.* **2012**;6:1-6
78. Foy R, Eccles M, Jamtvedt G, Young J, Grimshaw J, Baker R. What do we know about how to do audit and feedback? Pitfalls in applying evidence from a systematic review. *BMC Health Serv Res.* **2005**;5:50
79. Forbes LJL, Simon AE, Warburton F, Boniface D, Brain KE, Dossaix A, et al. Differences in cancer awareness and beliefs between Australia, Canada, Denmark, Norway, Sweden and the UK (the International Cancer Benchmarking Partnership): do they contribute to differences in cancer survival[quest]. *Br J Cancer.* **2013**;108:292-300
80. Whitaker KL, Macleod U, Winstanley K, Scott SE, Wardle J. Help seeking for cancer 'alarm' symptoms: a qualitative interview study of primary care patients in the UK. *Br J Gen Pract.* **2015**;65:e96-e105
81. Moffat J, Bentley A, Ironmonger L, Boughey A, Radford G, Duffy S. The impact of national cancer awareness campaigns for bowel and lung cancer symptoms on sociodemographic

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

inequalities in immediate key symptom awareness and GP attendances. *Br J Cancer*.
2015;112:S14-S21
82. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better reporting of
interventions: template for intervention description and replication (TIDieR) checklist and guide.
BMJ. **2014**;348:g1687

For Peer Review

Table 1. Prevalence of behaviour change techniques in community-based health worker interventions

Behaviour change technique	Prevalence (%)
Social support (practical)	64
Prompts and cues	58
Problem solving	52
Social support (unspecified)	30
Credible source	27
Social support (emotional)	21
Restructuring social environment	18
Reduce negative emotions	18
Information about others' approval	18
Information about health consequences	12

Note: Techniques appearing in less than 10% of the interventions included the following: adding objects to the environment (9%); demonstration of behaviour (6%); goal setting (behaviour) (6%); behavioural contract (6%); information about emotional consequences (6%); vicarious consequences (6%); salience of consequences (3%); identification of self as role model (3%); self-monitoring of behaviour (3%); instruction on how to perform a behaviour (3%); social comparison (3%). The 72 remaining techniques in the behaviour change taxonomy were not observed

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

Table 2. Meta-analyses of studies reporting the effect of community-based health worker interventions on cancer screening

	Sample		Meta-analysis				Heterogeneity		
	Studies	Total n	Odds Ratio	95% CI		P value	Q-value	P value	I ²
Primary and secondary outcomes									
Primary: Overall screening adherence	30	21990	1.901	1.60	2.26	<0.001	199.9	<0.01	85.5
Secondary: Uptake among non-adherent	20	12768	2.401	1.85	3.11	<0.001	149.1	<0.01	87.3
Sensitivity analyses									
Intention to treat data only	19	16300	1.978	1.57	2.49	<0.001	146.2	<0.01	87.7
Medical records data only	8	11658	2.092	1.36	3.21	0.001	112.6	<0.01	93.8
Self-report data only	18	8620	1.686	1.40	2.03	<0.001	64.0	<0.01	73.4
Subgroup analyses = type of procedure									
Breast cancer (mammography)	13	9641	1.923	1.44	2.57	<0.001	96.7	<0.01	87.6
Breast cancer (BSE)	4	1493	1.554	1.17	2.07	0.003	4.96	0.175	39.5
Breast cancer (CBE)	5	2582	1.528	1.19	2.00	0.001	8.76	0.067	54.4
Cervical cancer (pap test)	15	5276	1.922	1.39	2.64	<0.001	92.7	<0.01	84.9
Colorectal (any)	7	9425	1.983	1.31	3.01	<0.001	86.8	<0.01	93.1
Subgroup analyses = delivery setting									
Community	13	5621	2.249	1.63	3.11	<0.001	83.7	<0.01	85.7
Home-based	13	5779	1.808	1.40	2.34	<0.001	54.5	<0.01	78.0
Telephone	4	10590	1.322	1.14	1.54	<0.001	5.91	0.116	49.3

Subgroup analyses = intervention features

<i>Individual</i>	16	15256	1.680	1.40	2.02	<0.001	63.1	<0.01	76.2
<i>Group-based</i>	5	2378	1.633	1.36	1.96	<0.001	3.42	0.491	0.00
<i>Individual + Group</i>	8	3636	2.463	1.43	4.23	0.001	93.8	<0.01	92.5
<i>BCTs; 3 or less</i>	17	15433	1.660	1.34	2.05	<0.001	105.5	0.001	84.8
<i>BCTs; 4 or more</i>	13	6557	2.268	1.78	2.89	<0.001	50.057	0.001	76.0

Note: BSE, breast self-examination; CBE, clinical breast examination; ITT, intention to treat.

BOLD represents statistically significant benefit of CBHW interventions.

Figure legends

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

Figure 1. PRISMA flow diagram of study selection

Figure 2. Meta-analysis of cancer screening adherence following CBHW interventions in comparison to control conditions. Box size represents study weighting. Diamond represents overall effect size and 95% confidence intervals.

For Peer Review

Are community-based lay health worker interventions an effective approach for ~~cancer~~
~~prevention and~~ early diagnosis of cancer? A systematic review and meta-analysis

Sarah Bellhouse¹, Lorna McWilliams¹, Joseph Firth^{2,3}, Janelle Yorke^{1,4}, & David P.
French⁵

Running title: ~~LCB~~HWs, and Early Diagnosis of Cancer ~~and Cancer Prevention~~

Authors' affiliations:

¹Christie Patient Centred Research Group, School of Oncology, The Christie NHS Foundation
Trust, UK

²Division of Psychology and Mental Health, School of Health Sciences, University of
Manchester, UK

³NICM, School of Science and Health, University of Western Sydney, Australia

⁴Division of Nursing, Midwifery and Social Work, School of Health Sciences, University of
Manchester UK

⁵Manchester Centre for Health Psychology, School of Health Sciences, University of
Manchester, UK

Corresponding author:

Sarah Bellhouse, Christie Patient Centred Research Group, School of Oncology, The Christie
NHS Foundation Trust, Wilmslow Road, Withington, Manchester, M20 4BX, UK. Phone: 0161
918 2451; E-mail: sarah.bellhouse@christie.nhs.uk

Word count: 6,259 ~~6,000~~

Figures/tables: 4

Abstract

Objective: This systematic review aimed to assess the effectiveness of ~~lay~~ community-based health worker (LCBHW) interventions for early detection of cancer ~~and cancer prevention~~. Secondary aims were to consider the extent that interventions were based on theory, and potential moderators including behaviour change techniques (BCTs).

Methods: Six databases were searched for randomized controlled trials. Random-effects meta-analyses were applied to 30 eligible studies with a cancer screening outcome.

Results: Participation in LCBHW interventions was associated with increased receipt of screening (OR =1.901, 95% CI: 1.60-2.26, p<0.001) for breast, cervical and bowel cancer. Larger effect sizes were observed in participants previously non-adherent with recommended schedules of cancer screening. 25/30 studies were conducted with ethnic minority groups. Only 157 (459%) studies explicitly reported a theoretical foundation for intervention. The number of BCTs used by LCBHWs had a trend level association with observed effect size (p=0.08). Study quality was generally poor and common limitations were inadequate blinding and reliance on self-reported outcomes. ~~Only two studies considered the LHW approach for reducing cancer related lifestyle behaviours.~~

Conclusions: LCBHW interventions are an effective resource for increasing uptake of all three types of cancer screening in ethnic minority groups. Those previously non-adherent with recommended schedules of cancer screening benefitted the most from the LCBHW approach. However, better quality studies based on more explicit evidence-based theory are needed to optimise the effectiveness of LCBHW interventions on screening uptake. Further research is

needed to ascertain whether ~~L~~CBHWs can help promote symptom recognition and help-seeking behaviour to facilitate early diagnosis of cancer. ~~lifestyle behaviour change to reduce cancer risk factors.~~

Keywords: behaviour change techniques, cancer, ~~cancer prevention,~~ early diagnosis, ~~lay~~ community health worker, meta-analysis, oncology and systematic review

For Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1. Background

In 2013, The World Health Organization (WHO) published their global action plan for the prevention and control of non-communicable diseases, including cancer.¹ ~~They recommend providing community based health promotion services to reduce behavioural cancer-related risk factors including tobacco smoking and physical inactivity. However, t~~The WHO recognize that not all cancers are preventable and so health services are urged to focus on diagnosing cancer earlier in order to increase survival rates and reduce costs associated with treating the disease.² To facilitate this, more interventions aimed at ‘down-staging’ cancers such as increasing uptake of screening programmes are warranted.³

Even though recognition of cancer signs and symptoms are relatively high⁴, attendance rates for cancer screening have decreased in recent years in the UK and USA.⁵⁻⁷ Barriers to attending screening or raising a cancer-related health concern with healthcare professionals remain including; language/cultural barriers, embarrassment/fear and perceptions of wasting doctors’ time.⁸⁻¹⁰ ~~Evidence also suggests that public awareness of the links between cancer and lifestyle risk behaviours such as excessive alcohol consumption and obesity remains low.~~

One approach to overcoming barriers towards cancer screening and early diagnosis is using ~~volunteer~~ Lay Health Workers (LHWs) i.e., any health worker carrying out functions related to health care delivery who does not have any formal professional or paraprofessional qualifications¹¹. ~~non-professionals trained to deliver cancer prevention and early detection messages who help connect the community and healthcare providers.~~¹² LHW roles in a cancer context

include providing education to raise cancer awareness and overcoming individual barriers to attending screening. Two LHW models have been proposed in the literature, differentiated by setting: community based and clinic/hospital based.¹³ Although there is overlap in tasks completed by both types of LHW, community-based health workers (CBHWs) act as a liaison facilitating initial access between individuals and healthcare settings.^{12, 14} In contrast, LHWs based in clinic and hospital settings, commonly referred to as patient navigators, offer guidance to persons with an abnormal cancer screening test or a cancer diagnosis to access the cancer care system.^{15, 16} The present review will focus on CBHWs only as they provide the earliest possible opportunity to promote early cancer diagnosis.

Several systematic reviews have examined the effects of ~~L~~CBHW interventions on cancer outcomes, most commonly cancer screening uptake ~~on cancer screening uptake~~^{13, 17-21} ~~For instance,~~ Two previous systematic reviews which applied meta-analytic techniques found that ~~L~~CBHWs can improve breast cancer screening uptake, with small ~~to moderate~~ effects odds ratios of 1.05¹¹ and 1.06²² ~~and 1.27~~ reported.

Although these previous systematic reviews are useful, they have ~~four~~ five limitations that the present research aims to address. Firstly, the searches in these previous ~~se~~ systematic reviews were conducted some time ago (2001 and 2008)~~(2008 and 2009)~~, so there is a need to update systematic review evidence in this area. Secondly, previous reviews that have included quantitative estimates of effects on screening attendance have only examined mammography uptake, one of several available screening programmes in many countries. Since then, more recent studies have examined the effects of ~~L~~CBHWs on other forms of screening²³⁻²⁵, potentially allowing quantitative estimates of the effects of ~~L~~CBHW interventions on these other

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

kinds of screening. ~~Thirdly, previous reviews have not used a rigorous assessment to assess~~
~~how risk of bias of these studies affects their findings. Fourth~~Thirdly, previous reviews have
not considered the use of theory underpinning intervention development on effectiveness beyond
listing theories mentioned. Consequently, it is difficult to assess the extent to which these
theories are used in the design, analysis and interpretation of review results. ~~Fifth~~Fourth,
previous reviews have not assessed how the use of behaviour change techniques (BCTs) may
enhance ~~increase cancer prevention and~~ early detection outcomes. BCTs have been defined as
“observable, replicable, and irreducible component(s) of an intervention designed to alter or
redirect causal processes that regulate behaviour” (p82)²⁶, and have been shown to moderate the
effects of interventions for other behaviours.²⁷ Thus, previous reviews have not clearly described
the active intervention ingredients that ~~L~~CBHW interventions include.

The aim of the present review was to systematically identify and critically review studies that
investigate the effectiveness of ~~L~~CBHWs in promoting outcomes pertinent to ~~cancer prevention~~
~~and~~ early cancer diagnosis including screening, symptom recognition, early detection, ~~reducing~~
~~lifestyle-related risk factors~~ and help-seeking behaviour. Specific objectives were to:

- a) determine the effectiveness of lay health led interventions in targeting outcomes related
to early detection of cancer, with the expectation that screening uptake will be the likely
focus considering previous reviews in this area.
- b) identify the extent to which risk of bias may affect intervention effectiveness.
- c) assess the extent to which ~~L~~CBHW interventions are underpinned by a theoretical
foundation and determine the prevalence and types of BCTs included in interventions.

d) examine potential moderators of intervention effectiveness, including type of screening programme, mode of delivery, intervention setting, and use of BCTs.

2. Methods

2.1. Search strategy

This systematic review followed the PRISMA statement, with no ethical approval required.²⁸

Electronic database searches were conducted of MEDLINE, Embase, BNI, CINAHL, PsycINFO & AMED in May 2016, and updated in April 2017. No date restrictions were applied for any searches. A broad search strategy was used to identify relevant articles and variation of index terms across databases was taken into account. For the full search strategy for each database, refer to Appendix S1.

In addition to database searches, forward and backward citation searches were conducted. Companion papers were retrieved where necessary to ascertain further information about intervention development and content and LCBHW selection/training.

2.2. Eligibility criteria

Only English-language research articles published in ~~from~~ peer-reviewed journals were included in the review. Studies were included if they met the following criteria:

(1) Participants: general population (≥ 18 years).

- (2) Interventions were delivered by a **LCBHW** who did not require formal professional or paraprofessional education/qualifications to complete the role. The role of the CBHW was to facilitate initial engagement with healthcare providers and access to services related to early cancer diagnosis e.g. cancer screening or visiting the GP after identifying a potential cancer symptom. Therefore studies delivered in primary care settings would be eligible if the person was attending for a routine visit unrelated to cancer. Studies whereby CBHWs were providing follow up support for those already engaged with cancer related healthcare were excluded. Studies were excluded if **LCBHW** input could not be assessed where healthcare professionals were also involved. Interventions were included whether the CBHW did or did not receive payment for their work.
- (3) Controls: studies had to have at least one non **LCBHW** comparator arm, with no other restriction placed upon the nature of the comparison with the intervention group.
- (4) Outcomes: studies had to measure an outcome that promoted ~~prevention or~~ early diagnosis of cancer at baseline and post-intervention e.g. uptake/intention to complete cancer screening programmes or any measure of cancer symptom awareness/beliefs, knowledge of cancer risk factors, benefits of early detection and help seeking behaviour/confidence to detect a change that might be cancer. There had to be an explicit link between the targeted outcome and cancer.
- (5) Studies: RCTs and cluster RCTs were included. Only randomized trials with at least one comparator arm were included in this review because these study designs provide the strongest evidence for evaluating effectiveness of interventions.²⁹

2.3. Study selection

All studies identified during the database search were assessed for relevance in a two-stage screening process; firstly the studies were assessed based on the information contained in the title and abstract. If at this stage the study appeared to meet the inclusion criteria, or if this was unclear, the full article was retrieved. Papers selected for retrieval were primarily assessed by one reviewer (SB) to determine inclusion given the clearly defined a-priori criteria. In ambiguous cases, additional reviewers were consulted (LM, JY, DF).

2.4. Data extraction

Detailed information on sample demographics, **LCBHW** characteristics (including selection/training processes) and intervention characteristics was extracted and an example extraction form is available in Appendix S2. Relevant information was also extracted to code theory use, assess BCT prevalence and judge risk of bias, coded by one reviewer (SB). Five articles were double coded by two reviewers (SB, LM) to establish agreement. During the double coding process, advice was sought from a third reviewer (DF) regarding definitions of terminology to ensure consistency and fairness in coding. Substantial agreement was indicated for theory coding (chance-corrected $\kappa=.72$) and risk of bias judgements (chance-corrected $\kappa=.90$) and moderate agreement for BCTs (chance-corrected $\kappa=.0.55$). However it is not recommended to use the Kappa statistic when coding the BCT taxonomy due to the high likelihood of BCTs being absent artificially lowering observed Kappa statistics.³⁰ Given this, reporting percentage agreement is more appropriate; this was almost perfect at 97%. ~~it was agreed that the majority of the potential 93 BCT techniques were not present, percentage agreement may better reflect which was high at 97%.~~ Due to high agreement, one reviewer (SB) proceeded to code

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 | the remaining 30 articles and advice was sought from a third reviewer (DF) on an adhoc basis.

2 | ~~Any disagreements were resolved through discussion with a third reviewer (DF).~~

3 | **Theory application.** The Theory Coding Scheme³¹, a coding framework developed to
4 | assess extent of behaviour change theory use was used to code reported theory application in
5 | included articles. The framework consists of 33 questions which are rated “yes”, “no”, “don’t
6 | know” or “n/a”. It has previously been used in systematic reviews to code theory use based on
7 | intervention reports.³² The Theory Coding Scheme assesses the extent to which intervention
8 | techniques are explicitly linked to theoretical constructs. A theoretical construct is defined as a
9 | concept within a theory which predicts behaviour and is amenable to change e.g. perceived
10 | susceptibility in the Health Belief Model.³³ Percentages were calculated to assess the number of
11 | studies scoring “yes” to each question. An overall theory score (range 0-8) was calculated using
12 | the answers to items 3 to 11.³²

13 | **Behaviour change technique use.** A hierarchical taxonomy of 93 BCTs was used to
14 | code the content of the interventions.²⁶ The most recent hierarchical list was used, with published
15 | definitions guiding coding for each technique. The lead coder (SB) completed the online training
16 | resource for the BCT taxonomy. A BCT was not coded as present unless the text explicitly
17 | linked the technique to both the named target behaviour and the named population. For example,
18 | “**LCB**HWs helped participants identify their barriers to cancer screening and generated possible
19 | solutions to help overcome the barriers” adequately describes the problem solving BCT whereas
20 | stating that “barriers to cancer screening were discussed” is insufficient. Percentages were
21 | calculated to assess the proportion of studies using each BCT.

Risk of bias. Using the Cochrane Collaboration's tool for assessing risk of bias³⁴, a judgement of ~~low, unclear or high~~ risk of bias was made for items related to randomization and blinding procedures, incomplete data assessment, selective reporting and any other sources of bias. The additional guidance provided by the Cochrane Collaboration was followed when deciding between low, unclear or high risk judgements.

2.5. Statistical analyses

Meta-analyses of screening attendance measures were performed in Comprehensive Meta-Analysis 2.0.³⁵ To account for the expected heterogeneity between studies, a random-effects model was applied.³⁶ First, 'adherence to cancer screening' was calculated as a pooled odds ratio (O.R.) comparing the total numbers of participants who had taken part in screening for breast cancer, colorectal cancer or cervical cancer following ~~LCB~~HW interventions versus control conditions. Breast self-examination (BSE) and/or clinical breast examination (CBE) adherence data were not classified as forms of cancer screening in these analyses. Data from both medical records and self-report measures were used for analysis. Where studies had reported this separately, a mean O.R. was calculated for medical record and self-report data and used in the analysis. Similarly, where studies which had reported multiple cancer screening outcomes, a mean O.R. was calculated from all eligible measures within each respective study.

The secondary outcome was 'Uptake of cancer screening amongst non-adherent samples'. "Non-adherent" refers to individuals, who at the time of participation in the study were non-compliant with age appropriate recommended schedules of cancer screening. Thus "uptake" refers to the total number of non-adherent individuals who attended cancer screening after receiving a

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

LCBHW intervention (or control condition). Data from those studies which included only non-adherent samples from the outset, and those studies which reported screening uptake among non-adherent sub-groups of standard samples were used.

Heterogeneity between studies was quantified as Cochran’s Q (with respective p-value) and I² values.³⁷ Funnel-plots were generated to assess the possibility of publication bias influencing the main analyses and Egger’s test³⁸ and Begg & Mazumdar’s test³⁹ were applied to quantify the risk of publication bias. Where either was significant, a trim-and-fill analysis was applied to recalculate the O.R. effect of **LCB**HW interventions after removing all studies which could potentially be introducing publication bias.⁴⁰

Sensitivity analyses examined the size of main effects (i) only among trials with full outcome data or intention-to-treat analyses, and (ii) when using only medical record data or self-report measures alone.

Subgroup analyses were used to investigate four potential moderators of overall intervention effect. Firstly, the extent to which effects of **LCB**HW interventions on attendance were found for specific cancer types was examined, specifically breast cancer (mammography), colorectal cancer (any measure due to small number of included studies), or cervical cancer (Pap test), individually. As the BSE and CBE data still related to an outcome of interest (early detection of cancer symptoms), it was also included in this analysis. Secondly, moderator analyses considered which settings may be most effective for delivering **LCB**HW interventions to improve cancer screening adherence; comparing pooled effect sizes of interventions delivered in the home, community, ~~primary care settings~~ and those delivered by telephone only. A third subgroup analysis explored modes of delivery to assess which may be most effective to improve cancer

screening adherence; comparing pooled effect sizes of interventions delivered individually, in a group format and those delivered using a combination approach (individual and group).⁴¹ Finally, a mixed-effects meta-regression was performed to explore the relationship between two continuous moderators (number of BCTs applied and Theory Coding Scheme score) and intervention effect size.

3. Results

3.1. Search results

The searches identified 2493 results; 123 full text versions were retrieved and assessed, of which 335 articles were eligible for inclusion (screening process in Figure 1).

[Figure 1 insert here]

3.2. Included studies and participant details

Twenty individually randomized controlled trials and 135 cluster RCTs were included; 302 were conducted in the USA, two in a US-Mexico border region and one was conducted in Belgium.

The majority of studies focused on female participants from ethnic minorities, with only nine ten of the eligible studies including participants who were male (mean = 31.34%, range 16.4-50.0).

The mean age of participants was more than 50 years in 178 studies, 104 studies had a mean age less than 50 years, and six did not specify the average sample age. The average length of follow-up across all studies was six eight months, ranging from immediately post-intervention to 24 months. For more key study characteristics see Appendix S3.

3.2.1. Selection and training processes

1
2
3 1 A selection process for the **LCBHWs** was described in k=7 (2**10**%) studies⁴²⁻⁴⁸, which included
4
5 2 assessment of desirable skills/experience⁴⁴⁻⁴⁶, personality characteristics^{42, 43, 45, 48} and
6
7
8 3 practicalities such as availability.^{43, 45, 47} Gender concordance of **LCBHWs** with the target
9
10 4 population was reported in k=2**23** (6**76**%) studies.^{23-25, 42-60}. **LCBHWs** from the same cultural
11
12 5 background as the target audience were selected in k=18 (5**51**%) studies.^{23-25, 42, 43, 48, 50, 52-54, 57-64}
13
14
15 6 One study included personal experience of breast or cervical cancer as a selection criterion for
16
17 7 **LCBHWs**.⁵¹
18
19
20 8 Some discussion of the training **LCBHWs** received was reported in k=2**79** (8**23**%) studies.^{23, 24,}
21
22 9 ^{42-60, 62-67} The most commonly used pedagogic methodologies for training **LCBHWs** were visual
23
24 10 aids/flip charts, practice intervention sessions, and role-playing. A competency assessment
25
26 11 measure was described in k=1**89** (5**54**%) studies including; ongoing supervision throughout
27
28 12 intervention period, practice sessions and a written examination..^{23, 24, 42, 44, 45, 47, 49, 52-55, 59, 60, 62-66}
29
30
31 13 A form of research skills training including the principle of randomization and the importance of
32
33 14 protocol adherence was reported in k=12 (3**64**%) studies.^{24, 42, 44, 45, 49, 50, 52, 53, 55, 62-64} The
34
35 15 duration of training was described in k=1**78** (5**21**%) studies and the average duration was 11
36
37 16 hours (range: 4-24 hours).^{24, 42, 44, 47-49, 51-55, 59, 60, 62, 64-66} For the majority of studies, training was
38
39 17 conducted in one session or a series of sessions before the intervention commenced with only
40
41 18 k=3 (9%) reporting booster, refresher sessions at least once throughout the intervention period.^{45,}
42
43 19 ^{55, 62}

50 3.2.2. Theory application

51
52 21 A theory base was explicitly reported (i.e., coded yes to item 5 of Theory Coding Scheme) in
53
54 22 k=1**57** (4**59**%) interventions.^{23, 25, 43-45, 53-55, 59, 60, 62-64, 67, 68} Of these 1**57** studies, a combination of

theories was reported in k=89 (53%) (range 2-4).^{23, 25, 43, 45, 54, 60, 63, 64} The Transtheoretical Model was applied in k=810 (539%) studies and the Health Belief Model was reported in k=78 (47%) studies. At least one explicit link between an intervention technique and a theory-relevant construct was reported in k=67 (401%) interventions.^{23, 25, 60, 62, 64, 68} At least one explicit link between a theory-relevant construct and an intervention technique was reported in k=910 (6059%) interventions.^{23, 54, 55, 60, 62-64, 67, 68} Theoretically relevant constructs (self-efficacy and perceived severity) were measured pre and post-intervention in k=23 (69%) studies.^{44, 55} Only one study discussed the results in relation to the theoretical basis of the intervention.⁵⁵ Overall, the Theory Coding Scheme illustrated poor theory application; of the 335 interventions, k=18 (541%) scored zero and the highest score was four out of a possible eight. This pattern of results precluded assessment of theory score as a moderator variable.

3.2.3. Behaviour change technique use

Overall, 21 of 93 possible BCTs were present in the interventions included in this review. Interventions incorporated between zero and nine BCTs with a mean of four BCTs in each intervention. Table 1 demonstrates that the most commonly observed techniques involved providing practical social support, prompts and cues and problem solving. This remained the case when results were limited to the BCTs delivered by the LCBHW only and other components such as videos and media campaigns were discounted.

[Table 1 insert here]

3.2.4. Risk of bias

Overall, study quality was poor (see Appendix S4). Only one study had a published protocol.^{67,}

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

⁶⁹ Therefore the risk of bias for selective reporting was coded high for all remaining studies. Other areas of common bias were reliance on self-reported outcomes, inadequate blinding of key personnel and attrition bias. Attrition rates larger than 25% were reported in k=10 (~~30~~29%) studies.^{43, 44, 46, 51, 55, 58, 65, 68, 70, 71}

3.3. *Effects of lay health worker interventions on cancer screening adherence*

Results of all meta-analyses are displayed in **Table 2**. Adherence screening data for the primary outcome was available from a total of 21,990 participants across 30 studies; 11,487 were assigned to ~~LCB~~HW interventions, 10,503 to control conditions.^{23-25, 42-60, 62-68, 72} Random-effects meta-analyses found that ~~LCB~~HW interventions resulted in significantly greater uptake of overall cancer screening (see Figure 2) than control conditions (O.R.=1.90, 95% CI=1.60-2.26, p<0.001), although there was considerable heterogeneity among study findings (Q=199.9, p<0.01, I² = 85.5%).

[Figure 2 insert here]

3.4. *Publication bias and sensitivity analyses*

Although the risk of publication bias was not statistically significant according to Begg & Mazumdar’s test (Kendall’s t=0.15, p=0.24), Egger’s test did indicate publication bias (p=0.007). Nonetheless, the Duval and Tweedies trim-and-fill analysis showed that, after removing 12 studies which may introduce publication bias, ~~LCB~~HW interventions still significantly improved screening adherence more than control conditions (O.R.=1.40, 95% C.I.=1.15-1.69).

A sensitivity analysis was performed on the 19 studies which used ITT analyses or complete outcome data, with 16,300 participants in total.^{23, 42, 45-47, 49-51, 53, 54, 56-58, 62, 63, 65-67, 72} This found

that **L****C****B**HW interventions also resulted in increased cancer screening adherence on an intention-to-treat basis (O.R.=1.98, 95% CI=1.57-2.49, $p<0.001$) again with significant heterogeneity between studies ($Q=146.2$, $p<0.01$, $I^2=87.7\%$).

Further sensitivity analyses showed that **L****C****B**HW interventions resulted in significantly greater adherence to cancer screening than control conditions when using only medical records^{25, 47, 49, 50, 56, 58, 66, 72} ($N=8$, $n=11658$, O.R.=2.092, 95% CI=1.36- 3.21, $p=0.001$) or self-report data^{24, 25, 42, 43, 46, 48, 51, 52, 55-60, 62-64, 68} ($N=18$, $n=8620$, O.R.=1.686, 95% CI=1.40-2.03, $p<0.001$).

3.5. Effects of lay health worker interventions on cancer screening uptake in non-adherent samples

We also examined the effect of **L****C****B**HW interventions on uptake of any cancer screening among non-adherent samples (see Appendix S5). Across 20 studies with 12,769 previously non-adherent individuals, LHW interventions resulted in significantly greater likelihood of receiving cancer screening at follow-up compared to control conditions^{23, 24, 42, 44-49, 51, 53-55, 57, 58, 65-68, 72} (O.R.=2.40, 95% C.I.=1.85-3.11, $p<0.001$). However, there was statistical evidence of both between-study heterogeneity ($Q=149.1$, $p<0.01$, $I^2=87.3\%$) and publication bias (Egger's $t=2.33$, $p=0.03$). Nonetheless, the results still significantly favoured LHW interventions after applying the trim-and-fill analysis ($N=9$, O.R.=1.58, 95% C.I.=1.19- 2.09).

3.6. Factors associated with intervention efficacy

Further analyses were performed to examine effects of **L****C****B**HW interventions on the primary outcome (i.e. adherence to cancer screening) when (i) focusing on specific cancer screening

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

types, (ii) comparing different settings of delivery, (iii) comparing different modes of delivery, and (iv) number of BCTs used in interventions (see Table 2).

[Table 2 insert here]

Significant benefits of **LCB**HW interventions were observed across each type of screening measure, including mammography (k=13, n=9641, O.R.=1.923, 95% CI=1.44-2.57, p<0.001), Pap testing (k=15, n=5276, O.R.=1.922, 95% CI=1.39-2.64, p<0.001) and colorectal cancer screening (k=7, n=9425, O.R.=1.983, 95% CI=1.31-3.01, p<0.001). Furthermore, the benefits of **LCB**HW interventions were demonstrated for both BSE (k=4, n=1493, O.R.=1.554, 95% CI=1.17-2.07, p=0.003) and CBE (N=5, n=2582, O.R.=1.528, 95% CI=1.19-2.00, p=0.001).

Twenty-six studies used home or community settings, and found **LCB**HW interventions were effective when delivered in the home (k=13, n=5779, O.R.=1.808, 95% CI=1.40-2.34, p<0.001) or the community (k=13, n=5621, O.R.=2.249, 95% CI=1.63-3.11, p<0.001). Four studies examined ~~Only two studies each examined primary care or~~ telephone-only interventions, ~~and which~~ ~~1st telephone interventions did~~ demonstrated an overall benefit for **LCB**HWs (k=~~42~~, n=~~105904402~~, O.R.=1.3~~2219~~, 95% CI=1.14-1.5~~43~~, p<0.001), ~~primary care interventions did not (k=2, n=6188, O.R.=1.396, 95% CI=0.96-1.97, p=0.085).~~

Regarding mode of delivery, **LCB**HW interventions were equally as effective when delivered individually (k=16, n=15256, O.R.=1.680, 95% CI=1.40-2.02, p<0.001) or in a group format (k=5, n=2378, O.R.=1.633, 95% CI=1.36-1.96, p<0.001). A combined delivery approach (individual and group elements present) was found to be most effective (k=8, n=3636, O.R.=2.463, 95% CI=1.43-4.23, p=0.001).

Mixed-effects meta-regression found that number of BCTs used in **L****C****B****H****W** interventions held a trend-level association with observed effect size (see Appendix S6); as the O.R. for cancer screening adherence from **L****C****B****H****W** interventions increased with the number of BCTs used ($B = 0.061$, $S.E. = 0.036$, $Z = 1.71$, $p = 0.088$). A post-hoc subgroup analysis was conducted to examine the effects of **L****C****B****H****W** interventions which used a high number of BCTs (four or more) vs. those which used a low number of BCTs (three or less) (Table 2; see Appendix S7). These cut offs were selected in light of the average intervention containing four BCTs. **L****C****B****H****W** interventions with a high number of BCTs increased cancer screening with an odds ratio of 2.27 ($k = 13$, $n = 6557$, 95% C.I. = 1.78- 2.89, $p < 0.001$), whereas those with low use of BCTs increased cancer screening by only O.R. = 1.66 ($k = 17$, $n = 15433$, 95% C.I. = 1.34-2.05, $p < 0.001$), although the difference between High and Low BCT subgroups fell short of statistical significance ($Q = 3.613$, $p = 0.057$).

The finding of poor theory application precluded assessment of theory score as a moderator variable.

~~3.7. Effects of lay health worker interventions on cancer preventative behaviours~~

~~Two studies examined the effect of LHW interventions on promoting cancer preventative behaviours; improving diet and increasing physical activity levels.~~ ^{56, 61} **~~Havas~~**⁵⁶ **~~found significant improvements in self-reported daily consumption of fruits and vegetables among both intervention and control groups at follow-up.~~** **~~Campbell~~**⁶¹ **~~compared a tailored print and video only (TPV) intervention, a LHW only intervention and a combined intervention (TPV and LHW) with a control group. Neither of the two interventions~~**

~~involving LHWs resulted in significantly greater recreational exercise or increased fruit and vegetable consumption at follow-up when compared to the control group.~~

4. Discussion

4.1. Summary of main findings

The results from this systematic review and meta-analysis indicate that **LCBHW** interventions are associated with a statistically significant increase in cancer screening attendance, with a stronger effect size observed for participants previously non-adherent with recommended schedules of cancer screening. Similar odds ratios were found for screening for breast, cervical and colorectal cancer. The overall pattern of results was robust to sensitivity analyses, with similar effect sizes found irrespective of source of outcome measure (self-report or medical records), or whether intention-to-treat analyses were conducted or not. There was little use of theory in these interventions, making it difficult to identify the means by which the interventions changed screening attendance. The interventions generally did not use many BCTs, in line with the apparent lack of use of theory to develop interventions. Methodological quality of included studies was generally poor.

4.2. Strengths & limitations

The findings of this review build upon the results of previous smaller reviews examining mammography screening only.^{11, 22} This review has been the first to illustrate the effectiveness of **LCBHW** interventions across all types of cancer screening and other measures of early

detection (BSE and CBE). This allows the present review to draw conclusions relating to the efficacy of **LCBHW** interventions across screening for breast, cervical and colorectal cancer. Further the present review has been the first to apply the BCT taxonomy and Theory Coding Scheme ~~and a rigorous risk of bias tool~~ to cancer specific **LCBHW** interventions.

A limitation of the present review was that, as many terms are used to describe **LCBHWs**, it may be possible that we did not extract all relevant articles in the existing literature. However, to avoid this, a systematic, comprehensive electronic search was conducted using 45 different terms for **LCBHW** after a consultation with a trained health science librarian. The present review identified many more studies than did previous systematic reviews, and included studies identified by these previous reviews, indicating that this was not a major problem.

There were however, limitations of the primary evidence base that the present review has identified, but which limit the conclusions that can be drawn. First, substantial heterogeneity was found across the analyses. This between-study heterogeneity is unsurprising, given the clear differences between CBHW interventions in terms of the intervention components used, cancers screened for, guidelines in place at screening, populations studied and outcome measures applied, all sources of heterogeneity which are typical to meta-analytic research. Although this heterogeneity was statistically accounted for by the random-effects model applied, it is acknowledged that the strength of the conclusions from this review are limited as a result. Second, First, the research base itself was limited to cancer screening outcomes and heterogeneity prevented the combination of secondary outcome data into meaningful categories to examine effectiveness of **LCBHW** interventions in other areas of early cancer diagnosis

1 awareness (e.g., knowledge, intention, self-efficacy). It was also notable that all but one of the
2 included studies were implemented in the USA and therefore caution is needed to generalize and
3 apply findings to countries with different healthcare systems, cancer screening guidelines and
4 ethnic compositions.

5
6 The review identified several methodological biases present in the primary studies; high rates of
7 attrition, reliance on self-reported outcomes, and failure to report blinding which could have
8 contributed to biased estimates of interventional efficacy. However it is important to note that
9 there is an inherent difficulty with blinding in trials assessing the effectiveness of CBHWs. In the
10 majority of cases CBHWs recruit participants from their own social networks/communities as
11 shared characteristics between the CBHW and the audience facilitate learning and increase the
12 likelihood that participants will model the desired behaviour.⁷³ Therefore blinding may interfere
13 with one of the presumed mechanisms of effectiveness. Nevertheless, sensitivity analyses
14 suggested that these methodological limitations did not unduly affect the overall conclusions.
15 Furthermore, publication bias was indicated but after removing studies with smaller sample
16 sizes, improvements in screening attendance in **LCBHW** conditions remained significant.

17
18 *4.3. Interpretation of main findings*

19
20 This study has been the first to illustrate the effectiveness of **LCBHW** interventions beyond
21 mammography screening. Furthermore this meta-analysis yielded higher odds ratios than
22 previous reviews (1.90-2.40), indicating larger effects of **LCBHW** interventions than previous

1 reviews have suggested.^{11, 22} Subgroup analyses revealed similar effects for breast, cervical and
2 colorectal cancer screening.

3
4 The review provides an updated description of **LCBHW** training characteristics, crucial to the
5 successful implementation of **LCBHW** interventions.⁷⁴ Marked heterogeneity was present in the
6 reporting of selection and training processes in **LCBHW** literature. A conceptual model has been
7 proposed to standardize the reporting of such processes in the future.⁷⁵ This transparency will
8 facilitate learning for future intervention development. However, how training content is selected
9 remains unclear, and the lack of readily reported information about components of training
10 hinders the development of evidence based training packages.

11
12 The present review explored potential moderators of effectiveness to provide practical
13 recommendations for future **LCBHW** intervention development. Moderator analyses
14 demonstrated that **LCBHW** interventions were equally as effective across all types of cancer
15 screening. Subgroup analyses revealed that interventions were effective when delivered in
16 community and home settings, over the telephone and when **using** both individual and group
17 modes of delivery were used. Only one of the included interventions was delivered in a primary
18 care setting.⁷⁰ However as it measured knowledge changes only, there was no eligible data to
19 include in the meta-analysis of effects on screening behaviour. No beneficial effect of the
20 CBHW was found when compared to usual care but ~~The current evidence did not support the~~
21 ~~effectiveness of the LHW approach in primary care settings. However, only two studies~~
22 ~~used this type of setting and so~~ additional research is needed to establish whether delivering a
23 **LCBHW** intervention in primary care settings has the potential to be effective.

1
2
3
4 1
5
6 2 An in-depth analysis with Theory Coding Scheme items³¹ revealed substantial evidence of
7
8 3 ‘theory inspired’ interventions, whereby theory is not used to identify methods to change
9
10 4 behaviour, as evidenced by poor linkage between BCTs and theoretical constructs.⁷⁶ This
11
12 5 absence of an explicit theoretical basis for interventions makes it difficult to identify why
13
14 6 interventions worked, and how future interventions could work better: it prevents an
15
16 7 accumulation of knowledge on what basis future **LCB**HW interventions should be
17
18 8 developed.^{77, 78} Few BCTs were generally used: **LCB**HWs were found to most frequently provide
19
20 9 practical support to participants, resolve barriers and prompt the desired behaviour. There was a
21
22 10 trend (p=0.057) towards the use of BCTs being positively associated with intervention
23
24 11 effectiveness; larger effect sizes were observed in studies using more than four BCTs (OR =
25
26 12 2.27) compared to those using three or fewer (OR = 1.66). Given that few BCTs were generally
27
28 13 used, this would have reduced the association between BCTs and effectiveness, due to a lack of
29
30 14 range. Given this, at the least the inclusion of more BCTs should be considered in future studies,
31
32 15 to examine whether this results in increased intervention effectiveness.
33
34
35
36
37
38
39 16
40
41 17 Of note was the exclusive emphasis on cancer screening behaviour observed in this review. Half
42
43 18 of the included studies measured secondary outcomes related to knowledge but this was limited
44
45 19 to awareness of screening procedures, the benefits of early diagnosis, and cancer risk factors.
46
47 20 International comparisons have reported greater endorsement of barriers to help-seeking in UK
48
49 21 adults⁷⁹, in particular regarding the perception of not wanting to waste the doctor’s time or
50
51 22 cause a fuss.⁸⁰ Despite public awareness campaigns increasing cancer symptom awareness, GP
52
53 23 approachability remains a barrier to early engagement with primary care⁸, and a lack of
54
55
56
57
58
59
60

engagement is more pronounced in lower socioeconomic groups.⁸¹ This suggests that broadening the CBHW remit to increasing symptom recognition and promotion of help-seeking behaviour is a worthwhile avenue to pursue, particularly in a UK context where barriers to help-seeking remain high.

~~Mixed results of effectiveness of LHW approaches were observed in the two included studies promoting cancer preventative behaviours. It is likely the effectiveness was adversely affected by implementation challenges; in one study, only 10% of people in the LHW only and combined groups reported having talked with a LHW.⁶¹ The lack of eligible explicit cancer risk-related lifestyle interventions delivered by LHWs is reflective of lifestyle interventions focusing predominantly on chronic diseases including cardiovascular diseases.⁷⁵ There is evidence that UK people were less likely to identify unhealthy diet, excessive alcohol consumption or physical inactivity as risk factors for cancer compared to heart disease⁷⁶, indicating a need for awareness interventions that may encourage risk reducing behaviour change.⁷⁷~~

4.4. Implications and future research directions

This review has demonstrated that **LCBHW** interventions are a promising approach to addressing cancer screening disparities in the US, particularly in ethnic minority groups. Notwithstanding limitations in evidence base, the evidence and size of effect obtained in this review support the implementation of **LCBHW** interventions to increase cancer screening in ethnic minorities. Based on the current evidence base, those previously non-adherent with recommended schedules of cancer screening are most likely to benefit.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1 However substantial work is still needed to fully elucidate the conditions key to intervention
2 effectiveness using methodologically sound studies in different populations. As such, the
3 following recommendations for future research are made:

4 a) Guidelines such as the Template for intervention description and replication (TIDieR)⁸²
5 should be used more to increase transparency and facilitate learning between researchers.
6 This would contribute to the identification of key mechanisms of behaviour change, the
7 most effective components of training packages and reduce heterogeneity prevalent
8 across studies.

9 b) Use of explicit theory in the development and evaluation of interventions, to target
10 hypothetical mediators of behaviour change, such as knowledge and intent, to increase
11 intervention effectiveness. The use of theory in evaluation of such interventions should
12 clarify the processes of change initiated by **LCB**HWs. This would help inform the need
13 for refinement in terms of intervention components and BCTs.

14 c) The use of a greater range of BCTs should be considered in future interventions, to allow
15 an assessment of whether this would result in greater intervention effectiveness,
16 compared to **LCB**HW interventions conducted to date.

17 d) Further exploring the influence demographic factors such as participant gender has on
18 **LCB**HW intervention effectiveness across all cancer screening programmes. There is a
19 clear need for more research using populations outside the US to assess whether such
20 interventions are more or less effective in different settings.

- e) Exploratory ~~Further~~ work should ~~needs to~~ be conducted to assess the feasibility of using CBHWs to increase symptom awareness and promote help-seeking behaviour. ~~improve awareness of cancer-related lifestyle factors and to establish the effectiveness of LHWs in this area as well as other areas of early diagnosis such as help-seeking behaviour.~~

5. Conclusions

In conclusion, this review has found that LCBHWs are an effective resource for increasing cancer screening uptake, particularly for those previously non-adherent with recommended schedules of cancer screening. It is yet unknown whether LCBHW interventions are an effective approach for to other areas of early diagnosis including symptom awareness and help-seeking behaviour. ~~reduce lifestyle-related cancer risk factors.~~ The number of explicitly described BCTs used was found to be positively associated with effect size, although this did not reach statistical significance. At present, these conclusions are almost entirely limited to the US healthcare context and ethnic composition and limited by poor methodological quality and substantial heterogeneity. As such it remains unknown whether the effectiveness of LCBHW interventions would translate to different countries or other areas pertinent to early cancer diagnosis such as help-seeking behaviour.

Conflicts of interest

The authors declare no potential conflicts of interest.

References

References marked with an asterisk indicate studies included in the systematic review

1. World Health Organization. Global action plan for the prevention and control of NCDs 2013-2020 [Internet]. World Health Organization; 2013. Available from: http://apps.who.int/iris/bitstream/10665/94384/1/9789241506236_eng.pdf?ua=1
2. World Health Organization. Guide to cancer early diagnosis [Internet]. World Health Organization; 2017. Available from: <http://apps.who.int/iris/bitstream/10665/254500/1/9789241511940-eng.pdf?ua=1>
3. Ott JJ, Ullrich A, Miller AB. The importance of early symptom recognition in the context of early detection and cancer survival. *Eur J Cancer*. **2009**;45:2743-8
4. CRUK. Cancer Awareness Measure (CAM) Key Findings Report; 2014 & Trends Analysis (2008-2014) [Internet]. 2014. Available from: http://www.cancerresearchuk.org/sites/default/files/cam_key_findings_report_-_2014_trends_analysis_v5.pdf
5. Health and Social Care Information Centre. Cervical Screening Programme - England, 2014-15 [Internet]. National Statistics; 2015. Available from: <http://content.digital.nhs.uk/catalogue/PUB18932/nhs-cervical-stat-eng-2014-15-rep.pdf>
6. Health and Social Care Information Centre. Breast Screening Programme - England, 2014-15 [Internet]. National Statistics; 2016. Available from: <http://content.digital.nhs.uk/catalogue/PUB20018/bres-scre-prog-eng-2014-15-rep.pdf>
7. Smith RA, Manassaram-Baptiste D, Brooks D, Doroshenk M, Fedewa S, Saslow D, et al. Cancer screening in the United States, 2015: A review of current American Cancer Society guidelines and current issues in cancer screening. *CA Cancer J Clin*. **2015**;65:30-54
8. Power E, Wardle J. Change in public awareness of symptoms and perceived barriers to seeing a doctor following Be Clear on Cancer campaigns in England. *Br J Cancer*. **2015**;112:S22-S6
9. Guessous I, Dash C, Lapin P, Doroshenk M, Smith RA, Klabunde CN. Colorectal cancer screening barriers and facilitators in older persons. *Prev Med*. **2010**;50:3-10
10. Smith LK, Pope C, Botha JL. Patients' help-seeking experiences and delay in cancer presentation: a qualitative synthesis. *The Lancet*. **2005**;366:825-31
11. Lewin SA, Dick J, Pond P, Zwarenstein M, Aja G, van Wyk B, et al. Lay health workers in primary and community health care. *The Cochrane database of systematic reviews*. **2005**. CD004015.
12. Witmer A, Seifer SD, Finocchio L, Leslie J, O'Neil EH. Community health workers: integral members of the health care work force. *Am J Public Health*. **1995**;85:1055-8
13. Hou S-I, Roberson K. A Systematic Review on US-Based Community Health Navigator (CHN) Interventions for Cancer Screening Promotion—Comparing Community- Versus Clinic-Based Navigator Models. *J Cancer Educ*. **2015**;30:173-86
14. Rhodes SD, Foley KL, Zometa CS, Bloom FR. Lay Health Advisor Interventions Among Hispanics/Latinos: A Qualitative Systematic Review. *Am J Prev Med*. **2007**;33:418-27
15. Freeman HP. A model patient navigation program. *Oncology Issues*. **2004**;19:44-6
16. Wells KJ, Battaglia TA, Dudley DJ, Garcia R, Greene A, Calhoun E, et al. Patient navigation: State of the art or is it science? *Cancer*. **2008**;113:1999-2010
17. Gibbons MC, Tyus NC. Systematic review of U.S.-based randomized controlled trials using community health workers. *Prog Community Health Partnersh*. **2007**;1:371-81

18. Islam NS, Zanowiak JM, Riley L, Nadkarni SK, Kwon SC, Trinh-Shevrin C. Characteristics of Asian American, Native Hawaiian, and Pacific Islander community health worker programs: a systematic review. *J Health Care Poor Underserved*. **2015**;26:238-68
19. Viswanathan M, Kraschnewski JL, Nishikawa B, Morgan LC, Honeycutt AA, Thieda P, et al. Outcomes and Costs of Community Health Worker Interventions: A Systematic Review. *Med Care*. **2010**;48:792-808
20. Wadler BM, Judge CM, Prout M, Allen JD, Geller AC. Improving Breast Cancer Control via the Use of Community Health Workers in South Africa: A Critical Review. *J Oncol*. **2011**;2011:H382-7
21. Kim K, Choi JS, Choi E, Nieman CL, Joo JH, Lin FR, et al. Effects of Community-Based Health Worker Interventions to Improve Chronic Disease Management and Care Among Vulnerable Populations: A Systematic Review. *Am J Public Health*. **2016**;106:e3-e28
22. Wells KJ, Luque JS, Miladinovic B, Vargas N, Asvat Y, Roetzheim RG, et al. Do Community Health Worker Interventions Improve Rates of Screening Mammography in the United States? A Systematic Review. *Cancer Epidemiol Biomarkers Prev*. **2011**;20:1580-98
23. *Byrd TL, Wilson KM, Smith JL, Coronado G, Vernon SW, Fernandez-Esquer ME, et al. AMIGAS: A multicity, multicomponent cervical cancer prevention trial among Mexican American women. *Cancer*. **2013**;119:1365-72
24. *Nguyen BH, Stewart SL, Nguyen TT, Bui-Tong N, McPhee SJ. Effectiveness of Lay Health Worker Outreach in Reducing Disparities in Colorectal Cancer Screening in Vietnamese Americans. *Am J Public Health*. **2015**;105:2083-9
25. *Paskett ED, McLaughlin JM, Lehman AM, Katz ML, Tatum CM, Oliveri JM. Evaluating the Efficacy of Lay Health Advisors for Increasing Risk-Appropriate Pap Test Screening: A Randomized Controlled Trial among Ohio Appalachian Women. *Cancer Epidemiol Biomarkers Prev*. **2011**;20:835-43
26. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *Ann Behav Med*. **2013**;46:81-95
27. French DP, Olander EK, Chisholm A, Mc Sharry J. Which Behaviour Change Techniques Are Most Effective at Increasing Older Adults' Self-Efficacy and Physical Activity Behaviour? A Systematic Review. *Ann Behav Med*. **2014**;48:225-34
28. Moher D, Liberati A, Tetzlaff J, Altman DG, Group P. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med*. **2009**;6:e1000097
29. Evans D. Hierarchy of evidence: a framework for ranking evidence evaluating healthcare interventions. *J Clin Nurs*. **2003**;12:77-84
30. Wood CE, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. Applying the behaviour change technique (BCT) taxonomy v1: a study of coder training. *Transl Behav Med*. **2015**;5:134-48
31. Michie S, Prestwich A. Are interventions theory-based? Development of a theory coding scheme. *Health Psychol*. **2010**;29:1-8
32. Prestwich A, Sniehotta FF, Whittington C, Dombrowski SU, Rogers L, Michie S. Does theory influence the effectiveness of health behavior interventions? Meta-analysis. *Health Psychol*. **2014**;33:465-74

1
2
3 1 33. Janz NK, Becker MH. The Health Belief Model: A Decade Later. *Health Educ Q.* **1984**;11:1-
4 2 47
5 3 34. Higgins JPT, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane
6 4 Collaboration's tool for assessing risk of bias in randomised trials. *BMJ.* **2011**;343:d5928
7 5 35. Borenstein M, Hedges L, Higgins J, Rothstein H. Comprehensive Meta Analysis. 2 ed.
8 6 Englewood, NJ: Biostat; 2005.
9 7 36. DerSimonian R, Kacker R. Random-effects model for meta-analysis of clinical trials: An
10 8 update. *Contemp Clin Trials.* **2007**;28:105-14
11 9 37. Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med.*
12 10 **2002**;21:1539-58
13 11 38. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple,
14 12 graphical test. *BMJ.* **1997**;315:629-34
15 13 39. Begg CB, Mazumdar M. Operating Characteristics of a Rank Correlation Test for Publication
16 14 Bias. *Biometrics.* **1994**;50:1088-101
17 15 40. Duval S, Tweedie R. Trim and Fill: A Simple Funnel-Plot-Based Method of Testing and
18 16 Adjusting for Publication Bias in Meta-Analysis. *Biometrics.* **2000**;56:455-63
19 17 41. Dombrowski SU, O'Carroll RE, Williams B. Form of delivery as a key 'active ingredient' in
20 18 behaviour change interventions. *Br J Health Psychol.* **2016**;21:733-40
21 19 42. *Lam TK, Mc Phee SJ, Mock J, Wong C, Doan HT, Nguyen T, et al. Encouraging
22 20 Vietnamese-American Women to Obtain Pap Tests Through Lay Health Worker Outreach and
23 21 Media Education. *J Gen Intern Med.* **2003**;18:516-24
24 22 43. *Navarro AM, Senn KL, McNicholas LJ, Kaplan RM, Roppé B, Campo MC. Por La Vida
25 23 model intervention enhances use of cancer screening tests among Latinas. *Am J Prev Med.*
26 24 **1998**;15:32-41
27 25 44. *O'Brien MJ, Halbert CH, Bixby R, Pimentel S, Shea JA. Community Health Worker
28 26 Intervention to Decrease Cervical Cancer Disparities in Hispanic Women. *J Gen Intern Med.*
29 27 **2010**;25:1186-92
30 28 45. *Paskett E, Tatum C, Rushing J, Michielutte R, Bell R, Foley KL, et al. Randomized Trial of
31 29 an Intervention to Improve Mammography Utilization Among a Triracial Rural Population of
32 30 Women. *J Natl Cancer Inst.* **2006**;98:1226-37
33 31 46. *Sung JF, Blumenthal DS, Coates RJ, Williams JE, Alema-Mensah E, Liff JM. Effect of a
34 32 cancer screening intervention conducted by lay health workers among inner-city women. *Am J*
35 33 *Prev Med.* **1997**;13:51-7
36 34 47. *Han H-R, Song Y, Kim M, Hedlin HK, Kim K, Ben Lee H, et al. Breast and Cervical
37 35 Cancer Screening Literacy Among Korean American Women: A Community Health Worker-
38 36 Led Intervention. *Am J Public Health.* **2017**;107:159-65
39 37 48. *Mock J, McPhee SJ, Nguyen T, Wong C, Doan H, Lai KQ, et al. Effective Lay Health
40 38 Worker Outreach and Media-Based Education for Promoting Cervical Cancer Screening Among
41 39 Vietnamese American Women. *Am J Public Health.* **2007**;97:1693-700
42 40 49. *Goelen G, De Clercq G, Hanssens S. A community peer-volunteer telephone reminder call
43 41 to increase breast cancer-screening attendance. *Oncol Nurs Forum.* **2010**;37:E312-7
44 42 50. *Hunter JB, de Zapien JG, Papenfuss M, Fernandez ML, Meister J, Giuliano AR. The Impact
45 43 of a Promotora on Increasing Routine Chronic Disease Prevention among Women Aged 40 and
46 44 Older at the U.S.-Mexico Border. *Health Educ Behav.* **2004**;31:18S-28S

51. *Jandorf L, Bursac Z, Pulley L, Trevino M, Castillo A, Erwin DO. Breast and cervical cancer screening among Latinas attending culturally specific educational programs. *Prog Community Health Partnersh.* **2008**;2:195-204
52. *Nguyen TT, Le G, Nguyen T, Le K, Lai K, Gildengorin G, et al. Breast Cancer Screening Among Vietnamese Americans: A Randomized Controlled Trial of Lay Health Worker Outreach. *Am J Prev Med.* **2009**;37:306-13
53. *Nuño T, Martinez ME, Harris R, García F. A Promotora-administered group education intervention to promote breast and cervical cancer screening in a rural community along the U.S.–Mexico border: a randomized controlled trial. *Cancer Causes Control.* **2011**;22:367-74
54. *Russell KM, Champion VL, Monahan PO, Millon-Underwood S, Zhao Q, Spacey N, et al. Randomized Trial of a Lay Health Advisor and Computer Intervention to Increase Mammography Screening in African American Women. *Cancer Epidemiol Biomarkers Prev.* **2010**;19:201-10
55. *Sadler GR, Ko CM, Wu P, Alisangco J, Castañeda SF, Kelly C. A Cluster Randomized Controlled Trial to Increase Breast Cancer Screening Among African American Women: The Black Cosmetologists Promoting Health Program. *J Natl Med Assoc.* **2011**;103:735-45
56. *Taylor VM, Carey Jackson J, Yasui Y, Kuniyuki A, Acorda E, Marchand A, et al. Evaluation of an outreach intervention to promote cervical cancer screening among Cambodian American women. *Cancer Detect Prev.* **2002a**;26:320-7
57. *Taylor VM, Hislop TG, Jackson JC, Tu S-P, Yasui Y, Schwartz SM, et al. A Randomized Controlled Trial of Interventions to Promote Cervical Cancer Screening Among Chinese Women in North America. *J Natl Cancer Inst.* **2002b**;94:670-7
58. *Taylor VM, Jackson JC, Yasui Y, Nguyen TT, Woodall E, Acorda E, et al. Evaluation of a Cervical Cancer Control Intervention Using Lay Health Workers for Vietnamese American Women. *Am J Public Health.* **2010**;100:1924-9
59. *Walsh JME, Salazar R, Nguyen TT, Kaplan C, Nguyen L, Hwang J, et al. Healthy Colon, Healthy Life: A Novel Colorectal Cancer Screening Intervention. *Am J Prev Med.* **2010**;39:1-14
60. *Zhu K, Hunter S, Bernard LJ, Payne-Wilks K, Roland CL, Elam LC, et al. An Intervention Study on Screening for Breast Cancer among Single African-American Women Aged 65 and Older. *Prev Med.* **2002**;34:536-45
61. *Carney PA, Lee-Lin F, Mongoue-Tchokote S, Mori M, Leung H, Lau C, et al. Improving colorectal cancer screening in Asian Americans: Results of a randomized intervention study. *Cancer.* **2014**;120:1702-12
62. *Nguyen TT, Tsoh JY, Woo K, Stewart SL, Le GM, Burke A, et al. Colorectal Cancer Screening and Chinese Americans: Efficacy of Lay Health Worker Outreach and Print Materials. *Am J Prev Med.* **2017**;52:e67-e76
63. *Tong EK, Nguyen TT, Lo P, Stewart SL, Gildengorin GL, Tsoh JY, et al. Lay health educators increase colorectal cancer screening among Hmong Americans: A cluster randomized controlled trial. *Cancer.* **2017**;123:98-106
64. *Jo AM, Nguyen TT, Stewart S, Sung MJ, Gildengorin G, Tsoh JY, et al. Lay health educators and print materials for the promotion of colorectal cancer screening among Korean Americans: A randomized comparative effectiveness study. *Cancer.* **2017**. Epub 2017 Apr 25
65. *Fernández ME, Gonzales A, Tortolero-Luna G, Williams J, Saavedra-Embesi M, Chan W, et al. Effectiveness of Cultivando La Salud: A Breast and Cervical Cancer Screening Promotion Program for Low-Income Hispanic Women. *Am J Public Health.* **2009**;99:936-43

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

66. *Percac-Lima S, Grant RW, Green AR, Ashburner JM, Gamba G, Oo S, et al. A Culturally Tailored Navigator Program for Colorectal Cancer Screening in a Community Health Center: A Randomized, Controlled Trial. *J Gen Intern Med.* **2009**;24:211-7

67. *Thompson B, Carosso EA, Jhingan E, Wang L, Holte SE, Byrd TL, et al. Results of a randomized controlled trial to increase cervical cancer screening among rural Latinas. *Cancer.* **2017**;123:666-74

68. *Duan N, Fox SA, Derosé KP, Carson S. Maintaining mammography adherence through telephone counseling in a church-based trial. *Am J Public Health.* **2000**;90:1468-71

69. Duggan C, Coronado G, Martinez J, Byrd TL, Carosso E, Lopez C, et al. Cervical cancer screening and adherence to follow-up among Hispanic women study protocol: a randomized controlled trial to increase the uptake of cervical cancer screening in Hispanic women. *BMC Cancer.* **2012**;12:170

70. *Castañeda SF, Xiong Y, Gallo LC, Yepes-Rios M, Ji M, Talavera AC, et al. Colorectal Cancer Educational Intervention Targeting Latino Patients Attending a Community Health Center. *J Prim Care Community Health.* **2012**;3:164-9

71. *Sadler GR, Beerman PR, Lee K, Hung J, Nguyen H, Cho J, et al. Promoting Breast Cancer Screening Among Asian American Women: the Asian Grocery Store-Based Cancer Education Program. *J Cancer Educ.* **2012**;27:612-7

72. *Potter MB, Namvargolian Y, Hwang J, Walsh JME. Improving Colorectal Cancer Screening: A Partnership Between Primary Care Practices and the American Cancer Society. *J Cancer Educ.* **2009**;24:22-7

73. Bandura. Social cognitive theory. *Annals of Child Development.* **1989**;6:1-66

74. Swider SM, Martin M, Lynas C, Rothschild S. Project MATCH. *Diabetes Educ.* **2010**;36:98-108

75. O'Brien MJ, Squires AP, Bixby RA, Larson SC. Role Development of Community Health Workers: An Examination of Selection and Training Processes in the Intervention Literature. *Am J Prev Med.* **2009**;37:S262-S9

76. Michie S, Johnston M, Francis J, Hardeman W, Eccles M. From Theory to Intervention: Mapping Theoretically Derived Behavioural Determinants to Behaviour Change Techniques. *Appl Psychol.* **2008**;57:660-80

77. Michie S, Johnston M. Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychol Rev.* **2012**;6:1-6

78. Foy R, Eccles M, Jamtvedt G, Young J, Grimshaw J, Baker R. What do we know about how to do audit and feedback? Pitfalls in applying evidence from a systematic review. *BMC Health Serv Res.* **2005**;5:50

79. Forbes LJJ, Simon AE, Warburton F, Boniface D, Brain KE, Dessaix A, et al. Differences in cancer awareness and beliefs between Australia, Canada, Denmark, Norway, Sweden and the UK (the International Cancer Benchmarking Partnership): do they contribute to differences in cancer survival[quest]. *Br J Cancer.* **2013**;108:292-300

80. Whitaker KL, Macleod U, Winstanley K, Scott SE, Wardle J. Help seeking for cancer 'alarm' symptoms: a qualitative interview study of primary care patients in the UK. *Br J Gen Pract.* **2015**;65:e96-e105

81. Moffat J, Bentley A, Ironmonger L, Boughey A, Radford G, Duffy S. The impact of national cancer awareness campaigns for bowel and lung cancer symptoms on sociodemographic

inequalities in immediate key symptom awareness and GP attendances. *Br J Cancer*.
2015;112:S14-S21
 82. Hoffmann TC, Glasziou PP, Boutron I, Milne R, Perera R, Moher D, et al. Better
 reporting of interventions: template for intervention description and replication (TIDieR)
 checklist and guide. *BMJ*. **2014**;348:g1687

For Peer Review

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49

Table 1. Prevalence of behaviour change techniques in community-based health worker ~~lay health-led~~ interventions

Behaviour change technique	Prevalence (%)
Social support (practical)	64 0
Prompts and cues	58 5
Problem solving	52 1
Social support (unspecified)	30 4
Credible source	27 9
Social support (emotional)	21 0
Restructuring social environment	18
Reduce negative emotions	18 7
Information about others' approval	18 7
Information about health consequences	12

Note: Techniques appearing in less than 10% of the interventions included the following: adding objects to the environment (9%); demonstration of behaviour (~~6~~9%); goal setting (behaviour) (~~6~~9%); behavioural contract (6%); information about emotional consequences (6%); vicarious consequences (6%); salience of consequences (3%); identification of self as role model (3%); self-monitoring of behaviour (3%) instruction on how to perform a behaviour (3%); social comparison (3%). The 72 remaining techniques in the behaviour change taxonomy were not observed

Table 2. Meta-analyses of studies reporting the effect of community-based lay health worker interventions on cancer screening

	Sample			Meta-analysis			Heterogeneity		
	Studies	Total n	Odds Ratio	95% CI		P value	Q-value	P value	I ²
Primary and secondary outcomes									
Primary: Overall screening adherence	30	21990	1.901	1.60	2.26	<0.001	199.9	<0.01	85.5
Secondary: Uptake among non-adherent	20	12768	2.401	1.85	3.11	<0.001	149.1	<0.01	87.3
Sensitivity analyses									
Intention to treat data only	19	16300	1.978	1.57	2.49	<0.001	146.2	<0.01	87.7
Medical records data only	8	11658	2.092	1.36	3.21	0.001	112.6	<0.01	93.8
Self-report data only	18	8620	1.686	1.40	2.03	<0.001	64.0	<0.01	73.4
Subgroup analyses = type of procedure									
Breast cancer (mammography)	13	9641	1.923	1.44	2.57	<0.001	96.7	<0.01	87.6
Breast cancer (BSE)	4	1493	1.554	1.17	2.07	0.003	4.96	0.175	39.5
Breast cancer (CBE)	5	2582	1.528	1.19	2.00	0.001	8.76	0.067	54.4
Cervical cancer (pap test)	15	5276	1.922	1.39	2.64	<0.001	92.7	<0.01	84.9
Colorectal (any)	7	9425	1.983	1.31	3.01	<0.001	86.8	<0.01	93.1
Subgroup analyses = delivery setting									
Community setting	13	5621	2.249	1.63	3.11	<0.001	83.7	<0.01	85.7
Home-based setting	13	5779	1.808	1.40	2.34	<0.001	54.5	<0.01	78.0
Primary care setting	2	6188	1.372	0.96	1.97	0.085	4.38	0.036	77.1

1	Telephone only	42	10590	1.32219	1.14	1.543	<0.001	50.914	0.116	49.3
2			4402					332	0.00	
3	<u>Subgroup analyses = intervention features</u>									
4										
5	Individual	16	15256	1.680	1.40	2.02	<0.001	63.1	<0.01	76.2
6										
7	Group-based	5	2378	1.633	1.36	1.96	<0.001	3.42	0.491	0.00
8										
9	Individual + Group	8	3636	2.463	1.43	4.23	0.001	93.8	<0.01	92.5
10										
11	BCTs; 3 or less	17	15433	1.660	1.34	2.05	<0.001	105.5	0.001	84.8
12										
13	BCTs; 4 or more	13	6557	2.268	1.78	2.89	<0.001	50.057	0.001	76.0

14 Note: BSE, breast self-examination; CBE, clinical breast examination; ITT, intention to treat.
15 **BOLD** represents statistically significant benefit of ~~LCB~~HW interventions.

Figure legends

Figure 1. PRISMA flow diagram of study selection

Figure 2. Meta-analysis of cancer screening adherence following **LCBHW** interventions in comparison to control conditions. Box size represents study weighting. Diamond represents overall effect size and 95% confidence intervals.

For Peer Review

Appendix S1. Database search strategies

MEDLINE

(((((volunteer*) [TI] OR (("expert patient*") [TIAB] OR (natural ADJ2 helper*) [TIAB] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR educator OR adviser* OR advisor*)) [TIAB] OR (untrained ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (peer ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR exp VOLUNTEERS/) AND (("early diagnos*") [TIAB] OR ("early detection") [TIAB] OR (symptom*) [TIAB] OR ("risk factor*") [TIAB] OR exp "RISK FACTORS"/ OR ("screening program*") [TIAB] OR exp "EARLY DETECTION OF CANCER"/ OR ("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB] OR (self-efficacy) [TIAB] OR exp "SELF EFFICACY"/)) AND ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB] OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR (carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR chemotherap* [TIAB] OR (leukaem [TIAB] OR exp NEOPLASMS/ OR (leukem*) [TIAB] OR (radiotherap*) [TIAB] OR (lymphom*) [TIAB] OR (mesotheliom*) [TIAB] NOT ("clinical trial*") [TIAB]

Embase

(((((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (untrained ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (peer ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR exp VOLUNTEERS/ OR ("expert patient*") [TIAB] OR (natural ADJ2 helper) [TIAB] AND ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB] OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR (carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR chemotherap* [TIAB] OR (leukaem*) [TIAB] OR (leukem*) [TIAB] OR (radiotherap* [TIAB] OR (lymphom*) [TIAB] OR (mesotheliom*) [TIAB] OR exp NEOPLASM/)) AND (("early diagnos*") [TIAB] OR ("early detection") [TIAB] OR (symptom*) [TIAB] OR ("risk factor*") [TIAB] OR exp "RISK FACTORS"/ OR ("screening program*") [TIAB] OR exp "CANCER SCREENING"/ OR ("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB] OR (selfefficacy) [TIAB] OR exp "SELF ESTEEM"/)) NOT (("clinical trial*") [TIAB] OR exp "CLINICAL TRIAL (TOPIC)"/))

BNI

(((((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (untrained ADJ5 (worker* OR people OR person*

OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR exp "VOLUNTARY ORGANISATIONS"/ OR ("expert patient*") [TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (natural ADJ2 helper*) [TIAB] AND ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB] OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR (carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR (chemotherap* OR (leukaem*) [TIAB] OR (leukem*) [TIAB] OR (radiotherap*) [TIAB] OR (lymphom*) [TIAB] OR (mesotheliom*) [TIAB] OR exp CANCER/)) AND (("early diagnos*") [TIAB] OR ("early detection") [TIAB] OR ("symptom*") [TIAB] OR ("risk factor*") [TIAB] OR exp EPIDEMIOLOGY/ OR ("screening program*") [TIAB] OR exp "CANCER : PREVENTION AND SCREENING"/ OR ("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB] OR (self-efficacy) [TIAB]))

CINAHL

((((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (untrained ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (peer ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR exp "VOLUNTEER WORKERS"/ OR exp "VOLUNTEER EXPERIENCES"/ OR ("expert patient*") [TIAB] OR (natural ADJ2 helper*) [TIAB]) AND (exp NEOPLASMS/ OR ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB] OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR (carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR (chemotherap* [TIAB] OR (leukaem*) [TIAB]) OR (leukem*) [TIAB] OR (radiotherap*) [TIAB] OR (lymphom*) [TIAB] OR (mesotheliom*) [TIAB])) AND (("early diagnos*") [TIAB] OR ("early detection") [TIAB] OR (symptom*) [TIAB] OR ("risk factor*") [TIAB] OR exp "RISK FACTORS"/ OR ("screening program*") [TIAB] OR exp "CANCER SCREENING"/ OR ("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB] OR exp "SELFCONFIDENCE"/ OR (self-efficacy) [TIAB]))

PsycINFO

(((((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (untrained* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (peer ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR exp VOLUNTEERS/ OR ("expert patient*") [TIAB] OR (natural ADJ2 helper*) [TIAB]) AND ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB] OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR

(carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR
chemotherap* [TIAB] OR (leukaem*) [TIAB] OR (leukem*) [TIAB] OR (radiotherap*) [TIAB] OR
(lymphom*) [TIAB] OR (mesotheliom*) [TIAB] OR exp NEOPLASMS/) AND (("early diagnos*")
[TIAB] OR ("early detection") [TIAB] OR (symptom*) [TIAB] OR ("risk factor*") [TIAB] OR exp
"RISK FACTORS"/ OR ("screening program*") [TIAB] OR exp "CANCER SCREENING"/ OR
("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB]
OR exp "SELFCONFIDENCE"/ OR exp "SELF-EFFICACY"/ OR (self-efficacy) [TIAB]))

AMED

(((((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR helper* OR
educator* OR adviser* OR advisor)) [TIAB] OR (untrained* ADJ5 (worker* OR people OR person*
OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR
people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5
(worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor)) [TIAB] OR
(peer ADJ5 (worker* OR people OR person* OR helper* OR educator* OR adviser* OR advisor))
[TIAB] OR (community ADJ5 (worker* OR people OR person* OR helper* OR educator* OR
adviser* OR advisor)) [TIAB] OR exp VOLUNTEERS/ OR ("expert patient*") [TIAB] OR (natural
ADJ2 helper*) [TIAB]) AND AND ((tumour*) [TIAB] OR (cancer*) [TIAB] OR (neoplas*) [TIAB]
OR (oncolog*) [TIAB] OR (melanom*) [TIAB] OR (maligna*) [TIAB] OR (gliom*) [TIAB] OR
(carcin*) [TIAB] OR (metasta*) [TIAB] OR (sarcom*) [TIAB] OR (tumor*) [TIAB] OR
chemotherap* [TIAB] OR (leukaem*) [TIAB] OR (leukem*) [TIAB] OR (radiotherap*) [TIAB] OR
(lymphom*) [TIAB] OR (mesotheliom*) [TIAB] OR exp NEOPLASMS/) AND (("early diagnos*")
[TIAB] OR ("early detection") [TIAB] OR (symptom*) [TIAB] OR ("risk factor*") [TIAB] OR exp
"RISK FACTORS"/ OR ("screening program*") [TIAB] OR exp "CANCER SCREENING"/ OR
("help seeking behaviour*") [TIAB] OR ("help seeking behavior*") [TIAB] OR (confidence) [TIAB]
OR exp "SELFCONFIDENCE"/ OR (self-efficacy) [TIAB]))))

Appendix 2. Template data extraction form

Date of data extraction:				
Name of reviewer:				
Paper title:				
First Author:			Year/volume/pages:	
Comments:				
Participants	Control group	Group 1	Group 2	Overall
No. of included participants (those randomized)				
Mean age (SD)				
No. of males				
No. of females				
Ethnicity: White (No.) Non-white (No.)				
No of participants at each follow up stage				

Sample size	
Is a power calculation performed? Yes ☐ No ☐ If "no" proceed to intervention characteristics.	Justification given for sample size:
Is the power estimate achieved? Yes ☐ No ☐	Further detail:

Intervention characteristics	
Design of study: Randomised controlled trial ☐	Further detail:

Cluster randomised controlled trial ☐	
Control group type: Active control ☐ Delayed intervention ☐ Alternative intervention ☐ Usual care ☐ No intervention ☐	Details of what control group received:
Setting (Tick all that apply): Workplace ☐ Community setting ☐ Participant's home ☐ Primary care practice ☐ Outpatient clinic ☐ Telephone ☐ Unclear ☐ Other (specify):	Further information:
Intervention type: Individual ☐ Group ☐ Combination of individual and group ☐	Further information e.g. how many if group:
Number of intervention contact sessions:	
Duration of sessions:	
Content of any additional components to the LCBHW (Tick all that apply): Computer element ☐ Media ☐ No other components ☐	Further detail:
Was there a follow up component to the intervention? Yes ☐ No ☐ If "no", proceed to outcome measures.	Further detail:
Mode of follow up component (Tick all that apply): Media (e.g. educational pamphlets) ☐ Telephone call ☐ In person visit ☐ Unclear ☐	
Content of follow up component (Tick all that apply): Logistic/navigational assistance (e.g. making appointments, arranging transportation, accompanying someone to screening) ☐ Screening reminder ☐ Educational brochure ☐ Counselling on barriers ☐	Further detail:

Outcome measures	
Primary outcome measures: Screening uptake ☐ Intention to screen ☐	Measurement tool: Self-report ☐ Medical records ☐ Combination of both ☐
Secondary outcome measures: Knowledge/awareness ☐ Beliefs/attitude ☐ Help-seeking behaviour ☐ None ☐ Other (specify):	Further detail:

Selection process & lay health worker characteristics	
Method of recruitment of CBHWs: Nominated by others ☐ Self-selected ☐ By research team ☐ Not detailed ☐ Other (specify):	
Is the selection process described? Yes ☐ No ☐ Described elsewhere ☐ Other (specify):	Reference (if described elsewhere):
Content of selection process (Tick all that apply): Evidence of certain personality characteristics ☐ Evidence of desirable skills ☐ Evidence of previous community work ☐ Not described ☐	
If desirable personality characteristics are mentioned, please list:	
If desirable skills are mentioned, please list:	

Gender of LCBHWs: Female ☐ Male ☐ Male & female ☐ Unknown ☐	Further details about LCBHWs (e.g. if they are a survivor, ethnicity, SES):

Training	
Is training for the LCBHWs mentioned? Yes ☐ No ☐ If “no” proceed to quality/competence assessment.	
Training is delivered by (Tick all that apply): Members of the research team ☐ Healthcare professional ☐ Students ☐ Unknown ☐ Other (specify):	Further detail:
Duration of training:	
Evidence of booster training sessions throughout intervention period: Yes ☐ No ☐	Further detail:
Evidence of quality/competence assessment (Tick all that apply): Direct observation immediately after training (e.g. practice session) ☐ Sporadic observation during intervention period ☐ Quality checking forms ☐ On-going supervision ☐ Written examination ☐ Pre-test and post-test of knowledge ☐ No evidence of a quality/competence assessment ☐ Other (specify):	Further detail:
Content of training (Tick all that apply): Curriculum manual ☐ Research skills (e.g. randomisation, recruitment, protocol adherence) ☐ Communication skills ☐ Lectures ☐ Didactic role-plays ☐	Further detail:

Group discussions ☐
 Health knowledge ☐
 Taught how to tailor information ☐
 Practice intervention sessions ☐
 Modelling techniques ☐
 Motivational skills ☐
 Visual aids/flip charts ☐
 How to provide logistical/navigational assistance ☐
 Not detailed ☐
 Other (specify):

Risk of bias (Cochrane Handbook)	Judgement of risk (High/Low/Unclear)	Support for judgement
<i>Selection bias</i>		
Random sequence generation		
Allocation concealment		
<i>Performance bias</i>		
Blinding of participants and personnel		
<i>Detection bias</i>		
Blinding of outcome assessment		
<i>Attrition bias</i>		
Incomplete outcome data		
<i>Reporting bias</i>		
Selective reporting		
<i>Other bias</i>		
Other sources of bias		

Analysis

Time point of main analysis:

Number of participants at baseline:				
Reasons for drop out: Excluded by researcher ☐ Dropped out from intervention ☐ Could not be contacted ☐ Non-completion of measures ☐ Outliers ☐ Ineligible after baseline interview ☐ Refused to participate ☐ No attrition ☐ Not detailed ☐ Other (specify):			Further details:	
Retention				
Number lost to follow up at each stage:	Control (% given as proportion of those in the control group)	Group 1 (% given as proportion of those in Group 1)	Group 2	Overall (% given as proportion of those randomized)
Time 1				
Time 2				
Time 3				
How was attrition dealt with?				

Results					
Statistical techniques used:					
Time point 1:					
				Between group differences	
	Intervention %	Control %	Any other groups %	Odds ratio effect size	P-Value
Screening uptake					
Screening intent					

For Peer Review

Appendix 3. Study details and intervention summaries

Study population and setting				Outcome measure				Intervention description		
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTs	Theoretic framework
Cancer screening										
Byrd (2013)	Hispanic women	Not reported	Community	Cervical	6 mths	MR + SR	Individual (face to face)	Flipchart, educational information, video	8	SCT, HBM, TTM, TRA
Carney (2014)	Asian American men and women	46-91	Community	Colorectal‡	Immediately post intervention	SR (intention)	Group (face to face)	Educational information, logistical assistance, barriers counselling	2	N/A
Castañeda (2012)	Hispanic men and women	64 (8.0)	Primary care	Colorectal‡	Immediately post intervention	SR	Group (face to face)	Educational information, educational pamphlet	1	N/A
Duan (2000)	White, African American and Hispanic women	50-80	Telephone Home (telephone)	Breast	12 mths	SR	Individual (telephone)	Educational information, barriers counselling, logistical assistance	1	HBM
Fernandez (2009)	Hispanic women	50-70+	Home	Breast, Cervical	6 mths	MR + SR	Individual (face to face & telephone)	Educational information, DVD, survivor narratives, logistical assistance, follow up reminder	1	N/A
Goelen (2010)	Flemish women	50-69	Telephone Home (telephone)	Breast	4-6 weeks	MR	Individual (telephone)	Educational pamphlet, invitation letter for screening mammography, telephone reminder	2	N/A

Appendix 3. Study details and intervention summaries (Cont'd)

Study population and setting				Outcome measure			Intervention description			
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTs	Theoretic framework
Han (2017)	Asian American women	21-64	Community	Breast, Cervical	6 mths	MR	Group (face to face) + individual (telephone)	Educational information, educational pamphlet, DVD, logistical assistance, follow up reminder	2	N/A
Hunter (2004)	Hispanic women	40-70	Home	Breast, Cervical, CBE	Unclear	MR	Individual (face to face)	Educational pamphlets, logistical assistance, follow up reminder	4	N/A
Jandorf (2008)	Hispanic women	38.8 (13.8)	Community	Breast, Cervical, BSE, CBE	2 mths	SR	Group (face to face)	Educational information, survivor narratives, logistical assistance	3	N/A
Jo (2017)	Asian American men and women	61.4 (7.6)	Community	Colorectal	6 mths	SR	Group (face to face) + individual (telephone)	Flipchart, educational information, educational pamphlet, barriers counselling, follow up reminder	5	SCT, TTM
Lam (2003)	Asian American women	18-88	Community	Cervical	3-4 mths	SR	Group (face to face) + individual (telephone)	Flipchart, educational information, logistical assistance, follow up reminder, media campaign	2	N/A
Mock (2007)	Asian American women	18-88	Community	Cervical	3-4 mths	SR	Group (face to face) + individual (telephone)	Flipchart, educational information, follow up reminder, logistical assistance, media campaign	2	N/A

Appendix 3. Study details and intervention summaries (Cont'd)

Study population and setting				Outcome measure			Intervention description			
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTS	Theoretic framework
Navarro (1998)	Hispanic women	<40 (68.7%) 40-49 (20.2%)	Community	Breast, Cervical, BSE, CBE	Immediately post intervention	SR	Group (face to face)	Educational information, practical skills training, logistical assistance	0	SCT, SET
Nguyen (2009)	Asian American women	57.0 (10.1)	Primarily home but sometimes community	Breast, CBE	5-6 mths	SR	Group (face to face)	Flipchart, educational information, educational pamphlet, logistical assistance	6	N/A
Nguyen (2015)	Asian American men and women	50-74	Primarily home but sometimes community	Colorectal	6 mths	SR	Group (face to face) + individual (face to face & telephone)	Flipchart, educational information, barriers counselling, logistical assistance, follow up reminder	5	N/A
Nguyen (2017)	Asian American men and women	62.2 (6.9)	Community or home	Colorectal	6 mths	SR	Group (face to face) + individual (telephone)	Flipchart, educational information, educational brochure, logistical assistance, follow up reminder	4	TTM
Nuño (2011)	Hispanic women	59.2 (7.7)	Home	Breast, Cervical	12 mths	MR + SR	Group (face to face)	Educational information, logistical assistance	1	SCT
O'Brien (2010)	Hispanic women	32 (11.0)	Community	Cervical	6 mths	MR + SR	Group (face to face)	Educational information, educational pamphlet	0	HBM

Appendix 3. Study details and intervention summaries (Cont'd)

Study population and setting				Outcome measure			Intervention description			
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTs	Theoretic framework
Paskett (2006)	African American, Native American and White women	55.1 (54.33-55.83)	Home	Breast	12-14 mths	MR + SR	Individual (face to face)	Educational information, educational pamphlet, practical skills training, barriers counselling, logistical assistance, follow up reminder	5	SLT, TTM
Paskett (2011)	Ohio Appalachian women	43.7	Community	Cervical	12 mths	MR + SR	Individual (face to face & telephone)	Educational information, barriers counselling, follow up reminder	3	HBM, SLT, TTM
Percac-Lima (2009)	Predominantly White and Hispanic men and women	63.1 (7.7)	Community	Colorectal	9 mths	MR	Individual (face to face)	Educational information, barriers counselling, logistical assistance	5	N/A
Porter (2009)	Predominantly White and Asian men and women	51-64 (46.9%) 65+ (53.1%)	Telephone Primary care	Colorectal	3 mths	MR	Individual (telephone)	Educational information, educational pamphlet, barriers counselling, follow up reminder	3	N/A
Russell (2010)	African American women	51.3 (7.3)	Community	Breast	6 mths	MR + SR	Individual (face to face & telephone) + computer	Computer program including video demonstration, barriers counselling, logistical assistance, follow up reminder	9	HBM, TTM

Appendix 3. Study details and intervention summaries (Cont'd)

Study population and setting				Outcome measure			Intervention description			
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTs	Theoretic framework
Sadler (2011)	African American women	40.6 (13.0)	Community	Breast	6 mths	SR	Group + individual (face to face)	Educational information, media materials, practical skills training	3	HBM
Sadler (2012)	Asian American women	49.1 (12.0)	Community	Breast, CBE	2 mths	SR (intention)	Individual (face to face)	Educational information, educational pamphlet, barriers counselling, follow up reminder	3	N/A
Sung (1997)	African American women	18-97	Home	Breast, BSE, CBE	6 mths	SR	Individual (face to face)	Educational information, educational pamphlet, videotape	2	N/A
Taylor (2002a)	Asian American women	18-60+	Home	Cervical	12 mths	MR + SR	Group + individual (face to face & telephone)	Visual aids, barriers counselling, video, logistical assistance	3	N/A
Taylor (2002b)	Asian American women	20-69	Home	Cervical	6 mths	MR + SR	Individual (face to face & telephone)	Educational information, educational pamphlets, video, follow up reminder	9	N/A
Taylor (2010)	Asian American women	<50 (45%) ≥50 (55%)	Home	Cervical	6 mths	MR + SR	Individual (face to face & telephone)	Educational information, educational pamphlet, DVD, barriers counselling, follow up reminder	9	N/A

Appendix 3. Study details and intervention summaries (Cont'd)

Study population and setting				Outcome measure				Intervention description		
First author (ref.)	Target population	Age range†	Study setting	Type of cancer screening	Follow up duration	Data source for screening outcome	Delivery mode	Intervention components	No. of BCTs	Theoretic framework
Thompson (2017)	Hispanic women	43.9 (9.8)	Home	Cervical	7 mths	MR	Individual (face to face & telephone)	Educational information, video, logistical assistance, follow up reminder	8	SCT
Tong (2017)	Asian American men and women	50-75	Community	Colorectal	6 mths	SR	Group (face to face) + individual (telephone)	Flipchart, educational information, educational pamphlet, follow up reminder	4	SCT, TTM
Walsh (2010)	Hispanic & Asian American men and women	60.7 (6.8)	Telephone Primary care	Colorectal	9-12 mths	SR	Individual (telephone)	Educational information, educational pamphlet, barriers counselling	3	TTM
Zhu (2002)	African American women	65-85+	Home	Breast, BSE, CBE	12 mths	SR	Individual (face to face)	Educational information, educational pamphlets, barriers counselling	3	HBM, SST, TRA
Cancer preventative behaviours										
Study population and setting				Outcome measure				Intervention description		
First author (ref.)	Target population	Age range†	Study setting	Type of cancer	Follow up duration	Outcome measure	Delivery mode	Intervention components	No. of BCTs	Theoretic framework

Study	Population	Age	Intervention	Comparison	Duration	Primary Outcome	Intervention Details	Follow-up	Significance
Campbell (2004)	African-American men and women	<40 (25%) 40-49 (27.5%) 50+ (47.5%)	Community	Colorectal	12-mths	Fruit, vegetable and fat consumption, physical activity	Group (face to face) Educational information, organizing exercise groups	2	SCT, TTM, HBM, SST
Havas (1998)	African-American and White women	18-30+	Community	Any	8-mths	Fruit and veg consumption	Group + individual (face to face) Educational information, educational pamphlets, cooking demonstrations, video	6	TTM

Note: †Mean and SD or CI reported if range not reported. If mean not reported, age categories are given with corresponding percentages
‡No cancer screening outcome measured; colorectal cancer knowledge and intent to complete colorectal cancer screening only
~~§Outcome measure for colorectal screening not extracted because of healthcare professional involvement in activities related to screening~~
BSE, breast self-examination; CBE, clinical breast examination; MR, medical records; SR, self-report; BCTs, behaviour change techniques SCT, Social Cognitive Theory; HBM, Health Belief Model; TTM, Transtheoretical Model; TRA, Theory of Reasoned Action; SET, Self-Efficacy Theory; SLT, Social Learning Theory; SST, Social Support Theory; N/A, no theory mentioned

Appendix 4. Risk of bias graph

Appendix 5. Meta-analysis of cancer screening uptake in non-adherent samples receiving LCBHW interventions, in comparison to control conditions. Box size represents study weighting. Diamond represents overall effect size and 95% confidence intervals

Appendix 6. Mixed-effects meta-regression of number of BCTs

Appendix 7. Subgroup analysis of the effects of **LCBHW** interventions which used a high number of BCTs (4 or more) vs. those which used a low number of BCTs (3 or less). Box size represents study weighting. Diamond represents overall effect size and 95% confidence intervals.