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

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<td>PON-17-0368.R1</td>
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<td>Date Submitted by the Author:</td>
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| Complete List of Authors: | Bellhouse, Sarah; The Christie NHS Foundation Trust, Christie Patient Centred Research, School of Oncology  
McWilliams, Lorna; The Christie NHS Foundation Trust, Christie Patient Centred Research, School of Oncology  
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  
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  
French, David; The University of Manchester, Manchester Centre for Health Psychology, School of Health Sciences |
| Keywords: | cancer, oncology, behavior change techniques, early diagnosis, meta-analysis, systematic review, community health worker |

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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 Firth²,³, Janelle Yorke¹,⁴, & 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
needed to ascertain whether CBHWs can help promote symptom recognition and help-seeking behaviour to facilitate early diagnosis of cancer.

**Keywords:** behaviour change techniques, cancer, early diagnosis, community health worker, meta-analysis, oncology and systematic 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. 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. To facilitate this, more interventions aimed at ‘down-staging’ cancers such as increasing uptake of screening programmes are warranted.

Even though recognition of cancer signs and symptoms are relatively high, attendance rates for cancer screening have decreased in recent years in the UK and USA. 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.

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. 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. 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.

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.\textsuperscript{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 CBHW interventions on cancer
outcomes, most commonly cancer screening uptake.\textsuperscript{13, 17-21} Two previous systematic reviews
which applied meta-analytic techniques found that CBHWs can improve breast cancer screening
uptake, with small effects of 1.05\textsuperscript{11} and 1.06\textsuperscript{22} reported.

Although these previous systematic reviews are useful, they have four limitations that the present
research aims to address. Firstly, the searches in the previous systematic reviews were conducted
some time ago (2001 and 2008), 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 CBHWs on other forms of screening\textsuperscript{23-25}, potentially allowing quantitative estimates of
the effects of CBHW interventions on these other kinds of screening. 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. Fourth,
previous reviews have not assessed how the use of behaviour change techniques (BCTs) may
enhance 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)\textsuperscript{26}, and have been shown to moderate the effects of interventions for
other behaviours. 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. 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 CBHW selection/training.

2.2. Eligibility criteria

Only English-language research articles published in 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 CBHW 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 CBHW 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 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
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 $\kappa = .55$). 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.\textsuperscript{30} Given this, reporting percentage agreement is more appropriate; this was almost perfect at 97%. Due to high agreement, one reviewer (SB) proceeded to code the remaining 30 articles and advice was sought from a third reviewer (DF) on an adhoc basis.

**Theory application.** The Theory Coding Scheme\textsuperscript{31}, a coding framework developed to assess extent of behaviour change theory use was used to code reported theory application in included articles. The framework consists of 33 questions which are rated “yes”, “no”, “don’t know” or “n/a”. It has previously been used in systematic reviews to code theory use based on intervention reports.\textsuperscript{32} The Theory Coding Scheme assesses the extent to which intervention techniques are explicitly linked to theoretical constructs. A theoretical construct is defined as a concept within a theory which predicts behaviour and is amenable to change e.g. perceived susceptibility in the Health Belief Model.\textsuperscript{33} Percentages were calculated to assess the number of studies scoring “yes” to each question. An overall theory score (range 0-8) was calculated using the answers to items 3 to 11.\textsuperscript{32}
**Behaviour change technique use.** A hierarchical taxonomy of 93 BCTs was used to code the content of the interventions. 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 bias, 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. To account for the expected heterogeneity between studies, a random-effects model was applied. 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
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 I² values. Funnel-plots were generated to assess the possibility of publication bias influencing the main analyses and Egger’s test and Begg & Mazumdar’s test 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.

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). 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
carried out 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%) studies, which included
assessment of desirable skills/experience, personality characteristics and
practicalities such as availability. Gender concordance of CBHWs with the target
population was reported in k=22 (67%) studies. CBHWs from the same cultural
background as the target audience were selected in k=18 (55%) studies. One study included personal experience of breast or cervical cancer as a selection criterion for
CBHWs.

Some discussion of the training CBHWs received was reported in k=27 (82%) studies. 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. A form of research skills training including the principle of randomization and the importance of

protocol adherence was reported in k=12 (36%) studies. The duration of training was described in k=17 (52%) studies and the average duration was 11 hours (range: 4-24 hours). For the majority of studies, training was conducted in one session or a series of sessions before the intervention commenced with only k=3 (9%) reporting booster, refresher sessions at least once throughout the intervention period.

3.2.2. Theory application

A theory base was explicitly reported (i.e., coded yes to item 5 of Theory Coding Scheme) in k=15 (45%) interventions. Of these 15 studies, a combination of theories was reported in k=8 (53%) (range 2-4). The Transtheoretical Model was applied in k=8 (53%) studies and the Health Belief Model was reported in k=7 (47%) studies. At least one explicit link between an intervention technique and a theory-relevant construct was reported in k=6 (40%) interventions. At least one explicit link between a theory-relevant construct and an intervention technique was reported in k=9 (60%) interventions. Theoretically relevant constructs (self-efficacy and perceived severity) were measured pre and post-intervention in k=2 (6%) studies. Only one study discussed the results in relation to the theoretical basis of the intervention. Overall, the Theory Coding Scheme illustrated poor theory application; of the 33 interventions, k=18 (55%) 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 CBHW 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. 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%) studies.

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 CBHW interventions, 10,503 to control conditions. Random-effects meta-analyses found that CBHW 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, 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. 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, I²=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 (N=8, n=11658, O.R.=2.092, 95% CI=1.36-3.21, p=0.001) or self-report data (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.
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(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, I²=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.
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.
A limitation of the present review was that, as many terms are used to describe CBHWs, 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 CBHW 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, 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 CBHW interventions in other areas of early cancer diagnosis awareness (e.g., knowledge, intention, self-efficacy). It was also notable that all but one of the included studies were implemented in the USA and therefore caution is needed to generalize and apply findings to countries with different healthcare systems, cancer screening guidelines and ethnic compositions.
The review identified several methodological biases present in the primary studies; high rates of attrition, reliance on self-reported outcomes, and failure to report blinding which could have contributed to biased estimates of interventional efficacy. However it is important to note that there is an inherent difficulty with blinding in trials assessing the effectiveness of CBHWs. In the majority of cases CBHWs recruit participants from their own social networks/communities as shared characteristics between the CBHW and the audience facilitate learning and increase the likelihood that participants will model the desired behaviour. Therefore blinding may interfere with one of the presumed mechanisms of effectiveness. Nevertheless, sensitivity analyses suggested that these methodological limitations did not unduly affect the overall conclusions. Furthermore, publication bias was indicated but after removing studies with smaller sample sizes, improvements in screening attendance in CBHW conditions remained significant.

4.3. Interpretation of main findings

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

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

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

An in-depth analysis with Theory Coding Scheme items revealed substantial evidence of ‘theory inspired’ interventions, whereby theory is not used to identify methods to change behaviour, as evidenced by poor linkage between BCTs and theoretical constructs. This absence of an explicit theoretical basis for interventions makes it difficult to identify why interventions worked, and how future interventions could work better: it prevents an accumulation of knowledge on what basis future CBHW interventions should be developed. Few BCTs were generally used: CBHWs were found to most frequently provide practical
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 adults, in particular regarding the perception of not wanting to waste the doctor’s time or cause a fuss. Despite public awareness campaigns increasing cancer symptom awareness, GP approachability remains a barrier to early engagement with primary care, and a lack of engagement is more pronounced in lower socioeconomic groups. 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
limitations in evidence base, the evidence and size of effect obtained in this review support the
implementation of CBHW 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.

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

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

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

c) The use of a greater range of BCTs should be considered in future interventions, to allow
an assessment of whether this would result in greater intervention effectiveness,
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


inequalities in immediate key symptom awareness and GP attendances. *Br J Cancer.* 2015;112:S14-S21

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

<table>
<thead>
<tr>
<th>Behaviour change technique</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social support (practical)</td>
<td>64</td>
</tr>
<tr>
<td>Prompts and cues</td>
<td>58</td>
</tr>
<tr>
<td>Problem solving</td>
<td>52</td>
</tr>
<tr>
<td>Social support (unspecified)</td>
<td>30</td>
</tr>
<tr>
<td>Credible source</td>
<td>27</td>
</tr>
<tr>
<td>Social support (emotional)</td>
<td>21</td>
</tr>
<tr>
<td>Restructuring social environment</td>
<td>18</td>
</tr>
<tr>
<td>Reduce negative emotions</td>
<td>18</td>
</tr>
<tr>
<td>Information about others’ approval</td>
<td>18</td>
</tr>
<tr>
<td>Information about health consequences</td>
<td>12</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Meta-analysis</th>
<th>Heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>95% CI</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studies</td>
<td>Total n</td>
<td>Odds Ratio</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>------------</td>
</tr>
<tr>
<td>Primary and secondary outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary: Overall screening adherence</td>
<td>30 21990</td>
<td>1.901</td>
</tr>
<tr>
<td>Secondary: Uptake among non-adherent</td>
<td>20 12768</td>
<td>2.401</td>
</tr>
<tr>
<td>Sensitivity analyses</td>
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<td></td>
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<tr>
<td>Intention to treat data only</td>
<td>19 16300</td>
<td>1.978</td>
</tr>
<tr>
<td>Medical records data only</td>
<td>8 11658</td>
<td>2.092</td>
</tr>
<tr>
<td>Self-report data only</td>
<td>18 8620</td>
<td>1.686</td>
</tr>
<tr>
<td>Subgroup analyses = type of procedure</td>
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</tr>
<tr>
<td>Breast cancer (mammography)</td>
<td>13 9641</td>
<td>1.923</td>
</tr>
<tr>
<td>Breast cancer (BSE)</td>
<td>4 1493</td>
<td>1.554</td>
</tr>
<tr>
<td>Breast cancer (CBE)</td>
<td>5 2582</td>
<td>1.528</td>
</tr>
<tr>
<td>Cervical cancer (pap test)</td>
<td>15 5276</td>
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</tr>
<tr>
<td>Colorectal (any)</td>
<td>7 9425</td>
<td>1.983</td>
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<tr>
<td>Subgroup analyses = delivery setting</td>
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<tr>
<td>Community</td>
<td>13 5621</td>
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<tr>
<td>Home-based</td>
<td>13 5779</td>
<td>1.808</td>
</tr>
<tr>
<td>Telephone</td>
<td>4 10590</td>
<td>1.322</td>
</tr>
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### Subgroup analyses = intervention features

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Sample Size</th>
<th>Mean Δ</th>
<th>SD Δ</th>
<th>p</th>
<th>Odds R</th>
<th>95% C.I. Lower</th>
<th>95% C.I. Upper</th>
<th>ORR R</th>
<th>95% C.I. Lower</th>
<th>95% C.I. Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>16</td>
<td>15256</td>
<td>1.680</td>
<td>1.40</td>
<td>&lt;0.001</td>
<td>63.1</td>
<td>&lt;0.01</td>
<td>76.2</td>
<td></td>
<td></td>
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<tr>
<td>Group-based</td>
<td>5</td>
<td>2378</td>
<td>1.633</td>
<td>1.36</td>
<td>&lt;0.001</td>
<td>3.42</td>
<td>0.491</td>
<td>0.00</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Individual + Group</td>
<td>8</td>
<td>3636</td>
<td>2.463</td>
<td>1.43</td>
<td>0.001</td>
<td>93.8</td>
<td>&lt;0.01</td>
<td>92.5</td>
<td></td>
<td></td>
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<tr>
<td>BCTs; 3 or less</td>
<td>17</td>
<td>15433</td>
<td>1.660</td>
<td>1.34</td>
<td>&lt;0.001</td>
<td>105.5</td>
<td>0.001</td>
<td>84.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCTs; 4 or more</td>
<td>13</td>
<td>6557</td>
<td>2.268</td>
<td>1.78</td>
<td>&lt;0.001</td>
<td>50.057</td>
<td>0.001</td>
<td>76.0</td>
<td></td>
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</tr>
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</table>

**Note:** BSE, breast self-examination; CBE, clinical breast examination; ITT, intention to treat.  
**BOLD** represents statistically significant benefit of CBHW interventions.
Figure legends

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.
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 Firth²,³, Janelle Yorke¹,⁴, & David P. French⁵

Running title: LCBHWs, 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

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 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
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. They recommend providing community-based health promotion services to reduce behavioural cancer-related risk factors including tobacco smoking and physical inactivity. However, 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. To facilitate this, more interventions aimed at ‘down-staging’ cancers such as increasing uptake of screening programmes are warranted.

Even though recognition of cancer signs and symptoms are relatively high, attendance rates for cancer screening have decreased in recent years in the UK and USA. 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. 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 of paraprofessional qualifications, non-professionals trained to deliver cancer prevention and early detection messages who help connect the community and healthcare providers. 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. 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. 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. 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 CBHW interventions on cancer outcomes, most commonly cancer screening uptake. For instance, Two previous systematic reviews which applied meta-analytic techniques found that CBHWs can improve breast cancer screening uptake, with small to moderate effects odds ratios of 1.05 and 1.06 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 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 CBHWs on other forms of screening, potentially allowing quantitative estimates of the effects of CBHW interventions on these other...
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, 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, 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 LCBHW interventions include.

The aim of the present review was to systematically identify and critically review studies that investigate the effectiveness of LCBHWs 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 LCBHW 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. 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 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 \( \kappa = .55 \)). 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. 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
the remaining 30 articles and advice was sought from a third reviewer (DF) on an adhoc basis. Any disagreements were resolved through discussion with a third reviewer (DF).

Theory application. The Theory Coding Scheme\textsuperscript{31}, a coding framework developed to assess extent of behaviour change theory use was used to code reported theory application in included articles. The framework consists of 33 questions which are rated “yes”, “no”, “don’t know” or “n/a”. It has previously been used in systematic reviews to code theory use based on intervention reports.\textsuperscript{32} The Theory Coding Scheme assesses the extent to which intervention techniques are explicitly linked to theoretical constructs. A theoretical construct is defined as a concept within a theory which predicts behaviour and is amenable to change e.g. perceived susceptibility in the Health Belief Model.\textsuperscript{33} Percentages were calculated to assess the number of studies scoring “yes” to each question. An overall theory score (range 0-8) was calculated using the answers to items 3 to 11.\textsuperscript{32}

Behaviour change technique use. A hierarchical taxonomy of 93 BCTs was used to code the content of the interventions.\textsuperscript{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, “L-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 bias\textsuperscript{34}, a judgement of \textit{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.\textsuperscript{35} To account for the expected heterogeneity between studies, a random-effects model was applied.\textsuperscript{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 LCBIW 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
LCBH 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. Funnel-plots were generated to assess the possibility of publication bias influencing the main analyses and Egger’s test and Begg & Mazumdar’s test 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 LCBHW interventions after removing all studies which could potentially be introducing publication bias.

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 LCBHW 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 LCBHW 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). 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 35 articles were eligible for inclusion (screening process in Figure 1).

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
A selection process for the LCBLHWs was described in \( k=7 \) (21\%) studies, which included assessment of desirable skills/experience\(^{42-48}\), personality characteristics\(^{42, 43, 45, 48}\) and practicalities such as availability.\(^{43, 45, 47}\) Gender concordance of LCBLHWs with the target population was reported in \( k=22 \) (67\%) studies.\(^{23-25, 42-60}\) LCBLHWs 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 LCBLHWs.\(^{51}\)

Some discussion of the training LCBLHWs received was reported in \( k=279 \) (83\%) studies.\(^{23, 24, 42-60, 62-67}\) The most commonly used pedagogic methodologies for training LCBLHWs were visual aids/flip charts, practice intervention sessions, and role-playing. A competency assessment measure was described in \( k=189 \) (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 protocol adherence was reported in \( k=12 \) (36\%) studies.\(^{24, 42, 44, 45, 49, 50, 52, 53, 55, 62-64}\) The duration of training was described in \( k=178 \) (52\%) studies and the average duration was 11 hours (range: 4-24 hours).\(^{24, 42, 44, 47-49, 51-55, 59, 60, 62, 64-66}\) For the majority of studies, training was conducted in one session or a series of sessions before the intervention commenced with only \( k=3 \) (9\%) reporting booster, refresher sessions at least once throughout the intervention period.\(^{45, 55, 62}\)

### 3.2.2. Theory application

A theory base was explicitly reported (i.e., coded yes to item 5 of Theory Coding Scheme) in \( k=157 \) (43\%) interventions.\(^{23, 25, 43-45, 53-55, 59, 60, 62-64, 67, 68}\) Of these 157 studies, a combination of
theories was reported in $k=89$ (53%) (range 2-4). The Transtheoretical Model was applied in $k=84$ (53%) 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 $k=67$ (40.4%) interventions. At least one explicit link between a theory-relevant construct and an intervention technique was reported in $k=910$ (60.59%) interventions. Theoretically relevant constructs (self-efficacy and perceived severity) were measured pre and post-intervention in $k=23$ (69%) studies. Only one study discussed the results in relation to the theoretical basis of the intervention. Overall, the Theory Coding Scheme illustrated poor theory application; of the 335 interventions, $k=18$ (54%) 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.
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. 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.

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 LCBHW interventions, 10,503 to control conditions. Random-effects meta-analyses found that LCBHW 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, LCBHW 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. This found
that LCBHW 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, I²=87.7%).

Further sensitivity analyses showed that LCBHW 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 LCBHW 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, I²=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 LCBHW 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 LCBHW 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 LCBHW 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 LCBHW 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 telephone interventions did demonstrated an overall benefit for LCBHWs (k=42, n=105904402, O.R.=1.32219, 95% CI=1.14-1.543, 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, LCBHW 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 LCBHW interventions held a
trend-level association with observed effect size (see Appendix S6); as the O.R. for cancer
screening adherence from LCBHW 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 LCBHW 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. LCBHW
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. Havas found
significant improvements in self-reported daily consumption of fruits and vegetables
among both intervention and control groups at follow-up. Campbell 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.\textsuperscript{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 LCWH 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 LCWH interventions.

A limitation of the present review was that, as many terms are used to describe LCWHs, 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 LCWH 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, 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 LCWH interventions in other areas of early cancer diagnosis
awareness (e.g., knowledge, intention, self-efficacy). It was also notable that all but one of the included studies were implemented in the USA and therefore caution is needed to generalize and apply findings to countries with different healthcare systems, cancer screening guidelines and ethnic compositions.

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

4.3. Interpretation of main findings

This study has been the first to illustrate the effectiveness of LCBHW interventions beyond mammography screening. Furthermore this meta-analysis yielded higher odds ratios than previous reviews (1.90-2.40), indicating larger effects of LCBHW interventions than previous
reviews have suggested. Subgroup analyses revealed similar effects for breast, cervical and colorectal cancer screening.

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

The present review explored potential moderators of effectiveness to provide practical recommendations for future LCBHW intervention development. Moderator analyses demonstrated that LCBHW interventions were equally as effective across all types of cancer screening. Subgroup analyses revealed that interventions were effective when delivered in community and home settings, over the telephone and when using both individual and group modes of delivery were used. Only one of the included interventions was delivered in a primary care setting. However as it measured knowledge changes only, there was no eligible data to include in the meta-analysis of effects on screening behaviour. No beneficial effect of the CBHW was found when compared to usual care but The current evidence did not support the effectiveness of the LHW approach in primary care settings. However, only two studies used this type of setting and so additional research is needed to establish whether delivering a LCBHW intervention in primary care settings has the potential to be effective.
An in-depth analysis with Theory Coding Scheme items revealed substantial evidence of ‘theory inspired’ interventions, whereby theory is not used to identify methods to change behaviour, as evidenced by poor linkage between BCTs and theoretical constructs. This absence of an explicit theoretical basis for interventions makes it difficult to identify why interventions worked, and how future interventions could work better: it prevents an accumulation of knowledge on what basis future interventions should be developed. Few BCTs were generally used: LCBHWs were found to most frequently provide practical 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 adults, in particular regarding the perception of not wanting to waste the doctor’s time or cause a fuss. Despite public awareness campaigns increasing cancer symptom awareness, GP approachability remains a barrier to early engagement with primary care, and a lack of
engagement is more pronounced in lower socioeconomic groups.\textsuperscript{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.\textsuperscript{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.\textsuperscript{25} 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 disease,\textsuperscript{26} indicating a need for awareness interventions that may encourage risk reducing behaviour change.\textsuperscript{22}

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

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

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

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

d) Further exploring the influence demographic factors such as participant gender has on LCBHW 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 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 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 marked with an asterisk indicate studies included in the systematic review


38. Egger M, Smith GD, Schneider M, Minder C. Bias in metakausalysis detected by a simple, graphical test. BMJ. 1997;315:629-34


inequalities in immediate key symptom awareness and GP attendances. *Br J Cancer.* 2015;112:S14-S21

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

<table>
<thead>
<tr>
<th>Behaviour change technique</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social support (practical)</td>
<td>640</td>
</tr>
<tr>
<td>Prompts and cues</td>
<td>575</td>
</tr>
<tr>
<td>Problem solving</td>
<td>524</td>
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<tr>
<td>Social support (unspecified)</td>
<td>304</td>
</tr>
<tr>
<td>Credible source</td>
<td>279</td>
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<tr>
<td>Social support (emotional)</td>
<td>214</td>
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<tr>
<td>Restructuring social environment</td>
<td>18</td>
</tr>
<tr>
<td>Reduce negative emotions</td>
<td>187</td>
</tr>
<tr>
<td>Information about others’ approval</td>
<td>187</td>
</tr>
<tr>
<td>Information about health consequences</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: Techniques appearing in less than 10% of the interventions included the following: adding objects to the environment (9%); demonstration of behaviour (69%); goal setting (behaviour) (69%); 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

<table>
<thead>
<tr>
<th>Sample</th>
<th>Meta-analysis</th>
<th>Heterogeneity</th>
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<tbody>
<tr>
<td></td>
<td>Odds Ratio</td>
<td>95% CI</td>
</tr>
<tr>
<td>Studies</td>
<td>Total n</td>
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<tr>
<td>--------</td>
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<tr>
<td><strong>Primary and secondary outcomes</strong></td>
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<tr>
<td>Primary: Overall screening adherence</td>
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<tr>
<td>Secondary: Uptake among non-adherent</td>
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<tr>
<td><strong>Sensitivity analyses</strong></td>
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<tr>
<td><strong>Subgroup analyses = type of procedure</strong></td>
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</tr>
<tr>
<td>Breast cancer (mammography)</td>
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<td>Breast cancer (BSE)</td>
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<td>Colorectal (any)</td>
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<td>9425</td>
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<tr>
<td><strong>Subgroup analyses = delivery setting</strong></td>
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<tr>
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### Subgroup analyses = intervention features

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<th>Hazard Ratio</th>
<th>Confidence Interval</th>
<th>p-value</th>
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<td>1.3229</td>
<td>1.14</td>
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<td><strong>Subgroup analyses = intervention features</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Individual</td>
<td>16</td>
<td>1.680</td>
<td>1.40</td>
<td>2.02</td>
<td>&lt;0.001</td>
</tr>
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<td>Group-based</td>
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<td>1.633</td>
<td>1.36</td>
<td>1.96</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Individual + Group</td>
<td>8</td>
<td>2.463</td>
<td>1.43</td>
<td>4.23</td>
<td>0.001</td>
</tr>
<tr>
<td>BCTs; 3 or less</td>
<td>17</td>
<td>1.660</td>
<td>1.34</td>
<td>2.05</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>BCTs; 4 or more</td>
<td>13</td>
<td>2.268</td>
<td>1.78</td>
<td>2.89</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Note:** BSE, breast self-examination; CBE, clinical breast examination; ITT, intention to treat. **BOLD** represents statistically significant benefit of BCBHW 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.
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 (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 (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 (self-efficacy) [TIAB] OR exp "SELF ESTEEM"/) NOT ("clinical trial") [TIAB])

BNI

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For Peer Review


CINAHL

(((volunteer*) [TI] OR (volunteer* ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR (untrained ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR (voluntary* ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR (lay ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR (community ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR (peer ADJ5 (worker* OR people OR person* OR help* OR educator* OR adviser* OR advisor)) [TIAB] OR exp "VOLUNTEER WORKERS"/ OR exp "VOLUNTEER EXPERIENCES"/ OR ("expert patient*" [TIAB] OR (natural ADJ2 help*) [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 ("risk factor*" [TIAB] OR "screening program*" [TIAB]) OR exp "CANCER SCREENING"/ OR ("help seeking behaviour*" [TIAB] OR ("help seeking behavior*" [TIAB] OR (confidence) [TIAB] OR (self-efficacy) [TIAB]))

PsycINFO


http://mc.manuscriptcentral.com/pon
For Peer Review


AMED

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http://mc.manuscriptcentral.com/pon
# Appendix 2. Template data extraction form

<table>
<thead>
<tr>
<th>Date of data extraction:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of reviewer:</td>
</tr>
<tr>
<td>Paper title:</td>
</tr>
<tr>
<td>First Author:</td>
</tr>
<tr>
<td>Comments:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participants</th>
<th>Control group</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of included participants (those randomized)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of males</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of females</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethnicity:</td>
<td>White (No.)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-white (No.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No of participants at each follow up stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Sample size

<table>
<thead>
<tr>
<th>Is a power calculation performed?</th>
<th>Justification given for sample size:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ☐</td>
<td></td>
</tr>
<tr>
<td>No ☐</td>
<td></td>
</tr>
<tr>
<td>If “no” proceed to intervention characteristics.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is the power estimate achieved?</th>
<th>Further detail:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ☐</td>
<td></td>
</tr>
<tr>
<td>No ☐</td>
<td></td>
</tr>
</tbody>
</table>

## Intervention characteristics

<table>
<thead>
<tr>
<th>Design of study:</th>
<th>Further detail:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomised controlled trial ☐</td>
<td></td>
</tr>
</tbody>
</table>
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.

**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

<table>
<thead>
<tr>
<th>Primary outcome measures:</th>
<th>Measurement tool:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening uptake ☐</td>
<td>Self-report ☐</td>
</tr>
<tr>
<td>Intention to screen ☐</td>
<td>Medical records ☐</td>
</tr>
<tr>
<td></td>
<td>Combination of both ☐</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Secondary outcome measures:</th>
<th>Further detail:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge/awareness ☐</td>
<td></td>
</tr>
<tr>
<td>Beliefs/attitude ☐</td>
<td></td>
</tr>
<tr>
<td>Help-seeking behaviour ☐</td>
<td></td>
</tr>
<tr>
<td>None ☐</td>
<td></td>
</tr>
<tr>
<td>Other (specify):</td>
<td></td>
</tr>
</tbody>
</table>

### Selection process & lay health worker characteristics

<table>
<thead>
<tr>
<th>Method of recruitment of CBHWs:</th>
<th>Reference (if described elsewhere):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominated by others ☐</td>
<td></td>
</tr>
<tr>
<td>Self-selected ☐</td>
<td></td>
</tr>
<tr>
<td>By research team ☐</td>
<td></td>
</tr>
<tr>
<td>Not detailed ☐</td>
<td></td>
</tr>
<tr>
<td>Other (specify):</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is the selection process described?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ☐</td>
</tr>
<tr>
<td>No ☐</td>
</tr>
<tr>
<td>Described elsewhere ☐</td>
</tr>
<tr>
<td>Other (specify):</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content of selection process (Tick all that apply):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evidence of certain personality characteristics ☐</td>
</tr>
<tr>
<td>Evidence of desirable skills ☐</td>
</tr>
<tr>
<td>Evidence of previous community work ☐</td>
</tr>
<tr>
<td>Not described ☐</td>
</tr>
</tbody>
</table>

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):

**Duration of training:**

**Evidence of booster training sessions throughout intervention period:**
- Yes ☐
- No ☐

**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):

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

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):

Retention

Number lost to follow up at each stage:

<table>
<thead>
<tr>
<th></th>
<th>Control (% given as proportion of those in the control group)</th>
<th>Group 1 (% given as proportion of those in Group 1)</th>
<th>Group 2</th>
<th>Overall (% given as proportion of those randomized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time 2</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Time 3</td>
<td></td>
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</tr>
</tbody>
</table>

How was attrition dealt with?

Results

Statistical techniques used:

Time point 1:

<table>
<thead>
<tr>
<th></th>
<th>Intervention %</th>
<th>Control %</th>
<th>Any other groups %</th>
<th>Odds ratio effect size</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening uptake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screening intent</td>
<td></td>
<td></td>
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</tbody>
</table>
### Appendix 3. Study details and intervention summaries

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

**Cancer screening**
Appendix 3. Study details and intervention summaries (Cont’d)

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

<table>
<thead>
<tr>
<th>First author (ref.)</th>
<th>Target population</th>
<th>Age range†</th>
<th>Study setting</th>
<th>Type of cancer screening</th>
<th>Follow up duration</th>
<th>Data source for screening outcome</th>
<th>Delivery mode</th>
<th>Intervention components</th>
<th>No. of BCTS</th>
<th>Theoretic framework</th>
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<tbody>
<tr>
<td>Navarro (1998)</td>
<td>Hispanic women</td>
<td>&lt;40 (68.7%) 40-49 (20.2%)</td>
<td>Community</td>
<td>Breast, Cervical, BSE, CBE</td>
<td>Immediately post intervention</td>
<td>SR</td>
<td>Group (face to face)</td>
<td>Educational information, practical skills training, logistical assistance</td>
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<tr>
<td>Nguyen (2009)</td>
<td>Asian American women</td>
<td>57.0 (10.1)</td>
<td>Primarily home but sometimes community</td>
<td>Breast, CBE</td>
<td>5-6 mths</td>
<td>SR</td>
<td>Group (face to face)</td>
<td>Flipchart, educational information, educational pamphlet, logistical assistance</td>
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<td>Nguyen (2015)</td>
<td>Asian American men and women</td>
<td>50-74</td>
<td>Primarily home but sometimes community</td>
<td>Colorectal</td>
<td>6 mths</td>
<td>SR</td>
<td>Group (face to face) + individual (face to face &amp; telephone)</td>
<td>Flipchart, educational information, barriers counselling, logistical assistance, follow up reminder</td>
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<td>N/A</td>
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<tr>
<td>Nguyen (2017)</td>
<td>Asian American men and women</td>
<td>62.2 (6.9)</td>
<td>Community or home</td>
<td>Colorectal</td>
<td>6 mths</td>
<td>SR</td>
<td>Group (face to face) + individual (telephone)</td>
<td>Flipchart, educational information, educational brochure, logistical assistance, follow up reminder</td>
<td>4</td>
<td>TTM</td>
</tr>
<tr>
<td>Nuño (2011)</td>
<td>Hispanic women</td>
<td>59.2 (7.7)</td>
<td>Home</td>
<td>Breast, Cervical</td>
<td>12 mths</td>
<td>MR + SR</td>
<td>Group (face to face)</td>
<td>Educational information, logistical assistance</td>
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<td>SCT</td>
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<td>Community</td>
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### Appendix 3. Study details and intervention summaries (Cont’d)

<table>
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<th>Age range†</th>
<th>Study setting</th>
<th>Type of cancer screening</th>
<th>Follow up duration</th>
<th>Data source for screening outcome</th>
<th>Delivery mode</th>
<th>Intervention components</th>
<th>No. of BCTs</th>
<th>Theoretic framework</th>
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<tbody>
<tr>
<td>Paskett (2006)</td>
<td>African American, Native American and White women</td>
<td>55.1 (54.33-55.83)</td>
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<td>Breast</td>
<td>12-14 mths</td>
<td>MR + SR</td>
<td>Individual (face to face)</td>
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<td>SLT, TTM</td>
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<tr>
<td>Paskett (2011)</td>
<td>Ohio Appalachian women</td>
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<td>12 mths</td>
<td>MR + SR</td>
<td>Individual (face to face &amp; telephone)</td>
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<td>HBM, SLT, TTM</td>
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<td>Percac-Lima (2009)</td>
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<td>9 mths</td>
<td>MR</td>
<td>Individual (face to face)</td>
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<td>Potter (2009)</td>
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<td>Telephone \textit{Primary case}</td>
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<td>3 mths</td>
<td>MR</td>
<td>Individual (telephone)</td>
<td>Educational information, educational pamphlet, barriers counselling, follow up reminder</td>
<td>3</td>
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<td>Community</td>
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<td>6 mths</td>
<td>MR + SR</td>
<td>Individual (face to face &amp; telephone) + computer</td>
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†Age range is given as mean (standard deviation) unless otherwise noted.
### Appendix 3. Study details and intervention summaries (Cont’d)

<table>
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<th>Target population</th>
<th>Age range†</th>
<th>Study setting</th>
<th>Type of cancer screening</th>
<th>Follow up duration</th>
<th>Data source for screening outcome</th>
<th>Delivery mode</th>
<th>Intervention components</th>
<th>No. of BCTs</th>
<th>Theoretic framework</th>
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<td>Sadler (2011)</td>
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<td>40.6 (13.0)</td>
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<td>6 mths</td>
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<td>Group + individual (face to face)</td>
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<td>HBM</td>
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<tr>
<td>Sadler (2012)</td>
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<td>SR (intention)</td>
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<td>Educational information, educational pamphlet, barriers counselling, follow up reminder</td>
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<td>Sung (1997)</td>
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<td>Breast, BSE, CBE</td>
<td>6 mths</td>
<td>SR</td>
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<tr>
<td>Taylor (2002a)</td>
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<td>Cervical</td>
<td>12 mths</td>
<td>MR + SR</td>
<td>Group + individual (face to face &amp; telephone)</td>
<td>Visual aids, barriers counselling, video, logistical assistance</td>
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<td>Taylor (2002b)</td>
<td>Asian American women</td>
<td>20-69</td>
<td>Home</td>
<td>Cervical</td>
<td>6 mths</td>
<td>MR + SR</td>
<td>Individual (face to face &amp; telephone)</td>
<td>Educational information, educational pamphlets, video, follow up reminder</td>
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<td>Taylor (2010)</td>
<td>Asian American women</td>
<td>&lt;50 (45%) ≥50 (55%)</td>
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<td>Cervical</td>
<td>6 mths</td>
<td>MR + SR</td>
<td>Individual (face to face &amp; telephone)</td>
<td>Educational information, educational pamphlet, DVD, barriers counselling, follow up reminder</td>
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### Appendix 3. Study details and intervention summaries (Cont’d)

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

<table>
<thead>
<tr>
<th>First author (ref.)</th>
<th>Target population</th>
<th>Age range†</th>
<th>Study setting</th>
<th>Type of Cancer</th>
<th>Follow-up duration</th>
<th>Outcome measure</th>
<th>Delivery mode</th>
<th>Intervention components</th>
<th>No. of BCTs</th>
<th>Theoretic framework</th>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Age Groups</td>
<td>Setting</td>
<td>Compliance</td>
<td>Methods</td>
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<tr>
<td>Campbell (2004)</td>
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<td>≤40 (25%), 40-49 (27.5%), 50+ (47.5%)</td>
<td>Community</td>
<td>12 mths</td>
<td>Fruit, vegetable and fat consumption, physical activity§</td>
<td>SCT, TTM, HBM, SST</td>
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<tr>
<td>Havas (1998)</td>
<td>African American and White women</td>
<td>18-30+</td>
<td>Community</td>
<td>8 mths</td>
<td>Fruit and veg consumption</td>
<td>TTM</td>
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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 HCBW interventions, in comparison to control conditions. Box size represents study weighting. Diamond represents overall effect size and 95% confidence intervals.

<table>
<thead>
<tr>
<th>Study name</th>
<th>Odds ratio</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>Z-Value</th>
<th>p-Value</th>
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<tr>
<td>Byrd et al. 2013</td>
<td>2.619</td>
<td>1.611</td>
<td>4.257</td>
<td>3.882</td>
<td>0.000</td>
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<tr>
<td>Duan et al. 2000</td>
<td>1.119</td>
<td>0.633</td>
<td>1.807</td>
<td>0.461</td>
<td>0.645</td>
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<tr>
<td>Fernandez et al. 2009</td>
<td>1.348</td>
<td>0.789</td>
<td>2.302</td>
<td>1.093</td>
<td>0.274</td>
</tr>
<tr>
<td>Goelen et al. 2010</td>
<td>1.285</td>
<td>1.097</td>
<td>1.505</td>
<td>3.110</td>
<td>0.002</td>
</tr>
<tr>
<td>Han et al. 2017</td>
<td>11.610</td>
<td>7.349</td>
<td>18.502</td>
<td>10.428</td>
<td>0.000</td>
</tr>
<tr>
<td>Jandorf et al. 2008</td>
<td>1.890</td>
<td>1.286</td>
<td>2.777</td>
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<tr>
<td>Lam et al. 2003</td>
<td>2.807</td>
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<td>Mock et al. 2007</td>
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<td>3.717</td>
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<td>Nguyen et al. 2015</td>
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<td>Nuno et al. 2011</td>
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<td>Pcorc-Lima et al. 2009</td>
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<td>Potter et al. 2009</td>
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<td></td>
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http://mc.manuscriptcentral.com/pon
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.
Records identified through database searching
First search: \( n = 1885; 807 \text{ Embase}, 559 \text{ Medline}, 238 \text{ Cinahl}, 211 \text{ PsycINFO}, 61 \text{ BNI & 9 AMED} \)
Second search: \( n = 579; 307 \text{ Embase}, 143 \text{ Medline}, 83 \text{ Cinahl}, 33 \text{ PsycINFO} \& 13 \text{ BNI} \)

Records identified through other sources \((n = 29)\)

Records after duplicates removed \((n = 1448)\)

Full-text articles assessed for eligibility \((n = 123)\)

Full text articles included \((n = 33)\)

30 studies reporting any type of cancer screening uptake included in quantitative synthesis

Records excluded from title/abstract \((n = 1325)\)

Full-text articles excluded, with reasons \((n = 90)\):
- Ineligible study design \((n = 45)\)
- Effectiveness of intervention not described \((n = 13)\)
- Unclear if CBHW delivered entire intervention \((n = 9)\)
- No CBHW participation in delivery of intervention \((n = 8)\)
- Healthcare professional/staff input in intervention delivery \((n = 5)\)
- Ineligible outcome measured \((n = 4)\)
- No baseline measure \((n = 2)\)
- Intervention was for CBHWs \((n = 1)\)
- CBHW participation in both intervention & control conditions \((n = 1)\)
  - Conference abstract \((n = 1)\)
  - Conference proceeding \((n = 1)\)
### Study name

<table>
<thead>
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<th>Z-Value</th>
<th>p-Value</th>
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<td>1.419</td>
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### Odds ratio and 95% CI

Favours Control

Favours Intervention

http://mc.manuscriptcentral.com/pon