The Effectiveness of Community Health Workers for CVD Prevention in LMIC

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ABSTRACT

Community health workers (CHW) may be effective in tackling the burden of cardiovascular diseases in low- and middle-income countries (LMIC). This review examines whether CHWs can improve the identification and control of cardiovascular risk factors in LMIC. We searched for studies that used CHW as a basis for cardiovascular risk factor management. Our search yielded 11 articles that targeted cardiovascular risk factor assessment, hypertension, diabetes, smoking, diet and physical activity. There were 4 randomized controlled trials, 3 quasi-experimental studies, 3 cross-sectional studies, and 1 retrospective analysis. Eight studies reported positive results with CHW being able to effectively screen for cardiovascular risk factors, decrease systolic blood pressure, decrease fasting blood glucose, increase quit rates of smoking, decrease weight, and improve diet and physical activity. Our review demonstrates that CHW may be effective in helping tackle the burden of cardiovascular disease in LMIC.

Noncommunicable diseases are the leading cause of death in low- and middle-income countries (LMIC). Twenty-eight million people die each year from noncommunicable diseases in these countries, with cardiovascular diseases (CVD) accounting for nearly 50% of these deaths. Cancers, respiratory diseases, and diabetes cause an additional 30% of the burden. Moreover, 82% of the worldwide burden of premature mortality from noncommunicable diseases is in LMIC [1,2].

In 2012, the global community adopted a target of 25% reduction in premature mortality from noncommunicable diseases by 2025. Yet, progress in achieving these aims has been slow and uneven, especially in LMIC [3]. This is partially due to the limited health care systems in LMIC, which are configured to provide episodic care for acute infectious illnesses and have not yet adapted to accommodate the continuous nature of chronic illness.

Community health workers (CHW) are lay community members who undergo focused health care training, usually aimed at a particular disease or task. Unlike other nonphysician health workers (NPHW) such as nurses, social workers, or pharmacists, CHW typically do not have any formal certification and often work in an environment removed from traditional health care. For example, 600,000 CHW are paid through a fee-for-service system in India to deliver a specific set of primary care functions, such as immunization [4]. Desirable qualities of CHW often include leadership qualities, proficiency in the local language and culture, willingness to learn, previous health care or community experience, and a strong commitment to work in the community [5].

CHW have played a substantial, and growing, role in the progress made toward achievement of the Millennium Development Goals related to health: reduction in child mortality; improvement in maternal health; and combating human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS), malaria, and other diseases [6]. CHW may be able to provide similarly appropriate care for cardiovascular risk factor control. In this review, we examine the role and effectiveness of CHW in the management of risk factors for CVD in LMIC. Our objective is to assess the ability of CHW to increase the identification and control of these risk factors in LMIC and to examine barriers and facilitators for their effectiveness.

METHODS

Computer and manual searches were conducted of articles in the English language database from January 1, 1990, to July 1, 2015. The search was limited to articles from 1990 onward in order to focus only on contemporary evidence, and because some previous reviews have shown no relevant studies in LMIC before 1990 [7,8]. The databases used were Medline, Social Sciences Index, CINAHL (Cumulative Index to Nursing and Allied Health Literature), the Cochrane Review, and Web of Science. The references of the included articles were manually searched for additional articles. A CHW was defined as any health worker who performed functions related to health care delivery, was trained in some way in the context of the intervention, but had received no formal professional or paraprofessional certificate. These criteria were adapted from the definition of a lay health worker as used by the Cochrane Collaboration [9].

Only studies that incorporated CHW as a basis for cardiovascular risk factor management were included. We excluded other NPHW such as nurses, social workers, and

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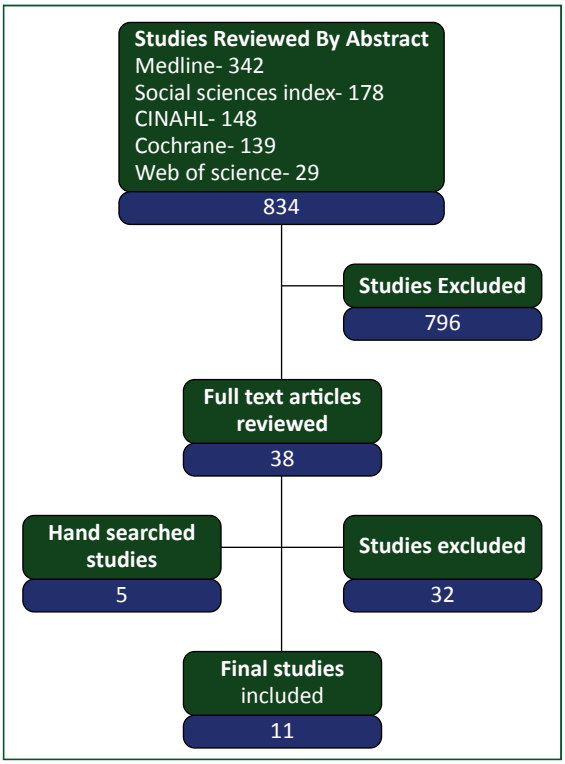

FIGURE 1. Search process for identifying relevant papers. CINAHL, Cumulative Index to Nursing and Allied Health Literature.

pharmacists. The following key terms were used: "community health worker"; "lay health worker"; "health education"; "cardiovascular disease"; "physical activity"; "diet"; "hypertension"; "diabetes"; "smoking cessation"; "community-based participatory research"; "developing countries"; "low- and middle-income countries"; "obesity"; "chronic disease"; and "noncommunicable diseases." Articles were included on the basis of the following: 1) publications focusing on cardiovascular risk reduction programs including smoking cessation, hypertension management, diabetes management, weight management, dietary modification, promoting physical activity, combined cardiovascular risk factor management and secondary prevention; 2) CHW-facilitated implementation of these programs; and 3) data-based reporting of outcomes.

RESULTS

Our search generated 834 abstracts, which resulted in 11 articles being included in the final review (Figure 1). Four studies were randomized controlled trials, 3 were quasi-experimental studies, 1 was a retrospective analysis, whereas the rest (n = 3) were cross-sectional studies. The sample size varied from 184 to 65,619 individuals. The geographical distribution of the study sites is shown in Figure 2. Four studies focused on cardiovascular risk assessment. Two studies examined the use of CHW for the management of hypertension, 2 studies for diabetes, and 1 study assessed the use of CHW for both hypertension and diabetes. One study each examined smoking cessation and diet/physical activity, respectively. The distribution of the studies by condition is summarized in Figure 3.

DATA EXTRACTION AND SYNTHESIS

A tailored data extraction form was created using guidelines outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* [10]. Each of the 11 studies were reviewed, and the following data was extracted: study design; sample characteristics and size; study location; intervention features; primary outcome measures; results; quality of the study; and treatment fidelity. The studies are summarized in Table 1 [5,11–24].

A high level of heterogeneity in the study design, objectives, outcome measures, and intervention methods of the included studies made a meta-analysis nonfeasible. Therefore, a narrative analysis of a group of CHW interventions for cardiovascular risk factor management was done.

METHODOLOGICAL QUALITY

The quality of the selected studies was evaluated using the Kmet's manual for quality scoring of quantitative studies [12]. The manual provides a checklist for scoring quantitative studies. Each study was assigned a score (Online Table 1), which varied from 57% to 100%. Strengths across studies included well-defined study objectives with respect to CHW, detailed reporting of results, and study conclusions that were supported by the results. Several studies were limited by small sample sizes, lack of a control group, absence of investigator blinding, inadequate control for confounding variables, a high attrition rate, and lack of reporting of variance for the main results.

Treatment fidelity of studies

Methodological and theoretical fidelity of the treatment was measured using guidelines provided by the National Institutes of Health Behaviour Change Consortium [11]. Seven of the 11 studies used a behavior change strategy for which treatment fidelity could be reported. The degree of fidelity was reported as the percentage of criteria met [25] and is reported in Table 2 [5,11,13–22]. Treatment fidelity was low for all studies, ranging from 16% to 52%. The relationship of study treatment fidelity and outcome is summarized in Figure 4 [11].

Common operational features of successful programs include short training periods, use of automated glucometers and blood pressure monitors, focus on participant education and lifestyle changes, increased duration of contact over time, use of a treatment manual, and consideration of cultural factors. However, most studies provided scant information on the details of CHW training, including information on method of training, assessment of

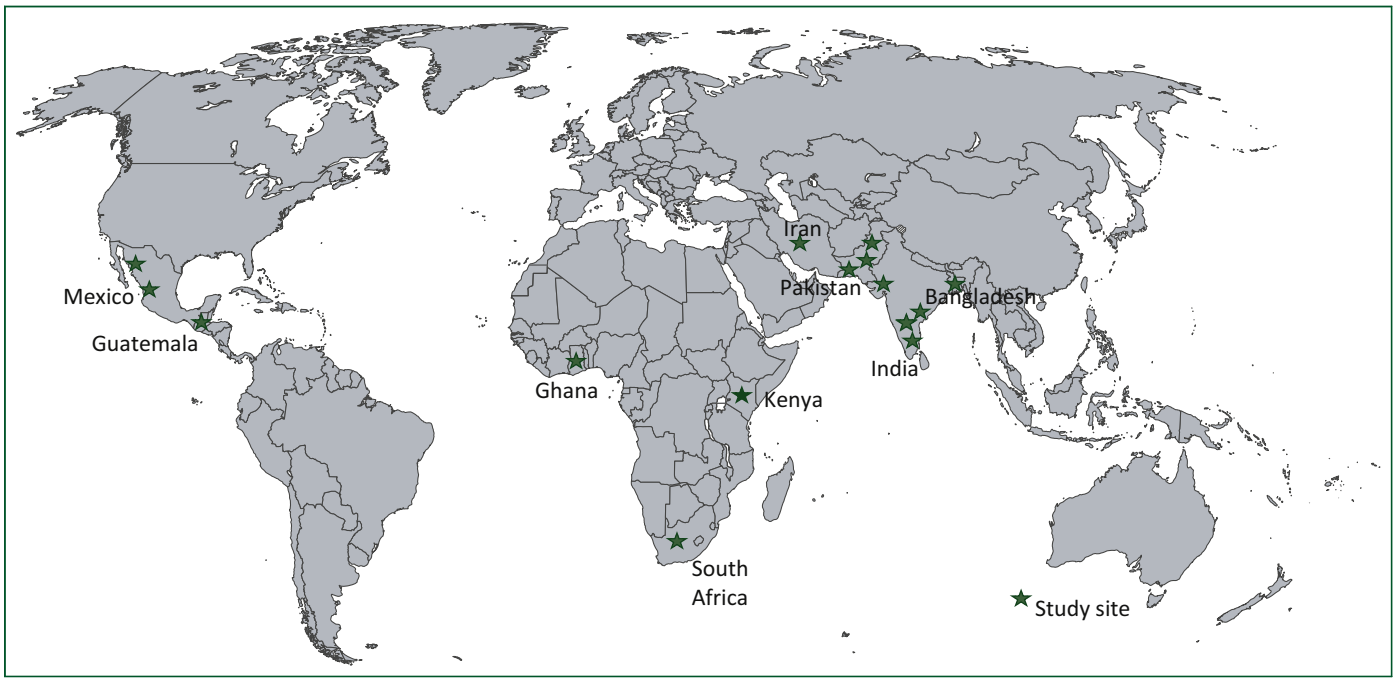

FIGURE 2. Distribution of sites for the included studies.

skills, maintenance of skills, and assessing fit between CHW and the program during hiring. There was also little to no emphasis on monitoring delivery of treatment and confirming receipt of treatment. Because results are sensitive to operational design, it is difficult to assess whether some negative findings are due to certain characteristics of the particular operation in question, or due to the inherent limitations of a CHW-based approach.

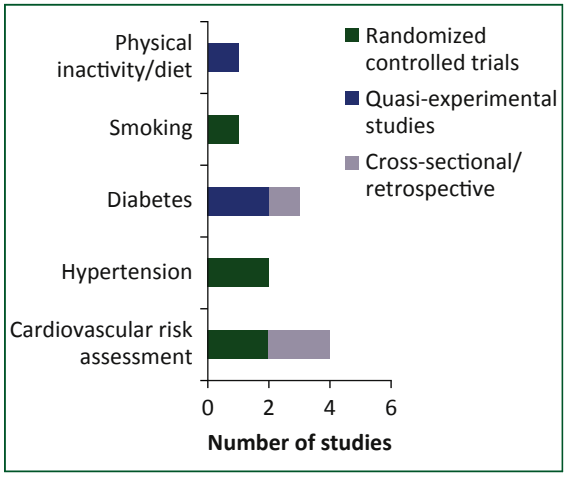

FIGURE 3. Distribution of studies by condition and study design.

EFFICACY OF INTERVENTIONS

The studies were grouped by condition to assess the efficacy of the various CHW interventions. Six groups were created: 1) cardiovascular risk assessment (4 studies); 2) hypertension (2 studies); 3) diabetes (3 studies); 4) smoking (1 study); 5) physical inactivity and diet (1 study); and 6) combined cardiovascular risk factor management or secondary prevention (no studies).

Cardiovascular risk assessment

Four studies examined CVD risk assessment. In Kenya, Pastakia et al. [17] compared home-based screening by CHW to community-based health fair screening by experienced clinical staff, with the goal of comparing CHW and professional screening results. The study found a discordance between the 2 approaches, with those screened by CHW being more likely to have elevated blood sugar (odds ratio [OR]: 3.51; $p = 0.01$) and less likely to have elevated blood pressure (OR: 1.93; $p = 0.06$, in favor of community screening). Methodological issues such as timing of blood sugar testing at home, possible white coat hypertension in the community setting, and self-selection bias for blood pressure measurement in the community may have contributed to such a finding. Conversely, a study by Abegunde et al. [15] that tested the inter-rater agreement between CHW and expert physicians in applying the World Health Organization (WHO) cardiovascular risk management package, with a priori agreement level set at >80%, found moderate to perfect levels of agreement in almost all sections of the package—counselling,

TABLE 1. Summary of included studies

	Study 1	Study 2	Study 3	Study 4	Study 5
Author, yr	Jafar et al., 2009 [13]	Cappuccio et al., 2006 [14]	Abegunde et al., 2007 [15]*	Joshi et al., 2012 [16]*	Pastakia et al., 2013 [17]
Condition targeted	Hypertension management	Population-wide BP management by reducing salt intake	Combined cardiovascular risk factor assessment (HTN, smoking, physical inactivity, and diet)	1. Identification of individuals at high risk of CVD 2. Cardiovascular health promotion	Screening for HTN and diabetes
Study type	Cluster randomized, 2 × 2 factorial, controlled trial	Cluster randomized controlled trial	Cross-sectional study	Cluster randomized, 2 × 2 factorial, controlled trial	Cross-sectional study
Sample size, description	1,341 adults in 12 geographical clusters with HTN	1,013 participants in 12 villages	649 paired applications of the WHO Cardiovascular Risk Management Package—scenario 1	1,137 high-risk individuals identified and surveyed in 44 villages (5 to 61 per village)	236 individuals screened at home by CHW who were previously HIV counsellors
Setting	Urban/Pakistan	Ghana	Urban/India and Pakistan	India	Rural/Kenya
Treatment/ intervention/ exposure	Home health education by CHW every 3 months + general practitioner education in HTN annually	Control group care + additional advice on not adding extra salt, limiting salty food such as certain fishes and meat	Protocol was independently applied by NPHW and "expert" physicians, analyzed using kappa statistic and logistic regression with a priori agreement level set at 80%	1. Identification and treatment of individuals at high risk of CVD using an algorithmic approach by NPHW 2. Organized health promotion campaign	Home-based screening done through automated BP monitors (SBP >160 mm Hg) and glucometer (random glucose >7 mmol/l) after a 1-day training session
Control group intervention	Usual care	Communal education sessions led by CHW on infectious diseases, as well as diabetes mellitus and HTN awareness. Frequency daily for 1 week, and once weekly thereafter. Medium used—flipcharts	None	Usual care with no health promotion	Comparison group: 346 individuals screened through experienced nurses and clinical staff at 1 booth set up in the community for 2 days
Primary outcome measures	Reduction in SBP from baseline to end of follow up at 2 years	Change in 24-h urinary sodium and change in SBP at 6 months	Inter-rater agreement between NPHW and physicians when applying different sections of the scenario 1 protocol	1. Proportion of individuals correctly identified as being at high risk of CVD at 18 months 2. Mean number of correct answers given to 6 questions about behavioral determinants of CVD	Differences in likelihood of screening positive between the 2 strategies
Results	Systolic BP reduction of 10.8 mm Hg (95% CI:8.9 −12.8) in intervention group versus 5.8 mm Hg (95% CI: 3.9−7.7) in control group (p <0.001)	At 6 months, compared with the control group, intervention group showed a reduction in SBP by 2.54 mm Hg (95% CI: 1.45−6.54; p = 0.01) Urinary sodium excretion: no significant change	Over 80% agreement between raters, with moderate to perfect levels of agreement in almost all sections in the package (counselling, prescription, and referral)	1. 63.3% in intervention group versus 51.4% in control group (p = 0.027) 2. No difference in knowledge of behavioral determinants of CVD between 2 groups	BP screening: OR: 1.93 (p = 0.06) in favor of the community-based participants BS screening: OR: 3.51 (p = 0.01) in favor of the home-based screening participants
Quality of study	26/26 (100%)	24/28 (85%)	15/20 (75%)	15/26 (57%)	13/20 (65%)
Percentage of fidelity elements described	48	29	NA	16	NA
Strengths and weaknesses	Strengths: simple, standardized, and reproducible intervention; well-designed population based study Weaknesses: 22% attrition rate, no detected mechanisms by which the intervention worked	Strengths: real-life, community-based study Weaknesses: control arm received more than standard care, likely contamination of control arm, mechanism of BP reduction unclear	Strengths: well designed and conducted, provides strong evidence of reliability of application of the WHO package by NPHW Weaknesses: no data on clinically relevant outcomes in a real-world setting	Strengths: large size, real-world setting Weaknesses: primary outcomes are process measures and of questionable clinical relevance, no objective systematic evaluation of high-risk patients, no baseline information collected so unable to examine for change in outcomes (e.g., knowledge or drug use), possible contamination of control groups	Strengths: demonstrates feasibility of CHW-based screening Weaknesses: only 1 BP reading obtained during screening, referral threshold not based on any standard guidelines, opportunistic screening methods

Fidelity was measured using guidelines provided by the National Institutes of Health Behaviour Change Consortium [11] and is reported as percentage of criteria met. Quality was evaluated using Kmet's manual for quality scoring of quantitative studies [12], and a checklist was used to assign a score.
BMI, body mass index; BP, blood pressure; BSS, behavioral support sessions; BSS+, behavioral support sessions +7 weeks of Bupropion therapy CDC, Centers for Disease Control and Prevention; CHW, community health workers; CI, confidence interval; CO, carbon monoxide; CVD, cardiovascular disease; FBG, fasting blood glucose; HIV, human immunodeficiency virus; HTN, hypertension; MET, metabolic equivalents; NA, not applicable; NPHW, nonphysician health workers; OR, odds ratio; SBP, systolic blood pressure; WHO, World Health Organization.

*The articles mention NPHW as the subject of study, but does not define them. Because the most common NPHW in India and Pakistan are CHW, known as ASHA (accredited social health activist) [23] and lady health workers [24], respectively, we included them in this review.

Study 6	Study 7	Study 8	Study 9	Study 10	Study 11
Denman et al., 2015 [18]	Balagopal et al., 2008 [19]	Farzadfar et al., 2012 [20]	Balagopal et al., 2012 [5]	Siddiqi et al., 2013 [21]	Gaziano et al., 2015 [22]
Physical inactivity, diet	Diabetes	Hypertension, diabetes	Diabetes	Smoking	Cardiovascular risk assessment by CHW
Nonrandomized, intervention study	Collective population approach	Retrospective analysis of the Iranian rural "Behvarz" system	Community-based participatory research	Cluster randomized controlled trial	Cross-sectional study
184 participants	703 village inhabitants, between 10 and 92 yrs of age	65,619 individuals with available FBG, SBP, BMI, and sociodemographic variables through the 2005 NCDSS (Non-Communicable Disease Surveillance Survey)	1,638 participants in 1 village	1,955 adult smokers with suspected tuberculosis	4,049 people screened for high cardiovascular risk
Urban/Northern Mexico	India	Rural and urban/Iran	India	Rural and urban/ Pakistan	Rural and urban/Bangladesh, Guatemala, South Africa, and Mexico
13-week program including weekly 2-h educational sessions and a physical activity group. 2 CHW intervened on 15–20 people	10 encounters focused on diet and physical activity. Methods included education, cooking demos, recipe competitions, stress relaxation exercise, and dancercise events. No pharmacological therapy used	Behvarz workers in rural Iran who diagnose, refer, monitor, and provide lifestyle advice for diabetes, as part of the national diabetes program. No specific role for Behvarz workers in the smaller national HTN program	10 encounters (5 one-on-one, 5 group based) focused on improving diet and physical activity	2 brief BSS, or BSS + 7 weeks of Bupropion therapy	CHW screened participants for high cardiovascular risk using a risk assessment tool based on age, sex, current smoking status, diabetes status, measured SBP, weight and height, and a decision support chart to determine a risk score. Health professionals independently generated a second risk score with the same instrument and the 2 sets were compared
Not applicable	Not applicable	Not applicable	Not applicable	Usual care	NA
At 3 months: 1. Increase in MET expended per day 2. Increase in meeting CDC daily exercise requirements 3. Increase in less likelihood for consuming whole milk 4. Decrease in daily servings of packaged foods	Reduction in FBG levels at 6 months	Reduction in population FBG and SBP for every additional Behvarz worker per 1,000 adults	Reduction in FBG levels at 6 months	Continuous abstinence 6 months after the quit date (determined by CO levels)	Level of direct agreement between risk scores assigned by the CHW and the health professionals
1. Increase in MET expended per day: +1,073 from baseline (95% CI: 119–2,028) 2. Increase in meeting CDC daily exercise requirements: +14% from baseline (95% CI: 1.7–2.7) 3. Increase in less likelihood for consuming whole milk: +21% from baseline (95% CI: 1.8–4.7) 4. Decrease in daily servings of packaged foods: −0.15 from baseline (95% CI: −0.28 to −0.03)	Reduction in FBG by 11% in pre-diabetic adults, 17% in pre-diabetic youth, and by 25% in adults with type 2 diabetes	Reduction in FBG by 0.09 mmol/l (95% CI: 0.01–0.18, p = 0.01) and reduction in SBP by 0.53 mm Hg (95% CI: −0.44 to 1.50, p = 0.28)	Reduction in FBG by 6.02 mg/dl and 19.08 mg/dl in individuals with pre-diabetes and diabetes, respectively (p < .001)	RR for continuous abstinence in BSS+: 8.2 (95% CI: 3.7 to 18.2) RR for continuous abstinence in BSS: 7.4 (95% CI: 3.4 to 16.4)	Mean level of agreement between the 2 sets of risk scores was 96.8% (weighted κ = 0.948, 95% CI: 0.936–0.961)
17/20 (85%)	19/20 (95%)	19/20 (95%)	19/20 (95%)	23/26 (88%)	18/20 (90%)
42	50	NA	50	52	NA
Strengths: detailed recording of dietary habits, real-world setting Weaknesses: no control group, 17% attrition rate	Strengths: community based, real-world setting, comprehensive intervention Weaknesses: no control group, 17% attrition rate	Strengths: large, representative health examination survey, novel analysis Weaknesses: use of data from only 1 health examination survey, unable to control for the effect of other factors on outcomes	Strengths: large community-based study, comprehensive intervention, measured changes in a wide range of indices Weakness: no control group	Strengths: well-designed large study, simple and reproducible intervention, used CO analysis to confirm abstinence Weaknesses: inability to validate longer term abstinence, differences in baseline characteristics	Strengths: multicountry study, use of a unique non-laboratory-based risk assessment tool Weaknesses: model could under detect risk due to diabetes, health professionals risk score was based on data collected by the CHW themselves

prescription, and referral. The WHO cardiovascular risk management package [26] was developed to aid systematic case management in low and medium resource settings. It starts with hypertension as an entry point, determines the presence of CVD by history, and focuses on lifestyle modification and smoking cessation. Similarly, Gaziano et al. [22] conducted a study in 4 countries that looked at the level of agreement between cardiovascular risk scores assigned by CHW and health professionals. The mean level of agreement between the 2 sets of risk scores was very high at 96.8% (weighted $\kappa = 0.948$, 95% confidence interval [CI]: 0.936 to 0.961).

Joshi et al. [16] conducted a randomized controlled trial in India that found that CHW-led opportunistic screening of people at high risk for CVD, compared with usual care in the community through primary care providers, resulted in a higher proportion of people being correctly identified at high cardiovascular risk (63.3% in intervention vs. 51.4% in control subjects; $p = 0.027$).

Hypertension

Jafar et al. [13] conducted a cluster randomized controlled trial that demonstrated a reduction in systolic blood pressure over 2 years (10.8 mm Hg in intervention group vs. 5.8 mm Hg in control group [$p < 0.001$]). The intervention was 2-pronged—home visits by CHW every 3 months and education of general practitioners every year. The home visits were focused on using behavior change communication strategies to communicate standardized health education messages about hypertension and to emphasize medication adherence and physician follow-up.

Another randomized controlled trial in Ghana [14], testing an education intervention to reduce salt intake in the general population, found a reduction in systolic blood pressure in the intervention group (n = 522), when compared with the control group (n = 491) (2.54 mm Hg; $p = 0.01$). However, the interpretation of these findings is confounded by the fact that urinary sodium excretion, a proxy for dietary sodium intake, did not appear to be altered in this study. Moreover, the trial was limited by significant delays between screening and intervention, likely contamination of the control arm, and low theoretical treatment fidelity.

Diabetes

In 2008, Balagopal et al. [19] tested a CHW-based strategy in India that emphasized changes in diet and physical activity through 10 face-to-face encounters. It was a cohort study in 703 participants, and compared with baseline, led to reduction in fasting blood glucose levels in pre-diabetic adults by an average of 11% (0.66 mmol/l, n = 79), and in diabetic adults by 25% (3.34 mmol/l, n = 30). In 2012, Balagopal et al. [5] performed a similar study, modifying the intervention to include 5 one-on-one encounters and 5 group encounters. The intervention continued to focus on diet and physical activity, with the addition of model meal demonstrations and cooking competitions. The intervention, tested in 1,638 individuals, reduced the fasting blood glucose in pre-diabetics by 5.6% (0.32 mmol/l, n = 316) and diabetics by 8.5% (0.83 mmol/l, n = 116).

A retrospective analysis of the Iranian rural primary health care system [20], in which CHW provide diagnostic, educational, and monitoring services for diabetic patients in rural areas, found that the addition of a single additional CHW per 1,000 adults was associated with a reduction in the district-level average fasting plasma glucose by 0.09 mmol/l (95% CI: 0.01 to 0.18; $p = 0.02$) and the district level average systolic blood pressure by 0.53 mm Hg (95% CI: −0.44 to 1.50; $p = 0.28$). Moreover, treatment lowered mean fasting plasma glucose by an estimated 1.34 mmol/l (0.58 to 2.10) in rural areas and 0.21 mmol/l (−0.15 to 0.56) in urban areas. These results were despite the greater physician availability and easier access to physicians in urban areas. There are no CHW in urban areas, which the investigators postulated leads to an absence of rigorous follow-up, and might be the reason for lower treatment effectiveness in urban areas. The lack of a significant decrease in systolic blood pressure may be due to the lack of a defined role for CHW in the national hypertension program, which is smaller than the diabetic program.

Tobacco use

Tobacco cessation with assistance from CHW has been evaluated within the structure of a tuberculosis treatment program in Pakistan by Siddiqi et al. [21]. Using directly observed therapy workers, they studied whether a behavioral support strategy could enhance the rates of smoking cessation in patients suspected of tuberculosis. Forty-one percent of patients in the behavioral support strategy group (n = 640) achieved continuous abstinence (measured 6 months after the quit date), compared with 8.4% of patients in the control group (n = 656), yielding an absolute benefit of 32.6%. The relative risk for continuous abstinence in the behavioral support strategy group was 7.4 (95% CI: 3.4 to 16.4), when compared with usual care. The workers received 1 day of training and delivered the intervention over 2 sessions, the first being a 30-min session emphasizing WHO's "5 A's" approach and encouraging patients to plan for a quit date a week later. The second session was delivered on the quit date and reviewed progress toward quitting.

Physical inactivity, diet, and obesity

Denman et al. [18] conducted a cohort study (n = 184) in Mexico that examined a 13-week program that included weekly 2-h educational sessions and a physical activity group. The educational sessions were focused on diet, physical activity, and maintaining a healthy weight. At the end of the 13 weeks, there was an increase in metabolic equivalent-minutes expended per week (+1,073 from baseline, 95% CI: 119 to 2,028), increase in meeting Centers for Disease Control and Prevention daily exercise

TABLE 2. Treatment fidelity of included studies

	Jafar et al., 2009 [13]	Cappuccio et al., 2006 [14]	Abegunde et al., 2007 [15]	Joshi et al., 2012 [16]	Pastakia et al., 2013 [17]	Denman et al., 2015 [18]	Balagopal et al., 2008 [19]	Farzadfar et al., 2012 [20]	Balagopal et al., 2012 [5]	Siddiqi et al., 2013 [21]	Gaziano et al., 2015 [22]
Treatment design											
Information about treatment											
Length of contact	1	0	NA	0	NA	1	0	NA	0	1	NA
Number of contacts	1	1	NA	0	NA	1	1	NA	1	1	NA
Content of treatment	1	1	NA	1	NA	1	1	NA	1	1	NA
Duration of contact over time	1	1	NA	0	NA	1	1	NA	1	1	NA
Information about control or comparison condition											
Length of contact	1	0	NA	0	NA	NA	NA	NA	NA	0	NA
Number of contacts	1	1	NA	0	NA	NA	NA	NA	NA	0	NA
Content of treatment	1	1	NA	1	NA	NA	NA	NA	NA	1	NA
Duration of contact over time	1	1	NA	0	NA	NA	NA	NA	NA	1	NA
Back-up plans for implementation setbacks	0	0	NA	0	NA	0	0	NA	NA	0	NA
Provider credentials	1	0	NA	0	NA	0	1	NA	1	1	NA
Theoretical model	0	0	NA	0	NA	0	1	NA	1	1	NA
CHW training											
How trained	0	0	NA	0	NA	0	1	NA	1	1	NA
Standardized training	0	0	NA	0	NA	0	1	NA	1	1	NA
CHW skills assessed	0	0	NA	0	NA	1	0	NA	0	0	NA
CHW skills maintenance	0	0	NA	0	NA	0	1	NA	0	0	NA
Desirable features in CHW articulated a priori	1	0	NA	0	NA	0	0	NA	1	1	NA
Assessing fit between CHW and intervention during hiring	0	0	NA	0	NA	0	0	NA	1	0	NA
Delivery of treatment											
Content delivered	0	0	NA	0	NA	0	0	NA	0	0	NA
Dose delivered	0	0	NA	0	NA	0	0	NA	0	0	NA
Provider adherence to intervention	0	0	NA	0	NA	0	0	NA	0	0	NA
Plan for preventing contamination	1	0	NA	0	NA	NA	NA	NA	0	1	NA

(continued)

TABLE 2. Continued

	Jafar et al., 2009 [13]	Cappuccio et al., 2006 [14]	Abegunde et al., 2007 [15]	Joshi et al., 2012 [16]	Pastakia et al., 2013 [17]	Denman et al., 2015 [18]	Balagopal et al., 2008 [19]	Farzadfar et al., 2012 [20]	Balagopal et al., 2012 [5]	Siddiqi et al., 2013 [21]	Gaziano et al., 2015 [22]
Treatment manual used	0	0	NA	0	NA	1	0	NA	0	1	NA
Plan for assessing whether active ingredients were delivered	0	0	NA	0	NA	0	0	NA	0	0	NA
Plan for assessing whether proscribed ingredients were delivered	0	0	NA	0	NA	0	0	NA	0	0	NA
Nonspecific treatment effects	0	0	NA	0	NA	1	0	NA	1	0	NA
Receipt of treatment											
Participant comprehension assessed	0	0	NA	0	NA	0	0	NA	0	0	NA
Method for improving comprehension	0	0	NA	0	NA	0	1	NA	0	0	NA
Performance skills assessed	0	0	NA	0	NA	0	0	NA	0	0	NA
Strategy to improve performance	1	0	NA	0	NA	1	1	NA	0	0	NA
Cultural factors considered	1	1	NA	1	NA	1	1	NA	1	1	NA
Enactment of treatment skills											
Skills assessed in relevant settings	1	1	NA	1	NA	1	1	NA	1	1	NA
Improve performance in relevant settings	1	1	NA	1	NA	1	1	NA	1	1	NA
Summary score (total sum/total possible sum)	15/31	9/31	NA	5/31	NA	11/26	13/26	NA	13/26	16/31	NA
Percentage of fidelity elements described	48	29	NA	16	NA	42	50	NA	50	52	NA

Fidelity was measured using guidelines provided by the National Institutes of Health Behaviour Change Consortium [11], and each criteria is reported as present (1), absent (0), or not applicable (NA). CHW, community health workers.

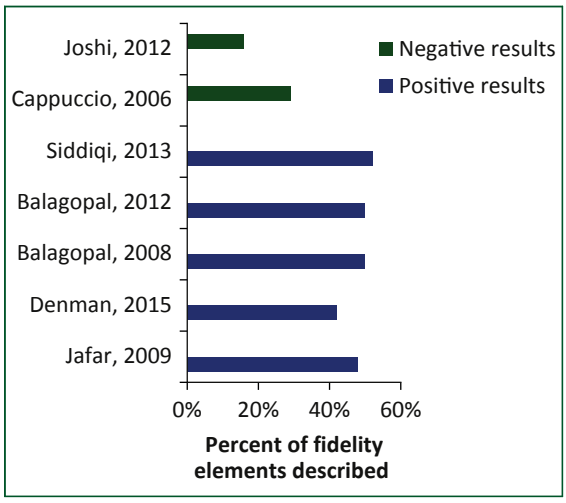

FIGURE 4. Relationship of treatment fidelity with study results. Fidelity was measured using guidelines provided by the National Institutes of Health Behaviour Change Consortium [11].

requirements (+14% from baseline, 95% CI: 1.7 to 2.7), decrease in likelihood for consuming whole milk (−21% from baseline, 95% CI: 1.8 to 4.7), and decrease in daily servings of packaged foods (−0.15 from baseline, 95% CI: −0.28 to −0.03).

In the study by Balagopal et al. [5] in 2012, in addition to reducing fasting blood glucose levels, the intervention also reduced body mass index (−0.46 kg/m^2 in general population [n = 1638], −1.02 kg/m^2 in diabetics [n = 116]) and waist circumference (−1.25 inches in general population [n = 1,638], −1.55 inches in diabetics [n = 116]).

Combined cardiovascular risk management and secondary prevention

No studies were located that looked at combined cardiovascular risk management or secondary prevention through CHW.

COST-EFFECTIVENESS

Whereas CHW-led programs are widely believed to be cost-effective, only 1 study [13] reported information on cost-effectiveness. Jafar et al. [27], in a separate publication, reported that the cost of their hypertension intervention was $3.99 annually per participant. The incremental cost-effectiveness ratio of the intervention was $23 per mm Hg reduction in systolic blood pressure, compared with usual care. The incremental cost of the intervention, versus usual care, was $1,226 per CVD disability-adjusted life years averted. Because the gross domestic product per capita of Pakistan was $881 in 2007 (World Bank estimates), and WHO classifies an intervention that saves 1 disability-adjusted life year for <3× the gross domestic product per capita as cost-effective, this intervention will be regarded as cost-effective.

DISCUSSION

With weak health care systems and a rising tide of CVD, novel health system innovations are being sought to help LMIC manage the pandemic of CVD [28,29]. CHW have been suggested as a way to achieve that goal, with their potential ability to quickly integrate into the health care system with short training periods, provide community-based care that is cost-effective, and achieve high-quality outcomes. Our review is a contemporary examination of the role that CHW can play in managing risk factors for CVD in LMIC.

We found that barriers to successful use of CHW include low levels of numeracy and literacy among CHW, which could potentially be addressed with the use of technology to assist the CHW [22]. Lack of trust in CHW to conduct cardiovascular risk assessment and make referrals was cited as another barrier [30]. The lack of trust extends to both patients and other parts of the health care system. Further analysis of barriers and facilitators to CHW effectiveness was limited by absence of detailed reporting on the operational design of most studies. This led to reduced internal and external validity and decreases the likelihood of successful replication [11].

Community-based studies in a real-life setting can be challenging, and many studies faced significant difficulties. Attrition was a noteworthy problem in most studies, with rates as high as 17% to 22%. Denman et al. [18] reported in their community health center–based study that attrition was driven by conflicting work schedules, lack of transportation, lack of child care, and family emergencies. Factors driving attrition in home-based settings were less clear. Cappuccio et al. [14] reported difficulties with blood sampling in Ghana, with rumors spreading in some areas that the blood was to be tested for HIV or sold in London. Other obstacles included difficulty recruiting men due to work schedules [18], minimizing contamination of control group participants [14] and control group health workers [16], and difficulty in tracing patient health records [31].

It is important to note that although the studies showed positive effects, the external validity of most of the studies is limited, and we did not examine publication bias. Of the 11 studies, only 5 were randomized controlled trials, with 3 of them conducted in South Asia. Only 1 study was multinational, and most studies were limited to either an urban or a rural location. It is clear that more studies are needed to confirm these findings and to clarify their generalizability. Future studies will also need to clarify whether a single model is appropriate for both urban and rural locations and across different LMIC.

There are at least 5 registered randomized controlled trials that are currently examining the role of CHW in

combined cardiovascular risk factor management and secondary prevention of CVD [30, 32–35].

It will also be necessary for future studies to elaborate on CHW intervention fidelity in order to increase reliability, reproducibility, and scientific confidence in the findings. Characteristics of successful community health worker programs, including their recruitment, compensation, training, and monitoring must be elucidated. Also, a focus on cost-effectiveness and mechanisms of action will further enhance the understanding of the manner in which CHW-led interventions can be scaled up.

Limitations

The main limitation of our review is the high level of heterogeneity in the studies, which limited a meta-analysis approach. Because our search was conducted entirely in the English language, we may have missed studies that were reported in other languages. We also excluded nontraditional cardiovascular risk factors, such as nonsmoking tobacco, from our initial query. Use of nonsmoking tobacco is especially prevalent in South Asia, where it may contribute to a significant proportion of the CVD burden [36].

Lastly, due to the absence of detailed reporting of treatment fidelity in most studies, we could not fully answer 1 of our review questions—what are the barriers and facilitators for the effectiveness of CHW in cardiovascular risk factor control?

SUMMARY

Cardiovascular diseases are an increasing source of morbidity and mortality in LMIC, with existing health care systems proving inadequate to the task. Our review shows that CHW can potentially help with the burden of CVD, with encouraging evidence of their ability to accurately screen for cardiovascular risk, increase control rates of hypertension, decrease population fasting blood sugar, increase physical activity, improve diet, promote weight loss, and increase smoking cessation. Evaluation of the effectiveness of CHW would be facilitated by future research focused on recruitment and training practices, mechanisms to enhance retention, monitoring of treatment fidelity, evaluation of costs, and elucidating mechanisms of action.

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THE EFFECTIVENESS OF COMMUNITY HEALTH WORKERS IN CVD PREVENTION IN LMIC

Protocol

Background. According to World Health Organization (WHO) estimates, nearly 75% of deaths due to noncommunicable diseases (NCD) occur in low- and middle-income countries (LMIC). LMIC share an even higher burden of premature mortality, suffering 82% of the 16 million NCD-related deaths before the age of 70 years. Cardiovascular diseases account for nearly 50% of all NCD deaths, with cancers, respiratory diseases, and diabetes causing an additional 30% [1]. In terms of risk factors, the leading NCD risk factor is elevated blood pressure (to which 13% of global deaths are attributed) followed by tobacco use (9%), raised blood glucose (6%), physical inactivity (6%), and overweight and obesity (5%) [1].

In 2012, WHO and the United Nations jointly adopted a global target of 25% reduction in premature mortality from NCD by 2025, as compared to 2010 levels. Despite WHO issuing a global NCD action plan to achieve these targets, progress in achieving these aims has been slow and uneven, especially in developing countries [2]. Moreover, it is unclear as to who can be mobilized to deliver care to achieve these targets, especially because health care systems in most LMIC are configured to provide episodic care for acute illnesses and have not yet been able to change to accommodate the continuous nature of chronic illness.

WHO's definition of community health workers (CHW) states "[they] should be members of the communities where they work, should be selected by the communities, should be answerable to the communities for their activities, should be supported by the health system but not necessarily a part of its organization, and have shorter training than professional workers" [3]. CHW are lay community members who undergo focused health care training, usually aimed at a particular disease or task. For example, 600,000 CHW are paid through a fee-for-service system in India to deliver a specific set of primary care functions, such as immunization and promoting institutional childbirth [4].

CHW have played a substantial, and growing, role in the progress made toward achievement of the 3 Millennium Development Goals related to health: reduction in child mortality; improvement in maternal health; and combating human immunodeficiency virus/acquired immunodeficiency syndrome, malaria, and other diseases [5]. It has been postulated that CHW can similarly provide appropriate care for cardiovascular disease control. This review examines the role and effectiveness of CHW in the prevention of cardiovascular disease in LMIC. The risk factors targeted by these interventions include smoking, hypertension, diabetes, physical inactivity, diet, obesity, and combined cardiovascular risk factor management.

Review questions. The aim of this review is to conduct a systematic review of studies looking at the effectiveness of CHW for the prevention of cardiovascular disease in LMIC. The specific review questions are:

1. Can CHW improve identification of risk factors for cardiovascular disease in LMIC?
2. Can CHW help increase control of risk factors for cardiovascular disease in LMIC, and if so, how?
3. What are the barriers and facilitators for the effectiveness of CHW in the management of risk factors for cardiovascular disease, in LMIC?

Inclusion criteria. Population: CHW working in LMIC for cardiovascular risk factor management.

Intervention: Only studies that incorporate CHW as a basis for cardiovascular risk factor management will be included. The definition of a CHW is any health worker who performed functions related to health care delivery, was trained in some way in the context of the intervention, but had received no formal professional or paraprofessional certificate. This is adapted from the definition of a lay health worker as used by the Cochrane Collaboration [6].

Disease conditions: These will be limited to cardiovascular disease, diabetes mellitus, hypertension, smoking cessation, physical inactivity, diet, obesity, cardiovascular risk factor identification, combined cardiovascular risk factor management.

Comparison: Usual care.

Outcome: Change in risk factor identification or control of participants and improved health care.

Types of studies: The review will include intervention studies using the following methods: randomized controlled trials; before/after studies; quasi-experimental studies; and retrospective analysis.

Exclusion criteria. Hospital-based studies and studies with no data-based reporting of outcomes will be excluded.

Search strategy. A search strategy with a combination of the following terms will be used: "lay health worker"; "community health worker"; "health education"; "hypertension"; "diabetes"; "community-based participatory research"; "developing countries"; "low- and middle-income countries"; "diet"; "cardiovascular disease"; "physical activity"; "smoking cessation"; "obesity"; "chronic disease"; "noncommunicable diseases." The following databases will be reviewed: Medline; Social Sciences Index; CINAHL (Cumulative Index to Nursing and Allied Health Literature), the Cochrane Review; Web of Science. Manual searches will also be performed. Only studies in English, from the year 1990 to July 2015 will be included.

Articles will be included on the basis of the following: 1) publications focusing on cardiovascular risk reduction programs including smoking cessation, hypertension management, diabetes management, weight management, dietary modification, promoting physical activity and

combined cardiovascular risk factor reduction; 2) CHW-facilitated implementation of these programs; and 3) data-based reporting of outcomes, beyond a description of the program itself.

The variables used in this analysis will include risk factor targeted, country of study, target population, role of CHW, and study outcomes.

Data collection. A librarian and 2 authors will review the published reports and extract the data independently. In case of a disagreement about the inclusion of a paper, a third author will be asked to adjudicate. The references of all the included papers will be checked for additional relevant papers. If a study is reported in 2 journals, the article with the maximum detail will be chosen. If needed, details will be gathered from >1 article. Study authors will be contacted for any missing data.

TABLE. PRISMA 2009 Checklist

Topic	#	Checklist Item	Reported in
Title			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title
Abstract			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	Abstract
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Introduction
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	Introduction
Methods			
Protocol and registration	5	Indicate whether a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	Supplementary file
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	Methods
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study investigators to identify additional studies) in the search and date last searched.	Methods, protocol
Search	8	Present full electronic search strategy for $\geq$1 database, including any limits used, such that it could be repeated.	Methods, protocol
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, protocol
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, protocol
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, protocol
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Not available
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	Not available
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	Not available
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	Results
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	Not available
Results			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Results, Figure 1
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Results, Table 1
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Results, Online Table 1

Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: 1) simple summary data for each intervention group; and 2) effect estimates and confidence intervals, ideally with a forest plot.	Results
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	Not available
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see item 15).	Results
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see item 16]).	Not available
Discussion			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	Discussion and summary
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Limitations
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion and summary
Funding			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	No funding

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ONLINE TABLE 1. Quality of included studies

	Jafar et al., 2009 [7]	Cappuccio et al., 2006 [8]	Abegunde et al., 2007 [9]	Joshi et al., 2012 [10]	Pastakia et al., 2013 [11]	Denman et al., 2015 [12]	Balagopal et al., 2008 [13]	Farzadfar et al., 2012 [14]	Balagopal et al., 2008 [15]	Siddiqi et al., 2013 [16]	Gaziano et al., 2015 [17]
Objective sufficiently described	2	2	2	2	2	2	2	2	2	2	2
Study design evident and appropriate	2	2	2	2	2	2	2	2	2	2	2
Participant selection described and appropriate	2	2	1	1	1	1	2	2	2	1	1
Participant characteristics sufficiently described	2	2	1	0	1	2	2	1	2	2	1
If interventional and random allocation possible, was it described?	2	2	NA	2	NA	NA	NA	NA	NA	2	NA
If interventional and blinding of investigators was possible, was it described?	2	0	NA	0	NA	NA	NA	NA	NA	0	NA
If interventional and blinding of subjects was possible, was it described?	NA	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
Outcome well defined and robust to measurement/ misclassification bias? Means of assessment reported?	2	1	2	1	1	1	1	2	1	2	2
Sample size appropriate?	2	2	1	2	0	1	2	2	2	2	2
Analytic methods described/ justified and appropriate?	2	2	2	2	2	2	2	2	2	2	2
Some estimate of variance is reported for the main results?	2	2	0	0	0	2	2	2	2	2	2
Controlled for confounding?	2	2	NA	0	NA	NA	NA	NA	NA	2	NA
Results reported in sufficient detail?	2	2	2	2	2	2	2	2	2	2	2
Conclusions supported by the results?	2	2	2	1	2	2	2	2	2	2	2
Summary score (total sum/ total possible sum)	26/26 (100%)	24/28 (85%)	15/20 (75%)	15/26 (57%)	13/20 (65%)	17/20 (85%)	19/20 (95%)	19/20 (95%)	19/20 (95%)	23/26 (88%)	18/20 (90%)

Quality was evaluated using the Kmet's manual for quality scoring of quantitative studies (Kmet LM, Lee RC, Cook LS. Standard Quality Assessment Criteria for Evaluating Primary Research Papers From a Variety of Fields. Edmonton, Alberta, Canada: Alberta Heritage Foundation for Medical Research, 2004). Total sum = (number of "yes" × 2) + (number of "partials" × 1). Total possible sum = 28- (number of NA × 2). 2, yes; 1, partial; 0, no; NA, not applicable.

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