Characteristics and Outcomes of Community Health Worker Training to Improve the Prevention and Control of Cardiometabolic Diseases in Low and Middle-Income Countries: A Systematic Review

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Abstract

Community health workers (CHWs) play an important role in controlling non-communicable diseases in low- and middle-income countries. The aim of this review was to describe the characteristics and outcomes of CHW training programs that focused on the prevention and control of cardiometabolic diseases in low- and middle-income countries (LMICs). Medline, CINAHL Complete, Academic Search Complete, Directory of Open Access Journal, ScienceDirect, ERIC, Gale Academic, and OneFile). Studies that described the training programs used to train CHWs for prevention and control of cardiovascular diseases and type2 diabetes mellitus in LMICs. Only studies that evaluated the outcomes of training programs in at least one of the 4 levels of Kirkpatrick's training evaluation model were included in the review. CHWs who underwent training focused on the prevention and control of cardiovascular disease and type 2 diabetes mellitus. We summarized the resulting evidence using qualitative synthesis through a narrative review. Training outcomes were assessed in relation to (1) CHW reactions to training, their degree of learning, and their behaviors following training, and (2) changes in biochemical and anthropometric indicators in target populations following the CHW program implementation. PROSPERO (CRD42020162116). Thirty-two studies were included. Methods used to train CHWs included: face-to-face lectures, interactive group activities, and blended teaching with online support. Training focused on identifying people with elevated risk of cardiometabolic diseases and their risk factors as well as supporting people to adopt healthy lifestyles. Many studies that utilized trained CHWs did not publish CHW training methods and evaluations, and therefore could not be included in this study. Training programs resulted in an increase in knowledge and skills among CHWs demonstrating that there are certain activities that can be shifted to CHWs following training.

Keywords

cardiovascular diseases, community health workers, low- and middle-income countries, training, Type 2 diabetes mellitus, systematic review, non communicable diseases

What we already know

Cardiovascular diseases account for one-third of all global deaths, disproportionately impacting low- and middle-income countries.
People with or at risk of cardiovascular diseases and type 2 diabetes mellites need support for disease self-management in terms of adhering to healthy lifestyles and prescribed medication at the primary health care level.
A shortage of trained health workers at the primary health care level is a major concern in many countries, resulting in a shift of certain tasks from health professionals to community health workers.

What this article adds

To develop training programs for CHWs, more evidence is required regarding the content, teaching and learning strategies, training duration and effectiveness of the training programs.

Although several preventive and control measures on cardiovascular diseases and type 2 diabetes ideally require medical professionals, there are certain activities that can be shifted to CHWs with proper training.

What are your research's implications toward theory, practice, or policy
CHWs can be trained to acquire knowledge and skills that can be applied in the community to prevent and control cardiovascular diseases and type 2 diabetes and training programs need to be tailored according to the needs of each respective setting.

Introduction

Non-communicable diseases (NCDs) contribute to more than 70% of all deaths globally.[1] cardiovascular diseases (CVD) and Type 2 diabetes mellitus (T2DM) are 2 cardiometabolic diseases that contribute to a substantial proportion of global deaths due to NCDs. CVD accounts for 31% of all deaths globally[2] and T2DM accounts for 1.6 million deaths globally.[3] These 2 diseases affect people in all regions and countries[4] but pose a disproportionately higher burden on low- and middle-income countries (LMICs).[2,3]

This burden is due to increasing aging population coupled with rapid lifestyle changes in LMICs.[5] The resource-constrained health systems in these countries have traditionally been more oriented toward control of infectious diseases and maternal and child health care.[6] Consequently, these countries are less prepared to tackle the long-term burden of chronic conditions like CVD and T2DM.

People with or at risk of CVD and/or T2DM need long-term and patient-centered care.[7] Access to such care can only be ensured through primary health care (PHC) system.[7] The PHC approach improves coverage and equity, and over time can result in better health outcomes. This further lowers health care costs by avoiding the higher expenses associated with CVD and T2DM related complications and disabilities.[8] A shortage of trained health workers along with many competing priorities are major challenges for addressing CVD and T2DM at the PHC level in most LMICs.[7,9] Health workers require a wide range of knowledge and skills to deliver health services at PHC level.[10] To overcome these issues, policy makers have weighed the merits of shifting certain tasks from health professionals to other personnel.[11,12] In this context, community health workers (CHWs) have begun to play a major role in supporting health care provision at the PHC level.

The common term "community health worker" (CHW) refers to a variety of workers who, depending on the country and health system, are also called: lay health workers, volunteer health workers, accredited social health activists (ASHAs) and/or non-professional health workers. These workers typically conduct a variety of tasks including some basic patient care, health education, community guidance, care coordination, and social support.[13] These workers often work with hard-to-reach populations, thereby bridging the gap between health services and health care delivery to such communities.

However, the term CHW is not always clearly defined due to the diverse roles and inconsistent nomenclature used in different countries.[14] The World Health Organization (WHO) defined CHWs as "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."(p.6)[15] CHWs often have a close understanding of the community served. This enables CHWs to serve as a liaison between health/social services and the community to facilitate access to service delivery. Despite not being health professionals, with proper training, CHWs have demonstrated an ability to improve community health outcomes and facilitate access to basic health services.[16-18]

There is limited evidence concerning the design and outcome of CHW training programs focused on the prevention and control of CVD and T2DM. To develop effective training programs more evidence is needed on training content, methods, duration, the extent of acquisition and/or retention of knowledge and skills by CHWs, and the effects of CHW led interventions on health outcomes. The objective of this review was to identify the key characteristics and outcomes of CHW training programs focused on the prevention and control of CVD and T2DM in LMICs.

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Methods

Protocol and Registration

We developed a protocol based on the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[19] and the protocol was registered on PROSPERO (CRD42020162116).

Eligibility Criteria

We included studies that described the training programs used to train CHWs for the prevention and control of CVD and T2DM in LMICs. Only studies that evaluated the outcomes of training programs in at least one of the 4 levels of Kirkpatrick's training evaluation model[20] were included in the review. The Kirkpatrick model considers 4 levels, in assessing the outcomes of training programs. "Level 1 Reaction" measures how trainees react to the training (eg, satisfaction). "Level 2 Learning" analyses if the trainees understood the content of the training (eg, increase in knowledge and skills). "Level 3 Behavior" analyses if the trainees are utilizing what they learned at work, and "Level 4 Results" analyses if the training has a positive impact in relation to ultimate goal of the training program.

Population

The population was the CHWs[15] who underwent training focused on the prevention and control of CVD and T2DM.

Intervention

The intervention was the training program used to train CHWs on how to prevent and control CVD and T2DM.

Comparison

The comparison of the outcomes of training were made within the same group through pre-post-study design or with a control group through randomized or non-randomized controlled trials.

Outcomes

The outcomes were assessed according to the Kirkpatrick's 4-level training evaluation model.[20] Trainee satisfaction with training (level 1), knowledge and skills acquisition (level 2), and apply of knowledge and skills into practice (level 3) were evaluated in relation to CHWs. Changes in blood pressure (BP), glycosylated hemoglobin (HbA1C), fasting blood glucose (FBG) and body mass index (BMI) in target populations, following trained CHWs led activities were evaluated at population level (level 4).

Eligible studies were original articles published in English in peer-reviewed journals from January 1, 2010, to August 31, 2019. We included studies published after 2010 because member states of the United Nations initiated greater commitment to preventing NCDs after the United Nations General Assembly Resolution in May 2010, increasing the priority accorded to NCD prevention and control in many LMICs.[21] We included studies conducted in LMICs classified by the World Bank Group 2018 classification of economies.[22] This review focuses on LMICs because, CHWs can play a significant role in the prevention and control of CVD and T2DM in settings with few resources.

Information sources and search strategy

We searched articles on Medline, CINAHL Complete, Academic Search Complete, Directory of Open Access Journal, ScienceDirect, ERIC, Gale Academic OneFile databases, between September 2 and 20, 2019. The references of relevant systematic reviews were checked for additional articles. The corresponding authors of all included articles in this review were contacted regarding missing information in the published articles and authors of 11 articles responded with additional information.

Various synonyms for "community health worker" were identified from the WHO report on CHWs[9] and from other literature.[14,23,24] We developed 40 search terms altogether grouped in 3 categories, in our search strategy: one group refers to "community health worker" and synonyms, second group refers to "training" and synonyms and then the third group refers to "cardiometabolic diseases" and synonyms. The full list of search terms used in our search strategy is available in Additional file −1. We selected studies implemented in LMICs at the time of title and abstract review.

Data Extraction and Quality Assessment

Two authors independently screened article titles and abstracts to assess eligibility using EndNote. Data were extracted using a semi-structured template developed for this study. Two authors extracted data independently and discussed discrepancies following consensus method.

We assessed the quality of each study of our review, using the Effective *Public Health Practice Project* (EPHPP) quality assessment tool.[25] This tool provided an overall methodological rating of strong, moderate or weak in 6 domains: selection bias, study design, confounders, blinding, data collection methods, and withdrawals/dropouts. Once the assessment was fulfilled, each study received a mark ranging between "strong," "moderate," and "weak" in each of those 6 domains. The global rating of a study was reported "strong" when there was no "weak" rating in any of the 6 domains assessed, global rating was reported "moderate" when there was 1 "weak" rating in any of the domains, and global rating

of a study was rated "weak" when there were 2 or more ratings of "weak" in any of the assessed domains of the tool. Two authors conducted the quality assessment and rated the studies independently, solving any discrepancies of the rating results by following consensus method.

Data Analysis

Given the high level of heterogeneity among studies, we summarized the resulting evidence using qualitative synthesis through narrative review. We conducted thematic synthesis of the findings under the following major themes: CHW characteristics, duration of the training program, teaching and learning strategies, training content, and training outcomes summarizing the findings under these themes.

Results

There was a high level of heterogeneity among the studies, so we summarized the resulting evidence using qualitative synthesis through narrative review. An attempt to do a meta-analysis in level 4 outcomes of trials to derive an estimate of the overall effect from the set of studies revealed high heterogeneity as $\chi^2 = 13.96$ ($P = .003$), $I^2 = 79\%$.

Characteristics of Included Studies

Our search strategy yielded 1166 articles. After removing duplicates, the titles and abstracts of 874 articles were screened, from which 85 articles were selected for full text screening. An additional 5 articles were selected from reference lists, totaling 90 articles for full text review. Of these, 32 articles met the inclusion criteria (Figure 1) and 58 studies were excluded because, they were reviews (n = 7), protocols (n = 10), not conducted in a LMIC (n = 8), the focus of training was not on CVD and/or T2DM (n = 8), trainees were not CHWs (n = 6) or the training program was not evaluated (n = 19). The countries where the studies were undertaken, and the study designs used are summarized in Table 1.

Characteristics of Community Health Workers

CHW characteristics are summarized in Table 1. The age of CHWs varied from 19 to 72 years. The highest attained education level of CHWs varied across studies from primary school to a master's degree and most studies reported education level of CHWs as secondary school level. Participating CHWs were either from the government health sector[26,33,39] or recruited through an interview specifically for the study. Eligibility criteria considered for the recruitment of CHWs included previous experience of working in the health sector,[27,29,50,53] willingness to be trained and work in the community,[27,36,45-47,50,52] proficiency in the local language,[27,30,33,39,46] good communication skills,[30,33] leadership skills,[52] and association with non-governmental organizations (NGOs).[31,32,39,48,49]

Trainers and Teaching Strategies

The trainers who conducted the CHW training programs included endocrinologists,[27,45] dietitians,[34] health educators,[36] public health practitioners,[27,31,39] clinicians,[28,34] and nurses.[32,34,39,40,50,55,58] In some studies, trainers consisted of NGO officers,[30,33] and medical students.[47]

All studies have reported teaching strategies as didactic lectures and practical sessions. Didactic lectures were facilitated with PowerPoint presentations, videos, flip charts, demonstrations with models, and group discussions. Practical sessions included assignments of what trainees learned from didactic lectures, cooking lessons, and role plays. In addition, 3 studies used blended training which combined in-person and online training and training materials.[42,43,53]

### Educating Community Health Workers

In 7 studies, CHWs were educated about hypertension, its risk factors, complications, medication adherence and healthy lifestyles.[26,32,34,38,44,55,58] CHWs were also educated about T2DM, its risk factors, complications, pharmacotherapy, healthy diet and physical activity.[27,29,31,35,36,45-48,52-54,56] Some trainings were focused on CVD and its risk factors, complications and management with pharmacotherapy and healthy lifestyles incorporating information on T2DM and hypertension.[30,39,40,49,50]

Skill Development in Community Health Workers

CHWs were trained to perform certain activities in the field. These included measuring BP using a digital BP measuring apparatus,[26,27,29,31,32,35,38-40,44,49,50,55] assessing capillary blood sugar using glucometers,[29,31,35] taking anthropometric measures,[26,27,29,30,35,39,40,42,44,49] calculating BMI and waist-hip ratio (WHR),[30,35,39,40,44,49] calculating CVD risk score using a CVD risk assessment tool,[39-41] providing foot care for diabetic patients[45] and refilling medications.[32] CHWs were also trained on how to support the community members to adopt healthier lifestyles,[26,27,38,44,53,55] to refer individuals to clinical care,[26,32,35,55] to facilitate group discussions and conduct meetings,[26,55] to prepare action plans and set goals,[26,30,46,57] to engage in patient-centered motivational communication,[27,29,30,34-36,40,47,49,52,54,57] to keep records,[32,35] to perform body movement and exercise demonstrations,[44] to navigate interactions with challenging patients.[52] and to conduct home visits.[52]

Outcomes of the CHW Trainings

Outcomes of the training programs are summarized in Table 2. Training outcomes were assessed in relation to (1) CHW outcomes which include CHW reactions to the training programs (level 1 of Kirkpatrick's model), their degree of learning (level 2 of Kirkpatrick's model) and behaviors of CHWs following training (level 3 of Kirkpatrick's model)
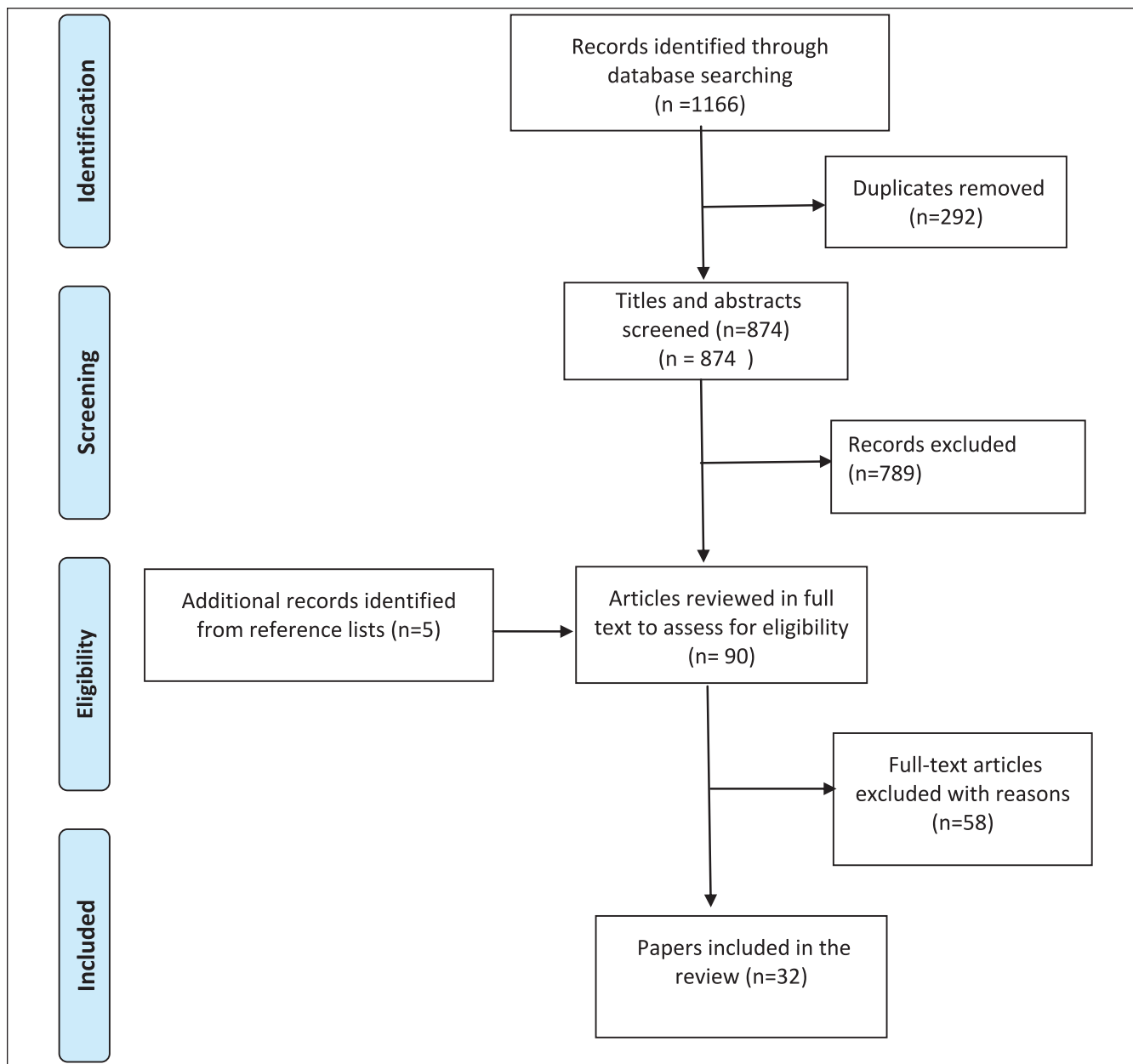
Figure 1. PRISMA flow diagram for the identification, screening for eligibility and inclusion of studies.

and /or (2) population outcomes (level 4 of Kirkpatrick's model) which include changes in biochemical and anthropometric indicators in target populations following program implementation by trained CHWs.

Training Outcomes in Relation to CHWs

Five studies[31,42-44,49] have reported training outcomes only in relation to knowledge gain and skill development of CHWs (level 2 of Kirkpatrick's model). Of these, 2 are non-randomized control trials,[42,43] and they reported significant ($P < .001$) knowledge and skill improvement following

training compared to non-trained CHWs. The other 2 are pre-post studies[44,49] and they reported post training knowledge and skill improvement of CHWs compared to pre-training baseline values.

Three pre-post studies[35,39,53] have reported training outcomes in levels 1 and 2 of Kirkpatrick's model and reported that CHWs were satisfied with the training programs and demonstrated improved knowledge and skills compared to pre-training test score.

Four cross sectional studies[28,40,41,50] have reported training outcomes in level 3 of Kirkpatrick's model and described about CHW performance as screening of the target

Table 1. Characteristics of Included Studies in the Review.

First author [Ref]	Country	Study design	CHWs	No of CHW	Gender	Age	Education level
Abdel-All et al[26]	India	pre – post	ASHAs	15	F	19-50 y	≥10 education
Balagopal et al[27]	India	pre – post	CHW	16	NP	NP	Diploma, degree.
Basu et al[28]	India	CS	CHW	10	F	25-45 y	Secondary level.
Jain et al[29]	India	RCT	CHW	2	M	25-30 y	Master's (social work).
Krishna et al[30]	India	RCT	NPHW	NP	M + F	NP	Up to 12th grade
Raithatha et al[31]	India	CS	VHW	38	NP	45 y	Mean of 9.9 schooling
Sankaran et al[32]	India	CS	CHW	24	F	30-40 y	10th grade
Xavier et al[33]	India	RCT	CHW	16	NP	NP	10th and 12th grade
Jafar et al[34]	Pakistan	RCT	CHW	06	NP	NP	Year 8-10
Gyawali et al[35] 2018	Nepal	Pre – post	FCHV	20	F	47 y	4-12 grades
Khan et al[36]	Bangladesh	Non-RCT	PE	08	M + F	>40 y	> higher secondary
Ashique et al[37]	Bangladesh	Pre -post	CHW	12	NP	30 y	NP
Jafar et al[38]	Bangladesh, Pakistan, Sri Lanka	Pre -post	CHW	NP	NP	NP	NP
Abrahams-Gessel et al[39]	Bangladesh, Guatemala, Mexico, South Africa	Pre -post	CHW	8-15	F	NP	From eighth grade to Masters
Gaziano et al[40]	Bangladesh, Guatemala, Mexico, South Africa	CS	CHW	10-15	F	NP	Grade 8 to Grade 12
Levitt et al[41]	Bangladesh, Guatemala, Mexico, South Africa	CS	CHW	8-15	NP	NP	Eighth grade to Masters
Sranacharoenpong and Hanning[42]	Thailand	Non-RCT	CHW	69	F	>35 year	Bachelor's degree
Sranacharoenpong et al[43]	Thailand	Non-RCT	NP	69	NP	NP	NP
Sangprasert[44]	Thailand	Pre – post	CHVs	240	F + M	20 -72 y	Primary to Bachelor's
Paz-Pacheco et al[45]	Philippines	Non-RCT	VPE	14	NP	NP	NP
Debussche et al[46]	Indonesia	RCT	VPE	10	NP	NP	NP
Taniguchi et al[47]	Cambodia	Pre – post	VPE	NP	F + M	NP	NP
Wagner et al[48]	Cambodia	Pre – post	Guides	185	F + M	44.7 year	Primary school +8years work as a Guide.
Puoane et al[49]	South Africa	Pre – post	CHW	15	F + M	23-36 year	Grade 12
Mannik et al[50]	Kenya	CS	CHW	05	F + M	NP	Secondary level
Balcázar et al[51]	Mexico	Pre – post	Promotors	22	F + M	46.1 year	Attended some school
Newman et al[52]	Mexico	Pre – post	CHW	NP	F	NP	NP
Colleran et al[53]	Mexico	Pre – post	CHW	44	F	>30 y	Vocational /technical, diploma, degree
Micikas et al[54]	Guatemala	Pre – post	CHW	21	NP	NP	NP
Reiger et al[55]	Honduras	Pre – post	CHA[1]	NP	NP	NP	NP
De Souza et al[56]	Brazil	Non-RCT	CHW	08	NP	NP	NP
Moura et al[57]	Brazil	Pre - post	CHA[2]	24	F	25-60 y	>Secondary school

Abbreviations: ASHAs = accredited social health activists; CHA[1] = community health aids; CHA[2] = community health agents; CHV = community health volunteers; CS = cross sectional study; FCHV = family community health volunteers; *F* = Female; *M* = Male; NP = not provided, NPHW = Non-professional health workers; RCT = randomized control trial; VHW = village health workers; VPE = volunteer peer educators.

population for CVD risk. Of these 4-studies, one study[40] reported that the mean level of agreement of risk scores between CHWs and professional health workers who screened for CVD risk was 96·8% (weighted κ = 0.948, 95% CI 0.936-0.961).

Two pre-post studies[26,48] reported training outcomes in levels 1, 2, and 3 of Kirkpatrick's model and describe that CHWs were satisfied with the training, their knowledge and skills improved following the training, and they were able to support the target population in adopting healthy lifestyles.

Table 2. Outcomes of Training Programs.

First author [Ref], study design	Training period	Outcome of training in Kirkpatrick's 4 level model
CHW outcomes		
Sranacharoenpong et al,[43] Non-RCT	16 sessions of 2.5 h each for 4 months	**Level 2**: knowledge increased on T2DM compared to non-trained CHW (*P* < .001)
Sranacharoenpong and Hanning,[42] Non-RCT	NP	**Level 2**: Post-training knowledge score higher in trained CHW than in non-trained CHW (*P* < .001)
Sangprasert et al,[44] Pre-post	NP	**Level 2**: Knowledge + skills to control hypertension increased from baseline (*P* < .001)
Puoane et al,[49] Pre-post	7 h/day for 1 month	**Level 2**: Knowledge + skills to screen for CVD increased from baseline
Raithatha et al,[31] CS	NP	**Level 2**: Gained scores in BP measurement 10/13 and BG measurement 9.7/14
Gyawali et al,[35] Pre-post	5 days	**Level 1**: CHW were satisfied with training **Level 2**: Knowledge + skills to control T2DM increased from baseline (*P* < .001)
Abrahams-Gessel et al,[39] Pre-post	1-2 weeks period over 4 months	**Level 1**: CHWs were satisfied with training **Level 2**: Knowledge + skills to screen for CVD risk increased above passing mark of 60%
Colleran et al,[53] Pre-post	2 days + weekly for 6 months	**Level 1**: CHWs were satisfied with training **Level 2**: Knowledge + skills to control T2DM increased from baseline
Basu et al,[28] CS	2 week and monthly booster training	**Level 3**: CHWs screened the community for CVD risk factors (90% of target households)
Levitt et al,[41] CS	NP	**Level 3**: CHWs screened people for CVD risk
Mannik et al,[50] CS	1 day	**Level 3**: CHWs screened people for CVD risk
Gaziano et al,[40] CS	1-2 weeks	**Level 3**: CHWs screened population for CVD risk and the mean level of agreement of risk scores between CHWs and professional health workers was 96·8% (weighted κ = 0·948, 95% CI 0.936-0.961)
Abdel-All et al,[26] Pre-post	5 days	**Level 1**: CHWs were satisfied with training **Level 2**: Knowledge + skills to control hypertension increased from baseline (*P* < .001) **Level 3**: Conducted meetings, supported self-management, measured BP and anthropometric measures
Wagner et al,[48] Pre-post	3 h	**Level 1**: CHWs were satisfied with training **Level 2**: Knowledge + skills to control T2DM increased from baseline **Level 3**: Promoted healthy diet and exercises in the community
Sankaran et al,[32] CS	7-months	**Level 2**: Knowledge + skills of CHWs increased **Level 3**: CHWs screened population for BP
Target population outcome		
Xavier et al,[33] RCT	5 days + booster training over 3 months	**Level 4**: Intervention versus standard group at 12 months consumed >80% of prescribed drugs (*P* = .006) and lower SBP, BMI, and HDL (*P* < .001), after CHW supported to adherence to pharmacotherapy, healthy lifestyle in patients with acute coronary syndrome
Khan et al[36] Non-RCT	3 days (8 h per day)	**Level 4**: After 3 months, HbA1c, FBG, and SBP decreased (*P* < .05) in both groups of diabetic patients received health education by CHWs and health professionals)
De Souza et al[56] Non-RCT	1 h per week for 4 week	**Level 4**: no significant difference in reduction of HbA1c (*P* = .13) and total cholesterol (*P* = .13) between intervention (health advice and support by CHW) and usual care groups of patients with T2DM
Jafar et al[34] RCT	6 week	**Level 4**: SBP increased significantly over 2 year in the control group in contrast to that of in intervention group (*P* = .02) after lifestyle intervention on blood pressure in children and young adults by CHWs
Paz-Pacheco et al[45] Non-RCT	2 days	**Level 4**: Intervention versus usual care group had higher HbA1C reduction (*P* = .049) and greater decrease in total cholesterol (*P* = .0002) after supporting self-management for T2DM by CHWs
Debussche et al[46] RCT	4 days	**Level 4**: Intervention versus usual care group at 12 months had higher HbA1C reduction (*P* = .006) and BMI (*P* < .001)

(continued)

Table 2. (continued)

First author [Ref], study design	Training period	Outcome of training in Kirkpatrick's 4 level model
CHW outcomes and target population outcomes		
Jain et al,[29] RCT	I week (50-60 h) +booster training (2-3 h) once in 3 months	**Level 2**: CHW knowledge + skill increased (scored >70%) to measure BP, BG, anthropometric measures, and provide health advice and support to patients with T2DM **Level 4**: No significant difference in SBP($P=.651$), DBP ($P=.644$), HbA1C ($P=.946$), LDL($P=.757$), HDL ($P=.286$), BMI ($P=.474$), WHR ($P=.879$ between intervention and usual care groups (at 6 month)
Krishna et al,[30] RCT	Over 6 months	**Level 2**: CHW knowledge + skill increased to support adherence to pharmacotherapy and healthy lifestyle in patients with acute coronary syndrome **Level 4**: Intervention versus standard group at 12 month had significantly lower SBP, BMI, WHR, and LDL ($P<.01$)
Balagopal et al,[27] Pre-post	4 week	**Level 3**: Educated and counseled general population, people with IFG and diabetes **Level 4**: FBG reduced from baseline ($P<.001$)
Ashique et al,[37] Pre-post	3 days	**Level 3**: Educated and counseled patients with hypertension **Level 4**: SBP ($P=.0004$) and DBP ($P=.003$) reduced from baseline
Jafar et al,[38] Pre-post	3.5 h/day over 4 days	**Level 3**: Provided health education and counseling to 90% of the targeted hypertensive patients **Level 4**: Both SBP and DBP reduced from baseline ($P<.001$)
Balcázar et al,[51] Pre-post	5 days	**Level 3**: Performed health promotion activities to prevent CVD in the community **Level 4**: BG reduced ($P=.03$), but no significant change in BP and anthropometric measures
Newman et al,[52] Pre-post	4 times weekly for I month	**Level 3**: Escorted patients with HTN and T2DM to clinics, medication adherence, psychological support. **Level 4**: From baseline to post intervention HbA1c & BP reduced ($P=.02$)
Micikas et al,[54] Pre-post	I week	**Level 3**: Educated patients with T2DM **Level 4**: From baseline to post intervention HbA1c reduced ($P\leq.001$)
Reiger et al,[55] Pre-post	NP	**Level 3**: Dispensed medicine and supported adherence in patients with hypertension **Level 4**: From baseline to post intervention BP reduced ($P=.01$)
Taniguchi et al,[47] Pre-post	6 week	**Level 3**: Educated and supported self-management in patients with T2DM **Level 4**: From baseline to post intervention both BP and FBG reduced ($P<.001$)
Moura et al,[57] Pre-post	32 h	**Level 1**: CHWs were satisfied with training **Level 3**: Interviewed patients with T2DM for behavior change **Level 4**: LDL ($P=.005$) and triglyceride ($P=.002$) reduced but no reduction in HbA1c ($P=.08$)

Abbreviations: NP = not provided; BP = blood pressure; FBG = fasting blood glucose; PPBS = postprandial blood sugar; HbA1C = glycosylated hemoglobin; BMI = body mass index; WHR = waist hip ratio; WC = Waist circumference; HDL = high density lipoprotein; LDL = low density lipoprotein; FGD = focus group discussions; CHW = community health workers; CVD = cardio vascular diseases; DBP = diastolic blood pressure; SBP = systolic blood pressure; T2DM = Type two diabetes mellitus.

Training Outcomes in Relation to Target Populations

Six community trials including 3 randomized controlled trials[33,34,46,] 3 non-randomized controlled trials[36,45,56] reported training outcomes only in level 4 of Kirkpatrick's model. Of these 6 studies, 4 studies[33,34,45,46] reported improvement in BP, HbA1c, and BMI in intervention groups following implementation of programs by trained CHWs in comparison to

control groups who received usual care. Another study[36] compared the target population outcome parameters of HbA1c, FBG, and SBP between 2 groups of diabetic patients, one of which received health education by trained CHWs while the other received health education by health professionals and this study found that these parameters decreased in both groups and there was no difference ($P < .05$) in magnitude of this decrease between the 2 groups. The other study[56] reported that there was no significant difference in

reduction of HbA1c and total cholesterol in the intervention group who received health advise and support by trained CHWs compared to those who received usual care.

Training Outcomes in Relation to Both CHWs and Target Populations

Two randomized controlled trials reported training outcomes in terms of knowledge and skill development of CHWs and also in relation to biochemical and anthropometric parameters at the target population level. Of these 2 trials, one study[30] reported that CHW knowledge and skills were increased to support adherence to pharmacotherapy and healthy lifestyle in patients with acute coronary syndrome and also there was a significant reduction of SBP, BMI, and LDL ($P < .01$) in the intervention group with acute coronary syndrome following implementation of interventions by these trained CHWs compared to a usual care group. However, the other study[29] reported and improvement of knowledge and skills in CHWs following the training, but there was no significant change in target population outcomes following interventions by these trained CHWs.

Nine pre-post studies[27,37,38,47,51,52,54,55,57] have reported training outcomes describing the implementation of interventions by CHWs following the training, and they also have reported an improvement of biochemical and anthropometric parameters of the target populations following these interventions by CHWs, compared to pre-intervention values of these parameters.

Study Quality

Assessment of study quality identified, 3 studies as having a strong quality rating,[27,46,48] 7 rated as moderate[26,32,34,36,43,47,54] and 22 rated as weak.[28-31,33,35,37-42,45,49-53,55-58] Please see Additional File 2, for details of the quality assessment for each of the 6 quality domains of these studies. The studies that were rated moderate quality, scored low in the quality assessment domains such as blinding,[26,34,36,47] and data collection methods.[32,43,54] Of the 22 studies that were rated weak, 8 studies scored low in 2 quality assessment domains, and of those, 6 studies[30,35,51,53,55,58] scored low on blinding and data collection methods while 2 studies[38,45] scored low on blinding and withdrawals/dropout domains.

Discussion

The results of this review show that although several preventive and control measures on CVD and T2DM ideally require medical professionals, there are certain activities that can be shifted to CHWs who received proper training. Identification of training designs, the evaluation of CHW performance after training and the ultimate impact from a population perspective is needed to build effective CHW training programs to improve the prevention and control of CVD and T2DM.

Policymakers seeking to institutionalize CHWs may find this review helpful in understanding how to tailor CHW training programs to best suit their respective settings.

Several systematic reviews have been undertaken to identify the evidence on CHWs and NCD control in LMICs. Jeet et al[59] have identified the effectiveness of CHW delivered NCD prevention interventions in LMICs, and concluded that compared with standard care, CHWs were effective in supporting people in tobacco cessation, BP control and self-management of T2DM. Huang et al[60] and Long et al[61] have identified the potential barriers and facilitating factors in delivering NCD related services by CHWs and concluded, "training of CHWs" is very important to improve the performance of CHWs. The review by Hill et al[62] assessed the roles, responsibilities and characteristics of CHWs involved in diabetes prevention and concluded that training is important to optimize CHW performance in diabetes prevention programs in the future. However, none of them have provided an in-depth understanding of the contents and delivery of CHW training programs. Our systematic review is unique in synthesizing the existing evidence on how training programs for CHWs are administered and how the training of CHWs impacts community level prevention and control of CVD and T2DM.

The training programs represented in our review had various durations. For example, Mannik et al[50] reported on a 1-day training program for CHWs that focused on screening CVD risk and entering patient data as a single short mobile phone text message. This is in contrast with Krishna et al[30] who implemented a 2-year study where CHWs received training over 6 months. Variation in training duration is consistent with other reviews related to CHW training.[63] Receiving training over months boosters knowledge and skill sets of CHWs while providing the window of opportunity to apply the learning on the job and to identify the gaps in knowledge and skills and make an effort to bridge those gaps at the next training sessions. This was evident in the studies that showed better training outcomes.[27,30,33,34,43] At the same time it is worth to consider the cost of training programs, when the time period of training is relatively long and the cost need to be analyzed versus the effectiveness of the programs, and reporting of this type of data were lacking in the articles that were included in our review.

The studies in our review showed that CHWs were often trained to screen the population for risk markers, refer patients to clinical care, deliver health education, and support the community to adopt healthy lifestyles. Similar types of activities are well documented in the literature.[60,64] The content of training programs should be customized to account for the knowledge and skills needed to perform targeted activities in the community.

The importance of CHWs is probably best exhibited with clinical tasks, such as measuring BP, testing capillary glucose levels, foot care for diabetic patients, and even medication refill. The CHWs were trained to record BP

using an electronic BP measuring apparatus and adhering to the standard of operations such as asking participants to rest for at least 5 to 10 minutes before the measurements. Blood sugar estimation of capillary blood has been done using glucometers.

Diabetic foot care examination was taught by the endocrinologists using visual aids in combination with didactic lectures. Following the training of CHWs, they were asked to do a return demonstration of these procedures to assess their acquisition of the skill. Course manuals and training curriculums had been prepared for trainees that described both the course content and the process of how to teach. Over a run-in period of 2 to 3 weeks before the start of the fieldwork, the supervisors/coordinators assessed the ability of CHWs to perform these tasks. The assessors observed the CHWs during their activities and provided feedback at the end of the observations. The CHWs who were not able to perform adequately were re-trained or withdrawn from further activities. In some cases, visiting nurses made trips to each village every 2 months, to observe and supervise CHWs providing clinical care, and sometimes once every 6 months a physician accompanied the visiting nurses to the villages to provide additional CHW observation to assess BP measurement, and other tasks performed by CHWs. Post-training evaluations revealed a satisfactory gain of skills by the CHWs. Only one study reported the performance of CHWs for reliability and reported that CHWs screened the population for CVD risk and the mean level of agreement of risk scores between CHWs and professional health workers was 96.8% (weighted $\kappa = 0.948$, 95% CI 0.936-0.961). Evidence suggests that it is important that these clinical tasks are trained by professionals such as nurses and /or physicians and to conduct training combined with intermittent booster training and random or regular onsite inspections by the supervisors at the field level.

Few controlled trials in our review reported that the improvement in clinical parameters at the end of the study was not significant in the intervention group in comparison with the usual care group. There are certain points that may explain why discrepancy existed.

The RCT conducted by Jain et al[29] showed that though there was a significant reduction in HbA1c and FBG in both the CHW intervention group and the usual care group, the results were not significant between these 2 groups at the end of 6 months of intervention. The authors explained that the possible reasons could be due to the small sample size (150 in each study arm) and reveals that a long period of follow-up, generally 1 year or more than 1 year may demonstrate a clear significant result of the CHW interventions. According to the quality assessment using the EPHPP tool, this study was graded as strong. The training was for 1 week with booster training once in 3 months. The RCT performed by Debussche et al[46] shows that the intervention Vs usual care group at 12 months had higher HbA1c reduction ($P = .006$) and according to the quality assessment using the EPHPP tool

this study was graded as moderate. However, a non RCT by Paz-Pacheco et al[45] shows a significant reduction in HbA1c in the CHW intervention group in comparison with the usual care group after 6-month follow-up period with a sample size of 85 in the intervention arm and 70 in the control arm. However, according to the quality assessment using the EPHPP tool this study was graded as weak. Variations in the quality of the conducted studies, sample size, and variation of the follow-up period may have contributed to discrepancies in the results.

The study by Khan et al[36] showed that health education provided by CHWs resulted in similar clinical outcomes compared to healthcare professionals. This study from Bangladesh, reports that after 3 months of education program, HbA1c, FBG, and SBP decreased ($P < .05$) in both groups of diabetic patients who received health education from CHWs and health professionals. The CHWs of this study were aged >40 years, has diabetes at least for 5 years with HbA1c $< 7\%$, graduated in education, committed to training, and were willing to spend sufficient time on the intervention. The authors comment that the short duration of follow-up is a limiting factor and ideally follow-up period needs to be for 1 year to assess the sustainability of the program. The trainers were accredited diabetes educators, training content included basic knowledge on diabetes and management, oral medicine, effective use of insulin, and a healthy lifestyle. The training method was interactive didactic lectures and practical sessions to teach counseling techniques. The training period was for 3 days including 8 hours per day.

Based on the EPHPP tool 3 studies have been rated as strong in quality review.[29,33,56] These 3 studies were rated as strong, if there were moderate or strong ratings in the domains of selection of study participants, study design, confounders, blinding, data collection method, and dropouts of the participants, and none of these domains had to be rated as weak. The studies were rated as weak in quality if 2 of aforementioned domains were rated as weak. In the RCT by Xavier et al[33] which was rated as strong in quality, the CHWs were with 10th and 12th-grade education, with good communication and motivational skills in the local language, and had a basic knowledge of English to understand key items in the hospital medical records. The CHWs underwent training at the central project office for 5 days and at their local sites for 3 months. CHWs were trained to educate patients with coronary heart disease on a healthy lifestyle and to improve drug adherence. The CHWs supported adherence to pharmacotherapy and a healthy lifestyle resulting in the intervention versus standard group at 12 months consuming $>80\%$ of prescribed drugs ($P = .006$) and lower SBP, BMI, and HDL ($P < .001$). The RCT by Jain et al[29] which too was rated as strong in quality, the CHWs had an education of Master's in social work and they had trained over 1 week with a booster training of 2 to 3 hours once in every month for 6 months. The training material was provided to the CHWs about

10 days before the intensive training workshop. During the workshop, there were small group discussions on the key concepts of diabetes and its epidemiology, types of diabetes, its complications, and risk factors. Case-based discussions were done to facilitate learning for topics like identifying hypoglycemia, diabetes, and its treatment-related complications. The demonstration was done regarding the evaluation of drug adherence based on history, pill count, and patient diary. They utilized role plays to demonstrate communications skills to approach patients and their families at their homes, taking history and detecting any symptoms, assessing any complications, evaluating drug adherence, and supporting healthy lifestyle changes. The CHWs were also taught to use the patient education material made in the local language for the reinforcement of nutrition, and exercise changes and to advise people to stop smoking. CHWs were taught how to take anthropometric measurements, and take BP using automated machines. They also demonstrated how to do the capillary measurement of blood glucose using glucometers. The results showed that CHW knowledge and skill increased (scored >70%) to measure BP, blood glucose, anthropometric measures, and provide health advice and support to patients with T2DM. Both the standard care group and intervention group showed significant improvement in their glycemic indices at the end of the study. There was no statistical difference between the intervention and the standard care group at the end of the study, however, the mean reduction of HbA1c and FBG was more in the intervention group as compared to the standard care group. The aim of the other none RCT that was rated as strong conducted by De Souza et al[56] was to evaluate the effect of a diabetes education program delivered to CHWs in improving the metabolic control of patients with T2DM. Each CHW was responsible for transmitting the acquired knowledge to patients. The primary outcome was changed in HbA1c, 3 months after the intervention. The intervention group of CHWs received training on diabetes education and were taught to transmit their knowledge during their visits. The Control group of CHWs received training in health issues not related to T2DM. The training was in the form of group classes, and the educational method used was collaborative in that the CHW were encouraged to participate actively in the learning process. The CHWs of both intervention and control groups visited T2DM patients at home once a month and delivered T2DM education in each meeting. 3 months after CHW training, patients were reassessed for BMI, BP, lipid profile, and HbA1c. No significant difference in reduction of HbA1c ($P=.13$) and total cholesterol ($P=.13$) between the intervention (health advice and support by CHW) and usual care groups of patients with T2DM. Authors have suggested additional studies, considering time for follow-up, contact time with patients, and the number of meetings, to identify specific, replicable characteristics of successful interventions involving CHW as well as their intervention effect on T2DM complications. A cross-sectional study conducted by Basu

et al[28] which was rated as weak in our review included CHWs with secondary level education and had training for 2 weeks and monthly booster training over the study period. Theoretical lectures followed by a practical demonstration with group learning were used for teaching. Results reported as screening of 1988 men and 4997 women for CVD risk was completed within 6 months and nearly 90% of the targeted households were covered. In the pre-post study by Balagopal et al[29] which was rated as weak in quality in our review, the CHWs had 4 weeks of structured training. The CHWs had either a diploma or a degree. This study also reveals that training was conducted by a dietitian, certified health educator, public health practitioner, and an endocrinologist. Didactic sessions and role-playing were used. The results showed as FBG reduced from baseline ($P<.001$) after healthy lifestyle intervention. There is a wide variation of the characteristics of the training programs of these studies. The quality of the study is also important to assess the effectiveness of the training outcome.

It may be worth describing additional information on the mechanism of training with the outcomes of some studies. In the cross-sectional study conducted by Gaziano et al[40] the CHWs screened population for CVD risk and the mean level of agreement of risk scores between CHWs and professional health workers was 96.8% with 95% CI 0.936 to 0.961. These CHWs were with education levels of grade 8 to 11 and they were trained by nurses and physicians for 2 weeks. Teaching techniques included didactic lectures and assessments. The training content consisted of how to take anthropometric measurements, calculate BMI, measure BP, conduction of in-person interviews, and assess CVD risk scores. In the study (none RCT) by Paz-Pacheco et al[45] the intervention Vs usual care group had higher HbA1c reduction ($P=.049$) and a greater decrease in total cholesterol ($P=.0002$) after supporting self-management for T2DM by CHWs. The CHWs were trained by endocrinologists for 2 days. The teaching techniques were lectures with interactive sessions and the training content consisted of an overview of T2DM and complications, exercise, diet, treatment, insulin therapy, and foot care. However, characteristics of CHWs were not reported in this study.

In a study conducted by Balagopal et al,[27] (pre-post study) FBG reduced from baseline ($P<.001$) following support by the CHWs to adhere to a healthy lifestyle. Dietitians, public health practitioners, endocrinologists, general practitioners, and medical specialists trained CHWs for 4 weeks. The training strategies were didactic sessions, and role-playing, and the training content included basic knowledge on T2DM and its risk factors and complications, dietary modification and nutrition, meditational practices, physical activity improvement, health screening, taking anthropometric measures, measuring BP, effective teaching methods, non-confrontational interviewing, ethics in dealing with people and survey. The CHWs were with a high school diploma or college degree. The education level of

CHWs in Jafar et al[34] study (RCT) was year 8 to 10 and they were trained by nutritionists, dietitians, and clinicians for 6 weeks. The results of this study were significant in Level 4 outcome (controlling BP in the community). The CHWs were trained in conveying health education messages through behavior change communication.

Very few studies in our review have reported on the instruments used to measure the outcomes. Gyawali et al[35] from Nepal, have adapted the Diabetes Knowledge Questionnaire (DKQ) that has been validated in Nepal to assess changes in the CHWs' level of diabetes knowledge. Sranacharoenpong and Hanning[42] have developed a knowledge questionnaire specifically for the study to assess knowledge about diabetes prevention and related risk factors among CHWs. The knowledge questionnaire consisted of 4 parts; understanding of nutritional terms (score=18), understanding of nutritional recommendations (score=25), knowledge of food sources related to the advice (score=36), and nutrition knowledge and general risk factors related to diabetes (score=21). There were 27 questions. The total score was 100. Content validity and reliability of the questionnaire were assessed by experts in the field. Wagner et al[48] have used a validated questionnaire of basic diabetes knowledge to assess the CHWs' knowledge and skill, before and after the training.

Studies in our review show that the CHW knowledge and skills improved significantly after training. This is consistent with other reviews that have evaluated CHW training outcomes on knowledge and skill acquisition.[65] Abdel-All et al[65] who evaluated the training of CHWs through post-training knowledge change and skill assessment also have proposed Kirkpatrick's 4-level training evaluation model as a standardized tool to assess short term and long-term training outcomes. Therefore, by using Kirkpatrick's 4-level training evaluation model to assess training outcomes in our review, we were able to describe the CHW training outcomes comprehensively and compare the training proposed in different studies.

After considering the diversity of CHW training programs, it is clear that there cannot be one standardized training program to control CVD and T2DM for CHWs. Therefore, training programs need to be tailored to suit their context and setting with regular updating through an iterative process.

Study Strengths and Limitations

This is the first systematic review to describe the CHW training programs and to evaluate the outcomes of those training programs for the prevention and control of CVD and T2DM in LMICs. One of the key review strengths is that the outcomes were comprehensively summarized following the Kirkpatrick's training evaluation model which was used as a framework. Another study strength is that we followed rigorous study methods and conducted the review in accordance with the PRISMA guidelines. We not only assessed the outcomes of the included studies but also the quality of included studies was assessed and considered when making conclusions about the available evidence on this topic. All articles were critically appraised using EPHPP quality assessment tool.

We acknowledge that some studies have not provided enough details on training programs and outcomes. In an effort to overcome this, we contacted all authors for more information and were able to obtain some additional data that were not published in the articles. When utilizing narrative synthesis in data analysis, there is a high potential of giving greater emphasis to the studies which provided more detailed information. However, this was overcome by extracting data according to a predesigned format and execution of data extraction by 2 authors independently. It is also important to note that many large, complex interventions that utilized trained CHWs did not publish their CHW training methods and evaluations, and therefore could not be included in this study.

Conclusion

CHWs acquired knowledge and skills that can be applied in the community to control CVD and T2DM. Although several aspects of care for CVD and T2DM ideally require medical professionals, there are certain activities that can be shifted to CHWs with training. This review provides evidence of successful training program models that can be adapted to enhance CHW involvement in the prevention and control of CVD and T2DM in LMICs. Training programs need to be tailored according to the needs of each respective setting. In order to create a lasting impact, a well-organized mechanism needs to be in place to mentor CHWs and to update them with information and resources over time. Further research is needed to evaluate the effectiveness of CHW training programs in real world settings on a long-term basis and the cost-effectiveness of such programs needs to be evaluated.

Authors' Contributions

SS contributed to study design, data screening, data extraction and wrote the manuscript. AD contributed to data screening, data extraction and manuscript editing. TH contributed to study design, checking the data screening and data extraction, assessing quality of studies and manuscript editing. DK contributed to study design and manuscript editing. AM contributed to assessing quality of studies and manuscript editing. JC contributed to study design and manuscript editing. AK contributed to study design and manuscript editing. BO contributed to overall supervision, study design and manuscript editing. All authors read and approved the final manuscript.

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Not applicable

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The study consists of a published literature review analysis; thus, no ethical approval was necessary.

Consent for Publication

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Supplemental Material

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