HHS Public Access

Author manuscript

Am J Prev Med. Author manuscript; available in PMC 2020 March 01.

Published in final edited form as:

Am J Prev Med. 2019 March ; 56(3): e95–e106. doi:10.1016/j.amepre.2018.10.009.

Economics of Community Health Workers for Chronic Disease: Findings from Community Guide Systematic Reviews

Verughese Jacob, PhD, MPH[1], **Sajal K. Chattopadhyay, PhD**[1], **David P. Hopkins, MD, MPH**[1], **Jeffrey A. Reynolds, MPH**[1], **Ka Zang Xiong, MPH**[1], **Christopher D. Jones, PhD, MSW**[2], **Betsy J. Rodriguez, MSN**[3], **Krista K. Proia, MPH**[3], **Nicolaas P. Pronk, PhD, MA**[4,5], **John M. Clymer, BA**[6], **Ron Z. Goetzel, PhD**[7,8], and **Community Preventive Services Task Force (CPSTF)**

[1]Community Guide Branch, Division of Public Health Information Dissemination, Center for Surveillance, Epidemiology, and Laboratory Services, Centers for Disease Control and Prevention (CDC), Atlanta, Georgia [2]Division for Heart Disease and Stroke Prevention, Office of Noncommunicable Diseases, Injury, and Environmental Health, CDC, Atlanta, Georgia [3]Division of Diabetes Translation, National Center for Chronic Disease Prevention and Health Promotion, CDC, Atlanta, Georgia [4]HealthPartners Institute, Minneapolis, Minnesota [5]Harvard T.H. Chan School of Public Health, Boston, Massachusetts [6]National Forum for Heart Disease and Stroke Prevention, Washington, District of Columbia [7]Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland [8]IBM Watson Health, Bethesda, Maryland

Abstract

Context: Cardiovascular disease in the U.S. accounted for healthcare cost and productivity losses of $330 billion in 2013–2014 while diabetes accounted for $327 billion in 2017. The impact is disproportionate on minority and low-SES populations. This paper examines the available evidence on cost, economic benefit, and cost effectiveness of interventions that engage community health workers to: prevent cardiovascular disease, prevent type 2 diabetes, and manage type 2 diabetes.

Evidence acquisition: Literature from the inception of databases to August 2016 were searched for studies with economic information, yielding nine studies in cardiovascular disease prevention, seven studies in type 2 diabetes prevention, and 13 studies in type 2 diabetes management. Analyses were done in 2017. Monetary values are reported in 2016 U.S dollars.

Evidence synthesis: The median intervention cost per patient per year was $329 for cardiovascular disease prevention, $600 for type 2 diabetes prevention, and $571 for type 2 diabetes management. The median change in healthcare cost per patient per year was –$82 for cardiovascular disease prevention, and –$72 for type 2 diabetes management. For type 2 diabetes prevention, one study saw no change and another reported –$1,242 for healthcare cost. One study

Address correspondence to: Verughese Jacob, PhD, MPH, Community Guide Branch, CDC, 1600 Clifton Road, Mailstop E69, Atlanta GA 30333. hir0@cdc.gov.

Names and affiliations of CPSTF members are available at: www.thecommunityguide.org/task-force/community-preventive-services-task-force-members

No financial disclosures were reported by the authors of this paper.

reported a favorable 1.8 return on investment from engaging community health workers for cardiovascular disease prevention. Median cost per quality-adjusted life year gained was $17,670 for cardiovascular disease prevention, $17,138 (mean) for type 2 diabetes prevention, and $35,837 for type 2 diabetes management.

Conclusions: Interventions engaging community health workers are cost effective for cardiovascular disease prevention and type 2 diabetes management, based on a conservative $50,000 benchmark for cost per quality-adjusted life year gained. Two cost per quality-adjusted life year estimates for type 2 diabetes prevention were far below the $50,000 benchmark.

CONTEXT

Cardiovascular disease (CVD)–related cost of treatment and loss of productivity in the U.S. reached $330 billion in 2013–2014,[1] accounting for approximately 14% of U.S. healthcare expenditures in that year. Diabetes-related treatment cost and productivity loss in the U.S. was $327 billion in 2017[2] constituting 14% of healthcare dollars spent in that year, and is expected to grow into the near future as more undiagnosed diabetes patients are diagnosed and treated, and some of the estimated 84 million people with prediabetes progress to type 2 diabetes mellitus (T2DM).[3]

Risk factors for CVD, such as hypertension and hyperlipidemia, are more prevalent within Hispanic, African American, and other minority populations compared with the general population,[4] as is the prevalence of risk factors for T2DM, such as smoking, obesity, physical inactivity, and poor diet.[5] Among those living with T2DM, the relative burden is greatest among American Indian/Alaska Natives, followed by those of Hispanic ethnicity, and Asians due to higher prevalence, underdiagnosis, and barriers to health care.[3] Interventions engaging community health workers (CHWs) have been proposed as one strategy to address these disparities in health status and access to care in the U.S., based on the growing evidence of their effectiveness in improving the quality of care and individual health outcomes.[6,7]

Three previous systematic reviews from the Community Guide established that interventions engaging CHWs are effective in: (1) preventing CVD,[8] (2) preventing progression to T2DM,[9] and (3) improving management of and reducing complications from T2DM.[10] The objective of the present paper is to report on the methods, results, and conclusions from the systematic economic reviews of the literature evaluating the cost, economic benefit, cost benefit, and cost effectiveness of these interventions.

Interventions engaging CHWs are delivered in group or individual sessions, or some combined format within community organizations, health systems, or homes. CHWs may work alone or as part of a team of counselors, clinicians, or other health professionals. Interventions engaging CHWs for CVD prevention screen for and educate patients about high blood pressure, high cholesterol, and behavioral risk factors for CVD, such as physical inactivity and smoking. Support is provided for medication adherence and health behavior changes.[8] Interventions engaging CHWs to prevent T2DM aim to reduce one or more risk factors primarily through improvements in diet, physical activity, and weight management. Activities may include education about T2DM prevention and lifestyle modification, or

informal counseling and coaching.[9] Interventions engaging CHWs for T2DM management aim to improve T2DM care and self-management behaviors among people living with T2DM, through education, coaching, or social support; interventions aim to improve T2DM testing and monitoring, medication adherence, diet, physical activity, or weight management.[10]

EVIDENCE ACQUISITION

Concepts and Methods

This study was conducted using established methods for systematic economic reviews, available online at The Guide to Community Preventive Services (The Community Guide),[11] at the Centers for Disease Control and Prevention. The review team (team) worked under the guidance of the Community Preventive Services Task Force, an independent, nonfederal panel of public health and prevention experts that provides evidence-based findings and recommendations about community preventive services, programs, and other interventions aimed at improving population health. The team included subject matter experts on CHW interventions, CVD, and T2DM from various agencies, organizations, and academic institutions, in addition to members of the Community Preventive Services Task Force and experts in systematic economic reviews from the Community Guide branch at the Centers for Disease Control and Prevention.

A societal perspective was taken for the three reviews, which means costs and economic benefits are aggregated regardless of who pays for, or benefits from the intervention. The following research questions were posed for each of the three interventions: What is the cost to implement the intervention? What is the effect of the intervention on healthcare cost? What is the effect of the intervention on productivity of patients at their workplaces? What is the net economic benefit of the intervention? What is the cost effectiveness of the intervention?

The published literature was searched for evaluation studies that answered one or more of the economic research questions for the three interventions engaging CHWs. Criteria for an economic study to be included as evidence were: met the scope of the intervention, matching what was described previously; conducted in a high-income country as defined by the World Bank; written in English; and included one or more economic outcomes described in the research questions. Studies of patients with established CVD were excluded in all three reviews and those with established T2DM were excluded from the prevention of T2DM review. Concepts and methods for the accurate measurement of intervention cost, expected benefits from averted healthcare cost and improved productivity, total cost, net benefit, and cost per quality-adjusted life year (QALY) gained were developed and described in detail below.

Intervention cost.

Implementation of CHW interventions requires labor and materials, where the intervention may be combined with additional interventions or may occur within a team-based organization of care. Team-based care (TBC) is an organizational intervention in which

primary care providers and patients work together with other providers to improve the efficiency of care delivery and self-management support for patients. The drivers of intervention cost are CHW wages and benefits and the cost of CHW training and supervision. Other costs include costs of education materials, patient testing supplies, and overhead. From the completeness of reporting in the included studies, estimates of intervention cost were considered reasonable if they included CHW wages and cost to supervise CHWs, plus the cost of any additional intervention.

Healthcare cost.

Changes in healthcare resource use are expected due to the intervention, leading to change in healthcare cost. The components of healthcare cost are outpatient visits, medications, labs, emergency room visits, and inpatient stays. Effective interventions can lead to decreased use of healthcare resources because of improved health, or increased appropriate use of healthcare resources because of improved access, such as for underserved populations. The net effect on healthcare cost is an empirical question and is also determined by the length of time to the follow-up measurement. The components that are drivers of healthcare cost are medication, inpatient, outpatient, and emergency room visits. From the completeness of reporting in the included studies, estimates of healthcare cost were considered reasonable if they included these cost drivers.

Total cost and cost effectiveness.

Total cost is defined as the cost of intervention plus the change in healthcare cost because of the intervention, an estimator designed to capture possible healthcare cost savings from the perspective of health systems.

$$\text{Total cost} = \text{intervention cost} + \text{change in healthcare cost} \quad (1)$$

Effective interventions are expected to improve health and thereby reduce healthcare utilization and associated cost in the longer term. Hence, the change in healthcare cost in (1) is expected to be negative in the longer term, and total cost may also be negative as a result, indicating overall cost saving.

Effective CHW interventions increase the quantity and quality of years lived by averting CVD and T2DM morbidity and mortality. Cost-effectiveness analysis seeks estimates for cost per QALY gained, where cost is the sum of intervention cost, change in healthcare cost, and other societal costs. An intervention is considered cost effective if the cost per QALY gained is less than a conservative benchmark of $50,000.[12,13]

For CHW interventions to prevent CVD, reductions in systolic blood pressure (SBP) when reported, were converted to QALYs gained to assess cost effectiveness. Two conversions from the published literature were used. Conversion (1) is from the Cardiff DiabForecaster model,[14] where a reduction of 1 mmHg of SBP=0.009 QALY gained per model cycle (year). The simulated population in the study had T2DM, mean age 52.6 years, 50% female, baseline SBP of 129.5 mmHg, and baseline HbA1c of 10.0%. QALY was calculated for CVD and T2DM events based on utility scores from literature. Conversion (2) was drawn

from a Markov model developed to evaluate control of blood pressure,[15] where a reduction of 1 mmHg of SBP=0.093 QALY gained over a lifetime (40 years). The simulated population in the study had T2DM, mean age 56 years, 49% female, baseline SBP of 160 mmHg, and baseline HbA1c from 7.2% to 8.3%. QALY was estimated with a Markov model for CVD events and utility scores from literature.

For CHW interventions for T2DM management, the conversion factor is drawn from the CORE-Diabetes model,[16] where 1 percentage point reduction in HbA1c=0.38 QALY gained over 35 years. The simulated population in the study had T2DM, mean age 59 years, 51% female, and baseline HbA1c from 7.0 to 9.5 for subgroups. QALY were calculated with a Markov model simulating effects of reducing HbA1c independent of other risk factors. No conversions were performed for CHW interventions to prevent T2DM because the studies did not report physiologic outcomes that could be converted to QALY gained.

Cost of intervention plus healthcare cost were cumulated over the same time horizon specified in the conversion formulas: 20 years in Conversion (1) for SBP, 40 years in Conversion (2) for SBP, and 35 years in the conversion for HbA1c. QALYs were cumulated over 20 years in converting SBP to QALY using Conversion (1). QALYs are already cumulated within the conversion formulas for SBP using Conversion (2) and within the conversion formula for HbA1c. A discount rate of 3% was assumed.

Productivity in the workplace.

Interventions that reduce CVD and T2DM lead to higher productivity from workers who are ill less or not absent from their jobs as often. These lead to better work performance and increased working years.

Cost benefit.

Cost-benefit assessments, whether expressed as net benefit or benefit-cost ratio, consider the cost of the resources necessary to carry out the intervention against the expected monetized benefits derived from reduction in healthcare cost, improved worksite productivity, and increased years lived because of the intervention.

Methods for Organization and Analysis

Studies that included other interventions in addition to the CHW engagement were identified. The inclusion of additional interventions has consequence for both intervention cost and for interpretation of outcomes. Cost for the CHW intervention and the cost of the additional intervention cannot be separated from the reported combined cost and the change in healthcare cost and other outcomes cannot be interpreted as being the result of the CHW intervention alone. The change in healthcare cost reported in studies also identifies whether the estimate from each study is based on all causes, T2DM-related, or CVD-related causes in order to clarify whether the outcome measured is commensurate with the defined objective of intervention (i.e., prevent CVD, prevent T2DM, or manage T2DM). Finally, it was identified for each study whether the measured outcomes were observed and recorded during the conduct of the study or modeled.

Economic results and conclusions are presented separately for each CHW intervention (i.e., CVD prevention, T2DM prevention, and T2DM management). All monetary values are in 2016 U.S. dollars, adjusted for inflation using the Consumer Price Index,[17] and converted from foreign currency denominations using purchasing power parities.[18] All analyses were conducted in 2017.

Search Strategy

The search covered publications listed in CINAHL, Cochrane, Google Scholar, National Technical Information Service, PubMed, Sociological Abstracts, Social Science Research Network, WorldCat, EconLit, and databases maintained at the Centre for Reviews and Dissemination at the University of York. The search period was from the inception of databases to August 2016. The detailed search strategy is available on The Community Guide website.[19] Reference lists of included studies were also searched, as were studies identified by subject matter experts.

EVIDENCE SYNTHESIS

Results

A total of 14,435 papers were screened, yielding 29 studies in 33 papers[20–52] for inclusion (Figure 1). Nine studies[20–22,29,31,34,36,39,40,52,53] provided economic evidence for interventions engaging CHWs for CVD prevention, seven studies[37,41–44,49,51] for interventions to prevent T2DM, and 13 studies[23–28,30,32,33,35,38,45–48,50] for interventions to manage T2DM (Table 1). Seven[20–22,31,36,39,40,52] of nine studies in CVD prevention, one[44] of seven studies in T2DM prevention, and 11[23–28,35,38,45–48,50] of 13 studies in T2DM management were interventions implemented for minority or low-SES populations. Six[21,22,29,34,36,39,40,53] of nine studies for CVD prevention, five[37,42–44,51] of seven studies for T2DM prevention, and nine[23,25–28,35,45–48,50] of 13 studies for T2DM management were RCTs, with the remaining studies being either pre to post without comparison groups or models. The comparison group in most studies received usual primary care. The average age of study patients was 60 years in CVD prevention, 57 years in T2DM prevention, and 52 years in T2DM management. The additional intervention of TBC occurred in three[20,21,34] of nine studies of CVD prevention and six[23,28,30,32,33,38,45,48] of 13 studies of T2DM management; no additional interventions occurred within the seven studies of T2DM prevention. Note that multiple publications that covered the same population and intervention are considered single studies, and they can be identified within Table 1 as those studies with more than one citation.

Although several studies reported intervention cost and effects on healthcare cost, only one study[29,53] reported productivity effects (Table 1). Also, only one study[39,40] performed a return-on-investment (ROI; ROI=[(averted cost/intervention cost)–1.0]) analysis from the perspective of a health plan. Ten studies[22–24,28,29,32,33,36,37,45,47,49,53] modeled the outcomes to cost per QALY gained. Converted cost per QALY gained estimates were derived for the three studies[21,38, 46] that provided both change in SBP or change in HbA1c and the total cost of the intervention. Details for individual studies and the estimates they provided are in Appendix Tables 1–4 (available online).

Estimates for intervention cost, healthcare cost, and total cost are shown in Table 2. The median cost to implement the intervention was $329 per patient per year based on eight studies[20–22,29,31,34,36,52,53] for interventions engaging CHWs for CVD prevention (median 293 patients), $600 per patient per year, based on seven studies[37,41–44,49,51] for those to prevent T2DM (median 134 patients), and $571 per patient per year based on 13 studies[23–26,28,30,32,33,35,38,45–48,50] for interventions to manage T2DM (median 90 patients). The substantial part of all three CHW interventions is made up of CHW wages, the cost of CHW supervision, and any additional intervention, such as TBC. Most studies included the wages of CHWs and the cost of any additional intervention in the estimates of intervention cost, but many did not report adequately to determine whether supervision of CHWs was included. Individual study details along with components of intervention cost included in the estimate are presented in Appendix Table 1 (available online).

The median change in healthcare cost was a reduction of $82 per patient per year for CHW interventions to prevent CVD, based on seven studies[20–22,29,31,34,36,53] (Table 2). Three studies estimated the change in healthcare cost for CHW interventions to prevent T2DM: one showing a decrease of $1,242 per patient per year,[43] the second showing no change, [37]and the third did not report the estimated value but included the effect of the intervention on healthcare cost in its model for cost per QALY gained.[49] For CHW interventions to manage T2DM, the median change in healthcare cost was a reduction of $72 per patient per year, based on four studies.[32,33,38,46,48] Among the studies that provided healthcare cost estimates, five[20,21,29,34,36,53] of the seven studies for CVD prevention included only CVD-related healthcare spending in the estimation; all studies for T2DM prevention included “all-causes” or CVD-related spending, and all studies for T2DM management included only T2DM-related spending. Therefore, the estimates for change in healthcare cost in the three reviews were appropriate for the objectives of the interventions, namely CVD prevention, T2DM prevention, and T2DM management, respectively. Outpatient care and medication were included in estimates for healthcare cost effects in most studies of CVD and T2DM prevention, but was not included or not reported clearly in about half of the six estimates for T2DM management. Inpatient stays and ER visits were included in estimates of change in healthcare cost for most studies that reported the inclusion/exclusion of components. Details about the studies and the estimates for change in healthcare cost related to the intervention are shown in Appendix Table 2 (available online).

The median total cost for CHW interventions to prevent CVD was an increase of $310 per patient per year based on seven studies[20–22,29,31,34,36,53] (Table 2). From the results of two studies, the change in total cost for CHW interventions to prevent T2DM were a reduction of $856[43] and an increase of $600[37] per patient per year, respectively. For CHW interventions to manage T2DM, the median change in total cost was an increase of $1,454 per patient per year based on four studies.[32,33,38,46,48] Most studies did not adequately report the components to determine the completeness of the estimates for total cost. Details for individual studies that contributed to the estimates are in Appendix Table 3 (available online).

The study[39,40] that performed an ROI analysis from the health plan perspective of a large urban service provider found that the savings in healthcare cost compared with the cost of

intervention generated an ROI of 1.8. Although the perspective is not societal, this study indicated that the engagement of CHWs for CVD prevention produced a favorable rate of ROI in the short term.

Table 3 provides study by study time horizon, patient demographics, clinical outcomes, incremental cost, incremental QALY, methods used to derive QALYs, and cost per QALY gained. Individual study estimates are followed by mean and median summaries across the studies. Estimates that were computed by the reviewers by converting SBP or HbA1c reductions to QALY gained are identified as such, with the conversion formula provided. Mean patient age was just under 60 years for CVD and T2DM prevention and just more than 50 years for T2DM management. Among patients in the CVD prevention interventions, the percentage with T2DM ranged from a low of about 14% to 54%. Mean reduction in SBP in the CVD prevention interventions was –5.7 mmHg from a baseline of about 142 mmHg, and the mean reduction in HbA1c in the T2DM management interventions was 0.91 percentage points from a baseline of 8.6.

The median cost per QALY gained for interventions engaging CHWs for CVD prevention was $17,670 (mean=$18,521), based on five estimates from four studies,[21,22,29,36,53] each of which were below the benchmark. One study[21] was a TBC intervention that engaged CHWs. The time horizon for the cost-effectiveness assessments varied widely, from 6-month within-trial assessments to lifetime models covering 480 months. QALYs were estimated using EuroQol-5D (EQ-5D) or modeled health states with utility scores drawn from standard or literature-based scores. Of the two cost per QALY estimates that were computed by the reviewers for one study,[21] the estimate based on Conversion (2) may be more accurate given the similarity in baseline SBP and HbA1c for this study population and the population for which the conversion formula was drawn, SBP=160 mmHg and HbA1c=7.2 to 8.3.

Two[37,49] studies of CHW interventions to prevent T2DM reported cost per QALY gained at $4,767[49] and $29,509,[37] respectively, both <$50,000 benchmark. Neither of these studies had interventions in addition to the CHW engagement. QALYs were estimated based on EQ-5D and standard utility scores[37] and a Markov model for T2DM health states with assumed utility weights.[49]

The median cost per QALY gained for CHW interventions to manage T2DM was $35,837 (mean=$44,675), <$50,000 benchmark, based on ten estimates from seven studies.[23,24,28,32,33,38,45–47] One study[23] assessed cost effectiveness within the trial horizon of 24 months, whereas the others modeled out 240, 420, and 480 months. The studies estimated QALY gained using established models from T2DM research and one[23] utilized EQ-5D. The reviewers computed two estimates of cost per QALY from two studies.[38,46] Three of ten individual estimates of cost per QALY were >$50,000, one from a study[46] that had a high intervention cost per patient and the remaining two for subgroups within one study population[32,33] that had lower baseline HbA1c, smaller reductions in HbA1c, and higher cost per patient. The cost per QALY gained was <$50,000 benchmark for two[24,47] of three studies[24,46,47] of CHW interventions to manage T2DM that did not have TBC as an additional intervention.

In summary, the evidence indicates interventions engaging CHWs for prevention of CVD and interventions engaging CHWs for management of T2DM are cost effective, based on a conservative $50,000 benchmark. Two studies evaluating interventions engaging CHWs for prevention of T2DM reported estimates for cost per QALY that were both far below the benchmark.

DISCUSSION

In the literature, CHW engagement and responsibilities are typically categorized by the models of care[54] and core roles.[55] The studies in the economic evidence engaged CHWs across many of the same models and core roles (Appendix Table 4), similar to the studies included in the three systematic reviews of effectiveness.[8–10] The most common model provided health education to patients, followed by CHWs engaged as members of the care delivery team. The three economic reviews did not provide enough evidence to determine the comparative cost effectiveness across CHW models of care and core roles.

The present reviews focused on CVD and T2DM so that estimated cost and benefit that result from the interventions are well defined and meaningful to implementers and funders. The conclusions reached in separate systematic reviews for different diseases and risks should be considered in the aggregate when assessing the economic merits of CHW engagements that serve a diverse patient population because CHWs can be trained to perform the required roles.

Limitations

Although some studies did not include important components considered to be drivers of the magnitude of estimates, others reported estimates without an adequate description of the components that went into their estimation, details in Appendix Tables 1–3. Hence, there is uncertainty about the reasonable capture of key and important drivers of estimates for intervention cost, healthcare cost, and cost per QALY gained.

Two estimates for cost per QALY in CVD prevention and two in T2DM management were computed by reviewers assuming a linear relationship from reductions in SBP and HbA1c, respectively, to QALY gained. This is obviously less than the ideal of direct evaluations of change in QALY using questionnaires, such as EQ-5D, and modeling of outcomes starting from trial data. However, and even if such resources were available for systematic reviews, it is quite rare for reviewers to have access to patient-level data from each study.

Some studies for CVD prevention and T2DM management had additional interventions added to the core intervention engaging the CHWs. In these cases, the reported cost of implementation and any economic benefit cannot be ascribed to the CHW engagement only. CHWs may add the most to the care process when they are embedded within care delivery teams, such as those organized as TBC, but the evidence did not allow the reviewers to draw such comparisons across the models of care.

Evidence Gaps

The lack of reasonable capture of important components of the cost of intervention and change in healthcare cost because of the intervention is a gap that needs to be addressed in future studies. Evaluations of interventions to prevent CVD and manage T2DM need to also measure and report appropriate physiologic outcomes, such as reductions in blood pressure and HbA1c, so that simple conversions of these intermediate outcomes to long-term QALY gained may be attempted, as done in the present reviews. Further research should also determine the comparative cost and economic benefit across the different CHW models of care and core roles.

CONCLUSIONS

Interventions engaging CHWs are cost effective for CVD prevention and T2DM management. For interventions engaging CHWs for prevention of T2DM, two studies reported cost per QALY that were far below a conservative $50,000 benchmark for cost effectiveness. Also, the evidence indicates the cost-effectiveness conclusions hold whether the CHW engagement occurred within care organized as TBC or otherwise. The evidence for cost effectiveness came substantially from studies of interventions that were implemented among low SES and minority populations who are the most burdened by CVD and T2DM in the U.S.

ACKNOWLEDGMENTS

The authors acknowledge the Division for Heart Disease and Stroke Prevention, Centers for Disease Control and Prevention (CDC) for support and subject matter expertise and the Division of Diabetes Translation, CDC for subject matter expertise. We thank members of our coordination team from the CDC and from partner organizations. The authors also thank Onnalee Gomez, MS, from the Library Services Branch, at CDC for her assistance throughout the reviews and Stacy Benton, BA, from the Community Guide Branch for editorial assistance with the manuscript.

The work of Jeffrey A. Reynolds and Ka Zang Xiong were partially supported with funds from the Oak Ridge Institute for Science and Education.

Appendix

Appendix Table 1.

Intervention Cost Components and Estimates

Study	CHW wages[a]	CHW supervision[a]	CHW training	Patient materials	Equipment	Other staff	Additional interventions[a]	Additional intervention: description	Intervention cost per patient per year
CHWs for CVD prevention									
Adair 2012[1]	Y	NI	NI	NI	ND	Y	Y	TBC	$431
Allen 2014[2]	Y	Y	NR	NR	NI	Y	Y	TBC	$264[b]
Barton 2012[3]	Y	Y	Y	NI	NR	ND	ND	—	$477[b]
Dixon 2016[4,5]	Y	NR	NR	Y	Y	ND	ND	—	$184
Fedder 2003[6]	NI	NI	NI	NI	NI	NI	ND	—	$48
Goeree 2013[7]	Y	Y	Y	Y	Y	Y	Y	TBC	$393[b]
Hollenback 2014[8]	Y	Y	Y	Y	Y	Y	ND	—	$393[b]
Kangovi 2016[9,10]	Y	Y	Y	Y	Y	Y	ND	—	NR[b]
Yun 2015[11]	Y	NR	NR	NR	NR	Y	ND	—	$70
CHWs for T2DM prevention									
Irvine 2011[12]	Y	Y	Y	NR	NR	Y	ND	—	$600[b]
Kramer 2011[13]	Y	NI	NI	Y	Y	ND	ND	—	$352
Krukowski 2013[14]	NI	NR	Y	Y	Y	ND	ND	—	$726
Lawlor 2013[15]	Y	Y	Y	Y	Y	Y	ND	—	$386[b]
Ockene 2012[16]	NR	NR	NR	NR	NR	ND	ND	—	$780
Smith 2010[17]	Y	NR	NR	NR	NR	Y	ND	—	$302
Vadheim 2010[18]	Y	NR	Y	Y	NR	Y	ND	—	$735
CHWs for T2DM management									
Bellary 2008[19]	Y	NR	NR	ND	Y	Y	Y	TBC	$331
Brown 2002[20]	Y	NR	NR	Y	ND	Y	ND	—	$565
Brown 2005[21,22]	Y	NR	NR	Y	ND	Y	ND	—	$175
Brown 2012[23]	Y	NR	NR	Y	ND	Y	ND	—	$385
Esperat 2012[24]	NR	NR	NR	ND	ND	NR	NR	TBC	$7,003
Gilmer 2007[25,26]	Y	NI	NI	NI	ND	Y	Y	TBC	$585
Greenhalgh 2011[27]	Y	NI	Y	Y	ND	Y	ND	—	$1,975
Kane 2016[28]	NR	NR	NR	NR	ND	NR	NR	TBC	$421
Prezio 2014[29,30]	Y	Y	NR	NR	Y	Y	Y	TBC	$392[b]

Study	CHW wages[a]	CHW supervision[a]	CHW training	Patient materials	Equipment	Other staff	Additional interventions[a]	Additional intervention: description	Intervention cost per patient per year
Rothschild 2014[31]	Y	NI	NI	NR	ND	ND	ND	—	$1,181
Ryabov 2014[32]	Y	NR	NR	Y	Y	Y	ND	—	$571
Segal 2016[33]	Y	Y	NR	NI	NI	Y	Y	TBC	$4,534[b]
Tang 2014[34]	Y	ND	ND	NI	NI	ND	ND	—	$700[b]

[a]Cost driver.

[b]Reasonably complete estimate.

CHW, community health workers; CVD, cardiovascular disease; T2DM, type 2 diabetes; ND, not delivered; NI, delivered but not included in estimate; NR, delivered but not reported if included in estimate; TBC, team-based care; Y, included in estimate.

Appendix Table 2.

Change in Healthcare Cost Components and Estimates

Study	Cause	Outpatient[a]	Medication[a]	ER[a]	Inpatient[a]	Change in healthcare cost per patient per year	Time horizon (Months)	Comparison group	Additional intervention	Modeled
CHWs for CVD prevention										
Adair 2012[1]	CVD	NI	Y	Y	Y	−$415	12	None	Y	No
Allen 2014[2]	CVD	NI	Y	NI	NI	$722	12	UC	Y	No
Barton 2012[3]	All	Y	Y	NR	Y	−$167	6	UC	N	No
Dixon 2016[4,5]	CVD	Y	Y	NR	Y	$14	24	UC	N	No
Fedder 2003[6]	All	Y	NI	Y	NI	−$3,594[d]	12	None	N	No
Goeree 2013[7]	CVD	Y	Y	Y	Y	−$18[b]	12	UC	Y	No
Hollenback 2014[8]	CVD	Y	Y	Y	Y	−$82[b]	120	UC	N	Yes
Kangovi 2016[9,10]	CVD	Y	Y	Y	Y	NR[b]	NR	UC with goal setting	N	No
CHWs for T2DM prevention										
Irvine 2011[12]	All	Y	Y	NR	Y	$0	7	UC	N	No
Lawlor 2013[15]	All	Y	Y	Y	Y	−$1,242[b,e]	24	UC with dietitian and client reminders	N	No
Smith 2010[17]	HTN/CVD	Y	Y	Y	Y	NR[b]	36	UC	N	Yes
CHWs for T2DM management										
Brown 2012[23]	DM	Y	Y	Y	Y	NR[b]	240	None	N	Yes
Gilmer 2007[25,26]	DM	NI[c]	Y	Y	Y	$1,141[f]	480	UC	Y	Yes
Kane 2016[28]	DM	NI	NI	NI	Y	−$143	12	None	Y	No
Prezio 2014[29,30]	DM	Y	Y	Y	Y	NR[b]	240	UC	Y	Yes
Rothschild 2014[31]	DM	NI	NI	Y	Y	$0	24	UC	N	No
Segal 2016[33]	DM	NI	NI	NI	Y	−$437	18	UC	Y	No

[a] Cost driver.

[b] Reasonably complete estimate.

[c] Included in the CORE-Diabetes model.

[d] Based on change in ER visit, ER admissions, hospital stays pre to post without comparison group.

[e] Magnitude is driven by the measure of hospital stays which was 0.22 for intervention priced at $4,778 and 0.56 for usual care priced at $6,994.

[f] Estimate is difference between medications +$1,582 and ER and hospital stays −$707.

CHW, community health workers; CVD, cardiovascular disease; HTN, hypertension; ER, emergency room; NI, not included in estimate; T2DM, type 2 diabetes; NR, not reported; UC, usual care; Y, included in estimate

Appendix Table 3.

Intervention and Healthcare Cost

Study	Intervention cost per patient	Change in healthcare cost per patient per year	Total cost[a] per patient per year	Time horizon (Months)	Comparison group	Additional intervention	Modeled
CHWs for CVD prevention							
Adair 2012[1]	$431	−$415	$16	12	None	Y	No
Allen 2014[2]	$264[b]	$722	$986	12	UC	Y	No
Barton 2012[3]	$477[b]	−$167	$310	6	UC with literature	N	No
Dixon 2016[4,5]	$184	$14	$198	24	UC	N	No
Fedder 2003[6]	$48	−$3,594	−$3,546	12	UC	N	No
Goeree 2013[7]	$393[b]	−$18[b]	$375[b]	12	UC	Y	No
Hollenback 2014[8]	$393[b]	−$82[b]	$311[b]	120	UC	N	Yes
Kangovi 2016[9,10]	NR[b]	NR[b]	NR[b]	NR	UC with goal setting	N	No
CHWs for T2DM prevention							
Irvine 2011[12]	$600[b]	$0	$600	7	UC	N	No
Lawlor 2013[15]	$386[b]	−$1,242[b]	−$856[b]	24	UC with dietitian and client reminders	N	No
CHWs for T2DM management							
Gilmer 2007[25,26]	$585	$1,141	$1,726	12	UC	Y	Yes
Kane 2016[28]	$421	−$143	$278	12	None	Y	No
Rothschild 2014[31]	$1,181	$0	$1,181	24	UC	N	No
Segal 2016[33]	$4,534	−$437[b]	$4,097	18	UC	Y	No

[a] Total cost is intervention cost plus change in healthcare cost.

[b] Reasonably complete estimate.

CHW, community health workers; CVD, cardiovascular disease; UC, usual care; T2DM, type 2 diabetes; NR, not reported.

Appendix Table 4.

CHW Roles and Models of Care

CHW models of care	CHW CVD prevention (n=9)	CHW T2DM prevention (n=7)	CHW T2DM management (n=13)
Health education provider and screening	9[1–11]	7[12–18]	9[19,20,23,25,26,28–32]
Outreach/enrollment/information agent	2[6,7]	2[15,16]	2[20,31]
Member of care delivery team	4[1,2,7,9,10]	0	8[19–22,25–30,33]
Navigator	1[6]	0	2[24,28]
Community organizer	0	0	0
CHW core roles			
Providing culturally appropriate health education and information	8[1–5,7–11]	4[12,13,15,16]	8[19,20,23,25,26,28–32]
Building individual and community capacity	4[1–3,6]	2[16,18]	4[20,25,26,29–31]
Providing coaching and support	8[1–6,8–11]	4[12,14,17,18]	10[19–24,27,28,31,33,34]
Case coordination and management, system navigation	0	0	7[20–22,24,28–30,33,34]
Cultural mediation between community and healthcare system	3[1,6,7]	0	3[20,23,24]
Providing direct services	2[6,7]	0	2[21,22,29,30]
Advocating for individual and community needs	0	1[15]	0
Implementing individual and community assessments	0	0	1[28]

CHW, community health worker; CVD, cardiovascular disease; T2DM, type 2 diabetes.

APPENDIX REFERENCES

1. Adair R, Christianson J, Wholey DR, et al. Care guides: employing nonclinical laypersons to help primary care teams manage chronic disease. J Ambul Care Manage. 2012;35(1):27–37. 10.1097/JAC.0b013e31823b0fbe. [PubMed: 22156953]
2. Allen JK, Dennison Himmelfarb CR, Szanton SL, Frick KD. Cost-effectiveness of nurse practitioner/community health worker care to reduce cardiovascular health disparities. J Cardiovasc Nurs. 2014;29(4):308–314. 10.1097/JCN.0b013e3182945243. [PubMed: 23635809]
3. Barton GR, Goodall M, Bower P, Woolf S, Capewell S, Gabbay MB. Increasing heart-health lifestyles in deprived communities: economic evaluation of lay health trainers. J Eval Clin Pract. 2012;18(4):835–840. 10.1111/j.1365-2753.2011.01686.x. [PubMed: 21518152]
4. Dixon P, Hollinghurst S, Ara R, Edwards L, Foster A, Salisbury C. Cost-effectiveness modelling of telehealth for patients with raised cardiovascular disease risk: evidence from a cohort simulation conducted alongside the Healthlines randomised controlled trial. BMJ Open. 2016;6(9):e012355 10.1136/bmjopen-2016-012355.
5. Dixon P, Hollinghurst S, Edwards L, et al. Cost-effectiveness of telehealth for patients with raised cardiovascular disease risk: evidence from the Healthlines randomised controlled trial. BMJ Open. 2016;6(8):e012352 10.1136/bmjopen-2016-012352.
6. Fedder DO, Chang RJ, Curry S, Nichols G. The effectiveness of a community health worker outreach program on healthcare utilization of west Baltimore City Medicaid patients with diabetes, with or without hypertension. Ethn Dis. 2003;13(1):22–27. [PubMed: 12723008]
7. Goeree R, von Keyserlingk C, Burke N, et al. Economic appraisal of a community-wide cardiovascular health awareness program. Value Health. 2013;16(1):39–45. 10.1016/j.jval.2012.09.002. [PubMed: 23337214]

8. Hollenback CS, Weiner MG, Turner BJ. Cost-effectiveness of a peer and practice staff support intervention. Am J Manag Care. 2014;20(3):253–260. [PubMed: 24884753]

9. Kangovi S, Carter T, Charles D, et al. Toward a scalable, patient-centered community health worker model: adapting the IMPaCT intervention for use in the outpatient setting. Popul Health Manag. 2016;19(6):380–388. 10.1089/pop.2015.0157. [PubMed: 27007164]

10. Kangovi S, Mitra N, Smith RA, et al. Decision-making and goal-setting in chronic disease management: baseline findings of a randomized controlled trial. Patient Educ Couns 2017;100(3): 449–455. 10.1016/j.pec.2016.09.019. [PubMed: 27717532]

11. Yun S, Ehrhardt E, Britt L, Brendel B, Wilson J, Berwanger A. Missouri community, public health, and primary care linkage: 2011–2012 pilot project results & evaluation. Mo Med. 2015;112(4): 323–328. [PubMed: 26455066]

12. Irvine L, Barton GR, Gasper AV, et al. Cost-effectiveness of a lifestyle intervention in preventing Type 2 diabetes. Int J Technol Assess Health Care. 2011;27(4):275–282. 10.1017/S0266462311000365. [PubMed: 22004767]

13. Kramer MK, McWilliams JR, Chen HY, Siminerio LM. A community-based diabetes prevention program: evaluation of the group lifestyle balance program delivered by diabetes educators. Diabetes Educ. 2011;37(5):659–668. 10.1177/0145721711411930. [PubMed: 21918204]

14. Krukowski RA, Pope RA, Love S, et al. Examination of costs for a lay health educator-delivered translation of the Diabetes Prevention Program in senior centers. Prev Med. 2013;57(4):400–402. 10.1016/j.ypmed.2013.06.027. [PubMed: 23831492]

15. Lawlor MS, Blackwell CS, Isom SP, et al. Cost of a group translation of the Diabetes Prevention Program: healthy living partnerships to prevent diabetes. Am J Prev Med. 2013;44(4 suppl 4):S381–S389. 10.1016/j.amepre.2012.12.016. [PubMed: 23498303]

16. Ockene IS, Tellez TL, Rosal MC, et al. Outcomes of a Latino community-based intervention for the prevention of diabetes: the Lawrence Latino Diabetes Prevention Project. Am J Public Health. 2012;102(2):336–342. 10.2105/AJPH.2011.300357. [PubMed: 22390448]

17. Smith KJ, Hsu HE, Roberts MS, et al. Cost-effectiveness analysis of efforts to reduce risk of type 2 diabetes and cardiovascular disease in southwestern Pennsylvania, 2005–2007. Prev Chronic Dis. 2010;7(5):A109. [PubMed: 20712936]

18. Vadheim LM, Brewer KA, Kassner DR, et al. Effectiveness of a lifestyle intervention program among persons at high risk for cardiovascular disease and diabetes in a rural community. J Rural Health. 2010;26(3):266–272. 10.1111/j.1748-0361.2010.00288.x. [PubMed: 20633095]

19. Bellary S, O'Hare JP, Raymond NT, et al. Enhanced diabetes care to patients of south Asian ethnic origin (the United Kingdom Asian Diabetes Study): a cluster randomised controlled trial. Lancet. 2008;371(9626):1769–1776. 10.1016/S0140-6736(08)60764-3. [PubMed: 18502301]

20. Brown SA, Garcia AA, Kouzekanani K, Hanis CL. Culturally competent diabetes self-management education for Mexican Americans: the Starr County border health initiative. Diabetes Care. 2002;25(2):259–268. 10.2337/diacare.25.2.259. [PubMed: 11815493]

21. Brown SA, Blozis SA, Kouzekanani K, Garcia AA, Winchell M, Hanis CL. Dosage effects of diabetes self-management education for Mexican Americans: the Starr County border health initiative. Diabetes Care. 2005;28(3):527–532. 10.2337/diacare.28.3.527. [PubMed: 15735182]

22. Brown SA, Hanis CL. Culturally competent diabetes education for Mexican Americans: the Starr County study. Diabetes Educ. 1999;25(2):226–236. 10.1177/014572179902500208. [PubMed: 10531848]

23. Brown HS, Wilson KJ, Pagan JA, et al. Cost-effectiveness analysis of a community health worker intervention for low-income Hispanic adults with diabetes. Prev Chronic Dis. 2012;9:E140 10.5888/pcd9.120074. [PubMed: 22916995]

24. Esperat MC, Flores D, McMurry L, et al. Transformacion Para Salud: a patient navigation model for chronic disease self-management. Online J Issues Nurs. 2012;17(2):2.

25. Gilmer TP, Philis-Tsimikas A, Walker C. Outcomes of Project Dulce: a culturally specific diabetes management program. Ann Pharmacother. 2005;39(5):817–822. 10.1345/aph.1E583. [PubMed: 15769828]

26. Gilmer TP, Roze S, Valentine WJ, et al. Cost-effectiveness of diabetes case management for low-income populations. Health Serv Res. 2007;42(5):1943–1959. 10.1111/j.1475-6773.2007.00701.x. [PubMed: 17850527]
27. Greenhalgh T, Campbell-Richards D, Vijayaraghavan S, et al. New models of self-management education for minority ethnic groups: pilot randomized trial of a story-sharing intervention. J Health Serv Res Policy. 2011;16(1):28–36. 10.1258/jhsrp.2010.009159. [PubMed: 20739577]
28. Kane EP, Collinsworth AW, Schmidt KL, et al. Improving diabetes care and outcomes with community health workers. Fam Pract. 2016;33(5):523–528. 10.1093/fampra/cmw055. [PubMed: 27418587]
29. Prezio EA, Pagan JA, Shuval K, Culica D. The Community Diabetes Education (CoDE) program: cost-effectiveness and health outcomes. Am J Prev Med. 2014;47(6):771–779. 10.1016/j.amepre.2014.08.016. [PubMed: 25455119]
30. Culica D, Walton JW, Prezio EA. CoDE: Community Diabetes Education for uninsured Mexican Americans. Proc (Bayl Univ Med Cent). 2007;20(2):111–117. 10.1080/08998280.2007.11928263. [PubMed: 17431443]
31. Rothschild SK, Martin MA, Swider SM, et al. Mexican American trial of community health workers: a randomized controlled trial of a community health worker intervention for Mexican Americans with type 2 diabetes mellitus. Am J Public Health. 2014;104(8):1540–1548. 10.2105/AJPH.2013.301439. [PubMed: 23947316]
32. Ryabov I Cost-effectiveness of community health workers in controlling diabetes epidemic on the U.S.-Mexico border. Public Health. 2014;128(7):636–642. 10.1016/j.puhe.2014.05.002. [PubMed: 24999158]
33. Segal L, Nguyen H, Schmidt B, Wenitong M, McDermott RA. Economic evaluation of indigenous health worker management of poorly controlled type 2 diabetes in north Queensland. Med J Aust. 2016;204(5):196 10.5694/mja15.00598.
34. Tang TS, Funnell M, Sinco B, et al. Comparative effectiveness of peer leaders and community health workers in diabetes self-management support: results of a randomized controlled trial. Diabetes Care. 2014;37(6):1525–1534. 10.2337/dc13-2161. [PubMed: 24722495]

REFERENCES

1. Benjamin EJ, Virani SS, Callaway CW, et al. Heart disease and stroke statistics—2018 update: a report from the American Heart Association. Circulation. 2018;137(12):e67–e492. 10.1161/CIR.0000000000000558. [PubMed: 29386200]
2. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. Diabetes Care. 2018;41(5):917–928. 10.2337/dci18-0007. [PubMed: 29567642]
3. CDC. National Diabetes Statistics Report, 2017. Atlanta, GA: CDC, HHS; 2017.
4. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics-2017 update: a report from the American Heart Association. Circulation. 2017;135(10):e146–e603. 10.1161/CIR.0000000000000485. [PubMed: 28122885]
5. Spanakis EK, Golden SH. Race/ethnic difference in diabetes and diabetic complications. Curr Diab Rep. 2013;13(6):814–823. 10.1007/s11892-013-0421-9. [PubMed: 24037313]
6. Support for community health workers to increase health access and to reduce health inequities. Policy no. 20091. Washington, DC: APHA www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2014/07/09/14/19/support-for-community-health-workers-to-increase-health-access-and-to-reduce-health-inequities. Published November 10, 2009 Accessed June 11, 2018.
7. American Public Health Association. Community Health Workers; 2018.
8. The Guide to Community Preventive Services (the Community Guide). Cardiovascular disease: interventions engaging community health workers. https://www.thecommunityguide.org/findings/cardiovascular-disease-prevention-and-control-interventions-engaging-community-health. Published March 2015. Accessed October 18, 2018.
9. The Guide to Community Preventive Services (the Community Guide). Diabetes prevention: interventions engaging community health workers. www.thecommunityguide.org/findings/diabetes-

prevention-interventions-engaging-community-health-workers. Published August 2016. Accessed October 18, 2018.

10. The Guide to Community Preventive Services (the Community Guide). Diabetes management: interventions engaging community health workers. www.thecommunityguide.org/findings/diabetes-management-interventions-engaging-community-health-workers. Published April 2017. Accessed October 18, 2018.
11. The Guide to Community Preventive Services (the Community Guide). Economic Reviews. www.thecommunityguide.org/about/economic-reviews. Accessed October 18, 2018.
12. Eichler H-G, Kong SX, Gerth WC, Mavros P, Jönsson B. Use of cost-effectiveness analysis in health-care resource allocation decision-making: how are cost-effectiveness thresholds expected to emerge? Value Health. 2004;7(5):518–528. 10.1111/j.1524-4733.2004.75003.x. [PubMed: 15367247]
13. Grosse SD. Assessing cost-effectiveness in healthcare: history of the $50,000 per QALY threshold. Expert Rev Pharmacoecon Outcomes Res. 2008;8(2):165–178. 10.1586/14737167.8.2.165. [PubMed: 20528406]
14. McEwan P, Peters JR, Bergenheim K, Currie CJ. Evaluation of the costs and outcomes from changes in risk factors in type 2 diabetes using the Cardiff stochastic simulation cost-utility model (DiabForecaster). Curr Med Res Opin. 2006;22(1):121–129. 10.1185/030079906X80350. [PubMed: 16393438]
15. Mason JM, Freemantle N, Gibson JM, New JP. Specialist nurse-led clinics to improve control of hypertension and hyperlipidemia in diabetes: economic analysis of the SPLINT trial. Diabetes Care. 2005;28(1):40–46. 10.2337/diacare.28.1.40. [PubMed: 15616231]
16. Valentine WJ, Palmer AJ, Nicklasson L, Cobden D, Roze S. Improving life expectancy and decreasing the incidence of complications associated with type 2 diabetes: a modelling study of HbA1c targets. Int J Clin Pract. 2006;60(9):1138–1145. 10.1111/j.1742-1241.2006.01102.x. [PubMed: 16939559]
17. Bureau of Labor Statistics. Archived Consumer Price Index detailed report: Data for December 2016. www.bls.gov/cpi/tables/detailed-reports/home.htm. Published 2016. Accessed 2016.
18. The World Bank. Purchasing Power Parities. PPP conversion factor, private consumption. https://data.worldbank.org/indicator/PA.NUS.PRVT.PP. Accessed October 18, 2018.
19. The Guide to Community Preventive Services (the Community Guide). Diabetes management: interventions engaging community health workers. Supporting materials: Search Strategy – Economic Review. www.thecommunityguide.org/findings/diabetes-management-interventions-engaging-community-health-workers. Published April 2017. Accessed October 18, 2018.
20. Adair R, Christianson J, Wholey DR, et al. Care guides: employing nonclinical laypersons to help primary care teams manage chronic disease. J Ambul Care Manage. 2012;35(1):27–37. 10.1097/JAC.0b013e31823b0fbe. [PubMed: 22156953]
21. Allen JK, Dennison Himmelfarb CR, Szanton SL, Frick KD. Cost-effectiveness of nurse practitioner/community health worker care to reduce cardiovascular health disparities. J Cardiovasc Nurs. 2014;29(4):308–314. 10.1097/JCN.0b013e3182945243. [PubMed: 23635809]
22. Barton GR, Goodall M, Bower P, Woolf S, Capewell S, Gabbay MB. Increasing heart-health lifestyles in deprived communities: economic evaluation of lay health trainers. J Eval Clin Pract. 2012;18(4):835–840. 10.1111/j.1365-2753.2011.01686.x. [PubMed: 21518152]
23. Bellary S, O'Hare JP, Raymond NT, et al. Enhanced diabetes care to patients of south Asian ethnic origin (the United Kingdom Asian Diabetes Study): a cluster randomised controlled trial. Lancet. 2008;371(9626):1769–1776. 10.1016/S0140-6736(08)60764-3. [PubMed: 18502301]
24. Brown HS, Wilson KJ, Pagan JA, et al. Cost-effectiveness analysis of a community health worker intervention for low-income Hispanic adults with diabetes. Prev Chronic Dis. 2012;9:E140 10.5888/pcd9.120074. [PubMed: 22916995]
25. Brown SA, Blozis SA, Kouzekanani K, Garcia AA, Winchell M, Hanis CL. Dosage effects of diabetes self-management education for Mexican Americans: the Starr County border health initiative. Diabetes Care. 2005;28(3):527–532. 10.2337/diacare.28.3.527. [PubMed: 15735182]

26. Brown SA, Garcia AA, Kouzekanani K, Hanis CL. Culturally competent diabetes self-management education for Mexican Americans: the Starr County border health initiative. Diabetes Care. 2002;25(2):259–268. 10.2337/diacare.25.2.259. [PubMed: 11815493]
27. Brown SA, Hanis CL. Culturally competent diabetes education for Mexican Americans: the Starr County study. Diabetes Educ. 1999;25(2):226–236. 10.1177/014572179902500208. [PubMed: 10531848]
28. Culica D, Walton JW, Prezio EA. CoDE: Community Diabetes Education for uninsured Mexican Americans. Proc (Bayl Univ Med Cent). 2007;20(2):111–117. 10.1080/08998280.2007.11928263. [PubMed: 17431443]
29. Dixon P, Hollinghurst S, Ara R, Edwards L, Foster A, Salisbury C. Cost-effectiveness modelling of telehealth for patients with raised cardiovascular disease risk: evidence from a cohort simulation conducted alongside the Healthlines randomised controlled trial. BMJ Open. 2016;6(9):e012355 10.1136/bmjopen-2016-012355.
30. Esperat MC, Flores D, McMurry L, et al. Transformacion Para Salud: a patient navigation model for chronic disease self-management. Online J Issues Nurs. 2012;17(2):2.
31. Fedder DO, Chang RJ, Curry S, Nichols G. The effectiveness of a community health worker outreach program on healthcare utilization of west Baltimore City Medicaid patients with diabetes, with or without hypertension. Ethn Dis. 2003;13(1):22–27. [PubMed: 12723008]
32. Gilmer TP, Philis-Tsimikas A, Walker C. Outcomes of Project Dulce: a culturally specific diabetes management program. Ann Pharmacother. 2005;39(5):817–822. 10.1345/aph.1E583. [PubMed: 15769828]
33. Gilmer TP, Roze S, Valentine WJ, et al. Cost-effectiveness of diabetes case management for low-income populations. Health Serv Res. 2007;42(5):1943–1959. 10.1111/j.1475-6773.2007.00701.x. [PubMed: 17850527]
34. Goeree R, von Keyserlingk C, Burke N, et al. Economic appraisal of a community-wide cardiovascular health awareness program. Value Health. 2013;16(1):39–45. 10.1016/j.jval.2012.09.002. [PubMed: 23337214]
35. Greenhalgh T, Campbell-Richards D, Vijayaraghavan S, et al. New models of self-management education for minority ethnic groups: pilot randomized trial of a story-sharing intervention. J Health Serv Res Policy. 2011;16(1):28–36. 10.1258/jhsrp.2010.009159. [PubMed: 20739577]
36. Hollenback CS, Weiner MG, Turner BJ. Cost-effectiveness of a peer and practice staff support intervention. Am J Manag Care. 2014;20(3):253–260. [PubMed: 24884753]
37. Irvine L, Barton GR, Gasper AV, et al. Cost-effectiveness of a lifestyle intervention in preventing Type 2 diabetes. Int J Technol Assess Health Care. 2011;27(4):275–282. 10.1017/S0266462311000365. [PubMed: 22004767]
38. Kane EP, Collinsworth AW, Schmidt KL, et al. Improving diabetes care and outcomes with community health workers. Fam Pract. 2016;33(5):523–528. 10.1093/fampra/cmw055. [PubMed: 27418587]
39. Kangovi S, Carter T, Charles D, et al. Toward a scalable, patient-centered community health worker model: adapting the IMPaCT intervention for use in the outpatient setting. Popul Health Manag. 2016;19(6):380–388. 10.1089/pop.2015.0157. [PubMed: 27007164]
40. Kangovi S, Mitra N, Smith RA, et al. Decision-making and goal-setting in chronic disease management: baseline findings of a randomized controlled trial. Patient Educ Couns. 2017;100(3):449–455. 10.1016/j.pec.2016.09.019. [PubMed: 27717532]
41. Kramer MK, McWilliams JR, Chen HY, Siminerio LM. A community-based diabetes prevention program: evaluation of the group lifestyle balance program delivered by diabetes educators. Diabetes Educ. 2011;37(5):659–668. 10.1177/0145721711411930. [PubMed: 21918204]
42. Krukowski RA, Pope RA, Love S, et al. Examination of costs for a lay health educator-delivered translation of the Diabetes Prevention Program in senior centers. Prev Med. 2013;57(4):400–402. 10.1016/j.ypmed.2013.06.027. [PubMed: 23831492]
43. Lawlor MS, Blackwell CS, Isom SP, et al. Cost of a group translation of the Diabetes Prevention Program: healthy living partnerships to prevent diabetes. Am J Prev Med. 2013;44(4 suppl 4):S381–S389. 10.1016/j.amepre.2012.12.016. [PubMed: 23498303]

44. Ockene IS, Tellez TL, Rosal MC, et al. Outcomes of a Latino community-based intervention for the prevention of diabetes: the Lawrence Latino Diabetes Prevention Project. Am J Public Health. 2012;102(2):336–342. 10.2105/AJPH.2011.300357. [PubMed: 22390448]
45. Prezio EA, Pagan JA, Shuval K, Culica D. The Community Diabetes Education (CoDE) program: cost-effectiveness and health outcomes. Am J Prev Med. 2014;47(6):771–779. 10.1016/j.amepre.2014.08.016. [PubMed: 25455119]
46. Rothschild SK, Martin MA, Swider SM, et al. Mexican American trial of community health workers: a randomized controlled trial of a community health worker intervention for Mexican Americans with type 2 diabetes mellitus. Am J Public Health. 2014;104(8):1540–1548. 10.2105/AJPH.2013.301439. [PubMed: 23947316]
47. Ryabov I Cost-effectiveness of community health workers in controlling diabetes epidemic on the U.S.-Mexico border. Public Health. 2014;128(7):636–642. 10.1016/j.puhe.2014.05.002. [PubMed: 24999158]
48. Segal L, Nguyen H, Schmidt B, Wenitong M, McDermott RA. Economic evaluation of indigenous health worker management of poorly controlled type 2 diabetes in north Queensland. Med J Aust. 2016;204(5):196 10.5694/mja15.00598.
49. Smith KJ, Hsu HE, Roberts MS, et al. Cost-effectiveness analysis of efforts to reduce risk of type 2 diabetes and cardiovascular disease in southwestern Pennsylvania, 2005–2007. Prev Chronic Dis. 2010;7(5):A109. [PubMed: 20712936]
50. Tang TS, Funnell M, Sinco B, et al. Comparative effectiveness of peer leaders and community health workers in diabetes self-management support: results of a randomized controlled trial. Diabetes Care. 2014;37(6):1525–1534. 10.2337/dc13-2161. [PubMed: 24722495]
51. Vadheim LM, Brewer KA, Kassner DR, et al. Effectiveness of a lifestyle intervention program among persons at high risk for cardiovascular disease and diabetes in a rural community. J Rural Health. 2010;26(3):266–272. 10.1111/j.1748-0361.2010.00288.x. [PubMed: 20633095]
52. Yun S, Ehrhardt E, Britt L, Brendel B, Wilson J, Berwanger A. Missouri community, public health, and primary care linkage: 2011–2012 pilot project results & evaluation. Mo Med. 2015;112(4):323–328. [PubMed: 26455066]
53. Dixon P, Hollinghurst S, Edwards L, et al. Cost-effectiveness of telehealth for patients with raised cardiovascular disease risk: evidence from the Healthlines randomised controlled trial. BMJ Open. 2016;6(8):e012352 10.1136/bmjopen-2016-012352.
54. Health Resources and Services Administration. Bureau of Health Professions. Community health worker national workforce study. Rockville, MD: Health Resources and Services Administration, HHS; 2007.
55. California Association of Community Health Workers. CHW Core Consensus Project: C3 Report; 2016.

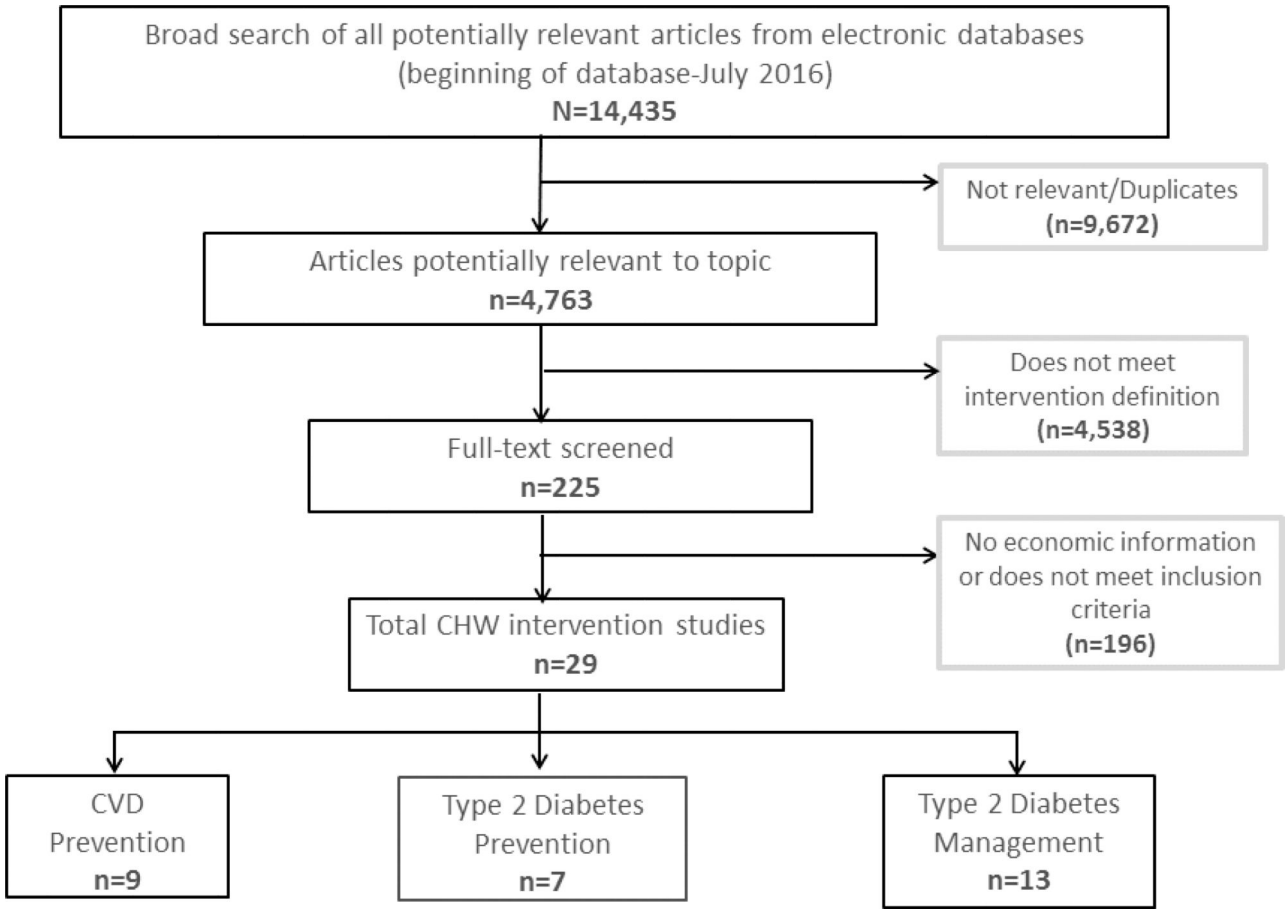

Figure 1.
Economic evidence search yield.

Table 1.

Characteristics of Included Studies

Study	Minority or low SES focus	Design	Mean age, years	Sample size	Intervention length, months	Additional intervention	Comparison	Setting	Actual economic outcomes	Modeled economic outcomes
CHWs for CVD prevention										
Adair 2012[20]	Yes	PP	61[a]	332	12	TBC	None	Primary care	IC, HC	—
Allen 2014[21]	Yes	RCT	54	261	12	TBC	UC	Community	IC, HC	—
Barton 2012[22]	Yes	RCT	53	72	12	No	UC with literature	Community	IC, HC, SS, CE	—
Dixon 2016[29,53]	NR	RCT	67	325	12	No	UC	Community	IC, HC, Pr	CE
Fedder 2003[31]	Yes	PP	57	238	37	No	UC	Community	IC, HC	—
Goeree 2013[34]	No	RCT	75	3,394	3	TBC	UC	Community	IC, HC	—
Hollenback 2014[36]	Yes	RCT	62	136	6	No	UC	Primary care	IC	HC, CE
Kangovi 2016[39,40]	Yes	RCT	56	NR	NR	No	UC with goal setting	Primary care	IC, HC	—
Yun 2015[52]	Yes	PP	52	4,405	12	No	UC	Community	IC	—
Median (Mean) across studies			57 (60)	293 (1,145)	12 (13)					
CHWs for T2DM prevention										
Irvine 2011[37]	NR	RCT	59	177	7	No	UC	Community	IC, HC, CE	—
Kramer 2011[41]	No	PP	53	81	12	No	None	Community	IC	—
Krukowski 2013[42]	No	RCT	71	116	12	No	UC with attention control	Senior centers	IC	—
Lawlor 2013[43]	No	RCT	60	151	24	No	UC with dietitian and client reminders	Community	IC, HC	—
Ockene 2012[44]	Yes	RCT	52	312	12	No	UC	Community	IC	—
Smith 2010[49]	No	Model	55	NR	36	No	UC	Primary care	IC	HC, CE
Vadheim 2010[51]	No	RCT	51	84	10	No	UC	Community	IC	—
Median (Mean) across studies			55 (57)	134 (154)	12 (16)					
CHWs for T2DM management										
Bellary 2008[23]	Yes	RCT	57	868	12	TBC	UC	Primary care	IC, HC, CE	—
Brown 2002[26]	Yes	RCT	54	252	12	No	UC	Community	IC	—
Brown 2005[25,27]	Yes	RCT	50	216	12	No	Longer intervention	Community	IC	—
Brown 2012[24]	Yes	PP	50	30	18	No	None	Community	IC	HC, CE
Esperat 2012[30]	NR	PP	NR	152	6	TBC	None	Community	IC	—
Gilmer 2007[32,33]	Mixed	Model	47 to 55	575 to 1,345	480	TBC	UC	Primary care	IC	HC, CE
Greenhalgh 2011[35]	Yes	RCT	58	79	3	No	Self-management support	Diabetes center	IC	—

Study	Minority or low SES focus	Design	Mean age, years	Sample size	Intervention length, months	Additional intervention	Comparison	Setting	Actual economic outcomes	Modeled economic outcomes
Kane 2016[38]	Yes	PP	50	885	12	TBC	None	Primary care	IC, HC	—
Prezio 2014[28,45]	Yes	RCT	47	90	12	TBC	UC	Diabetes center	IC	HC, CE
Rothschild 2014[46]	Yes	RCT	54	73	24	No	UC	Primary care	IC, HC	—
Ryabov 2014[47]	Yes	RCT	55	15	24	No	UC	Community	IC, CE	—
Segal 2016[48]	Yes	RCT	48	87	18	TBC	UC	Community	IC, HC	—
Tang 2014[50]	Yes	RCT	49	56	12	No	UC	Community	IC	—
Median (Mean) across studies			51 (52)	90 (289)	12 (50)					

[a]Median.

CHW, community health worker; CVD, cardiovasculardisease; TBC, team-based care; UC, usual care; PP, pre to post; IC, intervention cost; HC, healthcare cost; Pr, productivity at worksites; SS, social services; CE, cost-effectiveness; NB, net benefit: T2DM, type 2 diabetes.

Table 2.

Intervention Cost and Change in Healthcare Cost

Intervention	Intervention cost[a] Median (IQI) Mean # studies	Change in healthcare cost[a] Median (IQI) Mean # studies	Total cost[a] (Intervention cost plus healthcare cost) Median (IQI) Mean # studies	Median (Mean) time horizon Months	Number of modeled studies	Studies with comparison to other than usual care
CHWs for CVD prevention	$329 ($99 to $422) Mean $283 8[20–22,29,31,34,36,52,53]	−$82 (−$415 to $14) Mean −$506 7[20–22,29,31,34,36,53]	$310 ($16 to $375) Mean −$193 7[20–22,29,31,34,36,53]	12 (28)	1[36]	Goal setting sessions with patient[39,40]
CHWs for T2DM prevention	$600 ($352 to $735) Mean $554 7[37,41–44,49,51]	−$1,242 and $0 Mean −$621 2[37,43]	$600 and −$856 Mean −$128 2[37,43]	7 and 24 (16)	1[49]	Sessions with dietitian and client reminders[43]
CHWs for T2DM management	$571 ($389 to $1,578) Mean $1,448 13[23–26,28,30,32,33,35,38,45–48,50]	−$72 (−$364 to $856) Mean $140 4[32,33,38,46,48]	$1,454 ($504 to $3,504) Mean $1,821 4[32,33,38,46,48]	15 (17)	3[24,28,32,33,45]	Self-management support[35] and extended intervention[25,27]

[a]Per patient per year.

IQI, interquartile interval; CHW, community health worker; CVD, cardiovascular disease; T2DM, type 2 diabetes.

Table 3.

Cost-effectiveness: Cost per QALY Gained

Study	Time months	+TBC	Mean age	% Female	% T2DM	Mean change (Baseline)		Mean QALY gained	QALY method	Mean incr. cost	Cost per QALY gained
						A1c	SBP				
CHW for CVD prevention											
Allen 2014[21]	240	Yes	54	71	NR	−0.5 (8.9)	−6.2 (139.7)	0.830	Conversion (1): −1 mmHg SBP=0.009 QALY per year[14]	$14,669	$17,670
Allen 2014[21]	480	Yes	54	71	NR	−0.5 (8.9)	−6.2 (139.7)	0.576	Conversion (2): −1 mmHg=0.093 QALY per 40 years[15]	$2,291	$39,534
Barton 2012[22]	6	No	53	59.1	13.6	NR (NR)	NR (NR)	0.007	Health state: EQ-5D; Utility scores: York	$140	$20,722
Dixon 2016[29,53]	480	No	67	20	24	NR (NR)	−2.7 (147.6)	0.026	Health state: EQ-5D; Utility scores: UK EuroQoL	$72	$2,719
Hollenback 2014[36]	120	No	62	65.4	53.9	NR (NR)	−7.68 (140.5)	0.160	Markov model for BP medication; Utility scores from literature	$1,916	$11,960[a]
Summary (Mean across studies)	265	No	58	67	31	−0.5 (8.9)	−5.7 (141.9)	0.320		$3,818	$18,521 Median $17,670 IQI ($7,340 to $30,128)
CHW for T2DM prevention											
Irvine 2011[37]	7	No	59	46	0	NR (NR)	NR (NR)	0.013	Health state: EQ-5D; Utility scores: York	$379	$29,509
Smith 2010[49]	36	No	55	75	0	NR (NR)	NR (NR)	0.010	Markov model for T2DM progression; Assumed utility weights for treated, untreated, complicated, uncomplicated, no disease	$48	$4,767

Study	Time months	+TBC	Mean age	% Female	% T2DM	Mean change (Baseline)		Mean QALY gained	QALY method	Mean incr. cost	Cost per QALY gained
						A1c	SBP				
Summary (Mean across studies)	22		57	61	0	NR (NR)	NR (NR)	0.012		$214	$17,138 $29,509 and $4,767
CHW for T2DM management											
Bellary 2008[23]	24	Yes	57	48	100	−0.18 (8.2)	−0.4 (140.1)	0.015	EQ-5D; Utility scores: No details provided	$661	$44,060
Brown 2012[24]	240	No	50	13	100	−2.7 (9.9)	NR (NR)	0.06	*Archimedes* model for T2DM; Utility weights: built-in	NR	$36,673
Gilmer 2007[32,33]									*CORE-Diabetes* model; Utility weights: built-in		
Uninsured	240	Yes	47	64	100	−1.3 (9.4)	−3.1 (123.8)	0.562		$3,935	$7,000
County medical services	240	Yes	51	59	100	−0.8 (8.6)	−2.8 (128.9)	0.297		$10,400	$35,000
Medi-Cal	240	Yes	52	68	100	−0.5 (8.2)	−1.9 (126.7)	0.188		$12,500	$67,000
Commercial insured	240	Yes	55	49	100	−0.4 (7.8)	0 (122.6)	0.113		$14,318	$127,000
Kane 2016[38]	420	Yes	50	61	100	−0.9 (8.3)	−3.8 (129)	0.342	Conversion: −1 pctpt A1c=0.38 QALY per 35 years[16]	$5,973	$17,466
Prezio 2014[28,45]	240	Yes	46	64	100	−0.94 (9.5)	NR (126)	0.056	Archimedes model for T2DM; Utility weights: built-in	NR	$371
Rothschild 2014[46]	420	No	54	67	100	−0.69 (8.5)	0 (133.6)	0.262	Conversion: −1 pctpt A1c=0.38 QALY per 35 years[16]	$25,376	$96,783
Ryabov 2014[47]	480	No	55	80	100	−0.7 (7.6)	+4.7 (132)	0.700	*CDC Diabetes Cost-effectiveness Model*: Utility weights: Built-in	$10,776	$15,395
Summary (Mean across studies)	278		52	57	100	−0.91 (8.6)	−0.9 (129)	0.249		$10,492	$44,675 Median $35,837 IQI

Study	Time months	+TBC	Mean age	% Female	% T2DM	Mean change (Baseline)		Mean QALY gained	QALY method	Mean incr. cost	Cost per QALY gained
						A1c	SBP				
											($13,296 to $74,446)

[a]Reasonably complete estimate.

CVD, cardiovascular disease; T2DM, type 2 diabetes; TBC, team-based care; SBP, systolic blood pressure.