Community Health Worker Impact on Chronic Disease Outcomes Within Primary Care Examined Using Electronic Health Records

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Objectives. To investigate community health worker (CHW) effects on chronic disease outcomes using electronic health records (EHRs).

Methods. We examined EHRs of 32 147 patients at risk for chronic disease during 2012 to 2015. Variables included contact with clinic-based CHWs, vitals, and laboratory tests. We estimated a mixed model for all outcomes.

Results. Within-group findings showed statistically significant improvements in chronic disease indicators after exposure to CHWs. In health center 1, HbA1c (glycated hemoglobin) decreased 0.15 millimoles per mole (95% confidence interval [CI] = –0.24, –0.06), body mass index decreased 0.29 kilograms per meter squared (CI = –0.39, –0.20), and total cholesterol decreased 11.9 milligrams per deciliter (CI = –13.5, –10.2). In health center 2, HbA1c decreased 0.43 millimoles per mole (CI = –0.7, –0.17), body mass index decreased by 0.08 kilograms per meter squared (CI = –0.14, –0.02), and triglycerides decreased by 22.50 milligrams per deciliter (CI = –39.0, –6.0). Total cholesterol of 3.62 milligrams per deciliter (CI = –6.6, –0.6) in health center 1 was the only improvement tied to CHW contact.

Conclusions. Although patients' chronic disease indicators consistently improved, between-group models provided no additional evidence of impact. EHRs' evolution may elucidate CHW contributions moving forward. (*Am J Public Health.* 2017;107: 1668–1674. doi:10.2105/AJPH.2017.303934)

Community health workers (CHWs) are playing an increasingly important role in the delivery of health care services as members of health care teams. The 2010 Patient Protection and Affordable Care Act advanced the integration of CHWs into primary care as a means to enhance the cultural relevance and quality of services in patient-centered medical homes (PCMH).[1] CHWs—who work under a variety of titles, including health advisors, *promotores de salud*, and health advocates—are by definition frontline health workers with an intimate knowledge of and relationship to the community served.[2] Thus, the concept of CHW integration is intrinsic to patient-centered care, which is defined as creating an interdisciplinary primary care team that complements the comprehensive needs of the patient from the social determinants of health to direct medical services.[3,4] Under the PCMH model and depending on the health care setting, CHWs may contribute to patient outreach, education, navigation, social support, follow-up, and advocacy.[5]

In the health care system, CHWs are often employed by federally qualified health centers (FQHCs). FQHCs provide the backbone of the primary care system tasked with reaching underserved populations.[6] With encouragement from the Health Resources and Services Administration PCMH Recognition Initiative,[7] FQHCs have made strides toward adopting the PCMH model and have relied on CHWs to provide an array of services. This trend has the potential to improve the quality, efficiency, and cultural relevance of health care and to create links between primary care and community-based services.[8] Chronic disease management and risk factor reduction are often the focus of these efforts, and there is ample evidence of the effect of CHW interventions on chronic disease prevention and control.[9,10] CHWs are successful in addressing chronic disease through health education, preventive health screenings, and chronic disease management interventions.[11–13] CHWs are well connected to community networks and thus are able to offer instrumental and tangible social support and have proven effective in helping individuals with diabetes improve their self-management practices.[14] More specific to the PCMH model, a growing number of these studies are implemented in health care settings.[15,16] Because of the extent of the adoption of the CHW model in the PCMH approach, it is important to identify practice-based evaluation methods that can contribute to successful integration of CHWs and ensure that they are able to operate most effectively in a clinical environment.[8]

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ELECTRONIC HEALTH RECORDS

The use of electronic health records (EHRs) as a patient management system may provide new opportunities for practice-based research on CHW integration. Practice-based research allows timely feedback on strategies currently being employed in actual clinical settings.[17] Although EHRs present challenges to research because of variation in documentation practices across providers and systems, a major benefit of using EHRs is that data are collected in the clinical context and encompass the patient experience in the decision to seek care.[18] Furthermore, EHRs provide a relatively large data set, the data are unobtrusive because they have already been collected for patients' health assessments, and it is often not necessary to recruit patients and obtain their consent because the data can easily be de-identified.[19]

The use of EHR data is a time- and cost-effective method to amass data on large numbers of patients in health systems. However, because EHRs are designed as a clinical management tool rather than a research tool, there are considerable challenges related to data quality compared with data collected primarily for research.[20] Furthermore, the indicators collected in EHRs may not provide a comprehensive picture of factors influencing intervention impact. Although unwieldy as a practice-based evaluation tool, through partnership with academic institutions, EHRs may offer an efficient means for FQHCs to investigate the role of CHWs, other types of health care professionals, and various bottom-up or natural interventions in a PCMH.

There are few previous studies in which EHRs have been used to evaluate CHWs in health care settings. Two studies using EHRs to document the contribution of CHW services on increased posthospital primary care follow-up found that the interventions did not affect readmission rates.[21,22] A practice-based EHR study of CHWs providing clinic-based services and community education demonstrated decreased HbA1c (glycated hemoglobin) over a 3-year period among patients with uncontrolled diabetes.[23]

We used EHRs to evaluate the effect of CHW integration on chronic disease–related health indicators in the natural context of 2 FQHCs delivering primary care. Both FQHCs use EHRs to improve patient management and facilitate communication among all clinical staff providers.

METHODS

Our EHR health center outcomes study was part of a larger research effort to contribute to the national discussion regarding best practices of CHWs in a clinical setting. The FQHCs began employing between 5 and 10 CHWs as part of their clinical team more than 10 years ago and were also collaborators in a parallel observational study that details CHW roles in the PCMH. Observed CHW activities related to chronic disease risk included outreach, patient self-management support, navigation of health and social systems, patient education, and contributions to behavioral and emotional health. The study also documented CHWs' use of EHRs as a communication tool with other members of the clinical team, which was a requirement of their job descriptions.[24]

Data Extraction

We had ongoing contact with the supervisor of medical informatics for the 2 FQHCs involved in the study. We requested the following patient data: (1) a diagnosis of chronic disease or chronic disease risk (hypertension, hypercholesterolemia, or body mass index [BMI; defined as weight in kg divided by height in m^2] ≥ 25); (2) demographics (age, ethnicity, gender, income, insurance status); and (3) contact and frequency of contact with a CHW (including no contact).

We then engaged in a series of clarifying communications regarding issues such as how chronic disease risk was recorded, the best measure of socioeconomic status, and whether EHRs included an actual measure of depression. The medical informatics supervisor documented the workflow that delineated where and how CHWs documented patient encounters at each FQHC. When data extraction criteria were finalized, the medical informatics supervisors conducted data extraction for a 3-year period between October 2012 and November 2015, corresponding to the recording of CHW data in their systems.

Statistical Methods

Our primary aim was to estimate the effect of CHW exposure on health outcomes. We included patients who had diabetes, cardiovascular disease (CVD) or CVD risk, as determined by text (with many variants of acronyms, abbreviations, and common misspellings) in the "chronic problem" field of their EHR, which was filled out for all patients. We defined CVD risk as having hypocholesteremia, hypertriglycemia, hyperlipidemia, or hypertension. Outcome variables included HbA1c (glycated hemoglobin), BMI, systolic and diastolic blood pressure, and blood lipid profile (low-density lipoprotein cholesterol, total cholesterol, total cholesterol/high-density lipoprotein cholesterol, and triglycerides). Total cholesterol, high-density lipoprotein, low-density lipoprotein, and triglycerides are related through a formula (total cholesterol = low-density lipoprotein + high-density lipoprotein + 0.2 triglycerides); if a patient has 3 of these measurements available the fourth can be calculated.

EHR data contained several values well outside the realm of possibility, for example BMI values ranging from −305.0 to 1.9 million. We trimmed vital and laboratory values according to commonly accepted, reasonable values, the structure of our data, and by the National Health and Nutrition Examination Survey. We excluded patients with total cholesterol outside 0 to 350 milligrams per deciliter, triglycerides outside 0 to 1000 milligrams per deciliter, and BMI outside 15 to 60 from analysis.

Our primary exposure variable of interest was CHW contact. We explored ways to further code the type of contact; however, we were not confident in these data because they did not appear to match the frequency or quality of contact anticipated from the previous qualitative analysis.[24] Thus we modeled the most simple CHW exposure, examining changes in people who had at least 1 instance of some type of contact with a CHW, as well as differences between people with and those without CHW contact.

To estimate within-group changes for each outcome variable, we used a mixed

model with the average of the outcome variable before and after first CHW exposure. Fixed effects included a binary exposure indicator variable and a term for the proportion of CHW contacts of overall visits. We included a post-CHW exposure outcome in the analysis only if it occurred more than 90 days after the initial CHW contact visit. We determined the time frame from general physician recommendations for laboratory tests or weight loss in clinical practice as well as typical (12-week) research on CHW-delivered interventions.[9,10] We included a random patient effect to account for the repeated measures design.

To estimate between-group differences for each of the outcome variables, we used analysis of covariance to compare the mean of all observations for the group that never saw a CHW to the mean of all post-CHW contact observations for the group seeing a CHW at least once. The analysis of covariance model included a term for CHW contact and baseline outcome. To make these groups comparable, we used propensity score matching[25] on the following: age, gender, race/ethnicity (Hispanic White, non-Hispanic White, other), insurance status (commercial, Medicaid, Medicare, self-pay), diagnoses (diabetes, CVD, CVD risk), and BMI category. For matching, we categorized BMI as underweight (< 18.50), normal (18.50–24.99), overweight (25.00–29.99), obese (30.00–39.99), and morbidly obese (≥ 40.00). We assessed our matches using balance diagnostics on baseline outcome variables, defined as the first observed value in our data set. Balance diagnostics included the standardized mean difference and the variance ratio.

We carried out matching using the R (R Foundation for Statistical Computing, Vienna, Austria) package Matchit.[26] We used SAS version 9.4 (SAS Institute, Cary, NC) for all other analyses.

TABLE 1—Participant Characteristics by Federally Qualified Health Center and CHW Contact: United States, 2012–2015

Characteristic	FQHC1*		FQHC2**	
	No CHW (n = 6747), % or Mean ±SD	CHW (n = 2491), % or Mean ±SD	No CHW (n = 14 599), % or Mean ±SD	CHW (n = 8310), % or Mean ±SD
Age, y	60.9 ±15.3	59.7 ±13.4	56.6 ±14.7	57.5 ±12.3
Female gender	55.9	61.4	51.6	61.4
Insurance				
Private	18.0	13.0	21.4	11.1
Medicaid	31.9	39.8	33.4	32.8
Medicare	38.3	36.1	35.7	24.2
None	11.8	11.1	9.5	31.8
Race/ethnicity				
Hispanic White	26.7	6.3	28.0	22.9
Non-Hispanic White	71.1	92.6	50.8	67.5
Other	2.2	1.1	21.3	9.6
BMI (kg/m^2)				
Underweight (< 18.50)	0.6	0.2	13.7	14.1
Normal weight (18.50–24.99)	13.9	7.5	13.9	13.9
Overweight (25.00–29.99)	32.8	28.1	26.8	27.9
Obese (30.00–39.99)	43.0	49.6	35.3	35.8
Morbidly obese (≥ 40.00)	9.7	14.6	10.3	8.3
Chronic disease				
CVD	3.1	3.0	2.2	1.6
At risk for CVD	94.6	94.5	92.6	93.1
Diabetes	26.7	45.9	36.3	40.6

Note. BMI = body mass index; CHW = community health worker; CVD = cardiovascular disease; FQHC1 = federally qualified health center 1; FQHC2 = federally qualified health center 2. Mean ±SD is given for continuous variables and percentages are given for categorical variables. Presented is the summary after we applied diagnosis inclusion criteria and outlier criteria but before we performed matching.

*All group-wise $P < .001$ except CVD ($P = .73$) and at risk for CVD ($P = .93$).

**All group-wise $P < .005$ except at risk for CVD ($P = .14$).

RESULTS

Of the approximately 9000 patients seen at health center 1 who met the inclusion criteria during the study period, 26% had at least 1 contact with a CHW, whereas 36% of the approximately 23 000 patients in health center 2 had contact with a CHW. Table 1 presents the characteristics of patients in both health centers who had contact with a CHW and those who did not. The mean age and gender of participants were similar across the 2 health centers, whereas more patients at health center 1 were Hispanic (76.9%) than were patients at health center 2 (43.2%).

A majority of patients seen at both health centers were on Medicare or Medicaid (71.7% and 64.7%, respectively). Whereas in health center 1 there was little difference in the insurance rate among patients who had contact with a CHW versus those who did not (11.8% vs 11.2%), in health center 2 a larger percentage of patients seeing a CHW did not have health insurance (31.8% vs 9.5%). Patients at both health centers were experiencing a high degree of chronic disease risk, with 87.1% and 72.2%, respectively, classified as overweight, obese, or morbidly obese, and 94.5% and 93%, respectively, diagnosed with CVD risk. In health center 1, a greater proportion of patients who had CHW contact were diagnosed with diabetes than were those who did not have CHW contact (45.9% vs 26.7%), whereas in health center 2, the numbers were more similar (40.6% vs 36.3%).

After matching, the number of CHW and non-CHW patients were identical in both health centers (Table 2), with 1319 patients in each treatment group at health center 1 and 5465 patients in each treatment group at health center 2.

TABLE 2—Baseline Participant Characteristics by Federally Qualified Health Center and CHW Contact for Propensity Score–Matched Sample: United States, 2012–2015

Characteristic	FQHC1* No CHW (n = 1319), % or Mean ±SD	FQHC1* CHW (n = 1319), % or Mean ±SD	FQHC1* SMD	FQHC2** No CHW (n = 5465), % or Mean ±SD	FQHC2** CHW (n = 5465), % or Mean ±SD	FQHC2** SMD
Age, y	58.0 ±14.1	57.9 ±13.7	–0.01	57.2 ±14.6	56.8 ±12.3	–0.03
Female gender	57.2	59.2	0.04	57.8	59.2	0.03
Insurance						
Private	13.5	14.0	. . .	12.9	11.0	. . .
Medicaid	41.4	40.4	–0.04	40.3	30.2	–0.03
Medicare	29.6	29.3	–0.02	25.3	19.4	–0.22
None	15.5	16.4	–0.01	21.6	39.4	–0.15
Race/ethnicity						
Hispanic White	6.9	6.7	–0.01	24.1	24.0	–0.00
Non-Hispanic White	91.7	91.8	0.00	65.4	65.7	0.01
Other	1.4	1.5	. . .	10.5	10.3	. . .
BMI (kg/m^2)						
Underweight (<18.50)	0.1	0.2	0.03	13.6	14.1	0.02
Normal weight (18.50–24.99)	7.4	7.5	0.01	14.6	13.9	–0.02
Overweight (25.00–29.99)	27.9	28.1	0.00	27.0	27.9	0.02
Obese (30.00–39.99)	50.6	49.6	–0.02	36.0	35.8	–0.01
Morbidly obese (≥40.00)	14.0	14.6	. . .	8.7	8.3	. . .
Chronic disease						
CVD	1.9	2.1	0.02	1.3	1.3	0.00
At risk for CVD	94.4	94.0	–0.02	93.9	93.1	–0.03
Diabetes	41.3	41.5	0.00	36.3	36.5	0.00

Note. BMI = body mass index; CHW = community health worker; CVD = cardiovascular disease; FQHC1 = federally qualified health center 1; FQHC2 = federally qualified health center 2; SMD = standard mean difference. Mean ±SD is given for continuous variables and percentages are given for categorical variables. No CHW group is matched to CHW group on age, gender, insurance status (commercial, Medicaid, Medicare, self-pay), race/ethnicity (Hispanic White, non-Hispanic White, other), diagnoses (diabetes, CVD, CVD risk), and BMI category (underweight, normal, overweight, obese, morbidly obese).

*All group-wise $P > .25$.

**All group-wise $P > .1$ except insurance type ($P < .001$).

Matching induced balance in most of the included baseline characteristics among the CHW and non-CHW groups. There was a notable difference in the insurance status in health center 2 even after matching, with a greater proportion of those seeing a CHW being uninsured (39.4%) than those not seeing a CHW (21.6%). Additionally, the variance ratio for age at health center 2 is 0.70, but the means are close: 56.8 and 57.2 years, respectively. The SD for the non-CHW group, 14.6 years, is slightly larger than is that of the CHW group, 12.3 years.

Within-Group Analyses

The within-group analysis in health center 1 showed small but statistically significant decreases for all patient outcomes when comparing no CHW contact to CHW contact. As shown in Table 3, HbA1c decreased 0.15 millimoles per mole (95% confidence interval [CI] = –0.2, –0.06; $P = .001$), BMI decreased 0.22, and total cholesterol decreased 11.9 milligrams per deciliter (95% CI = –13.5, –10.2; $P < .001$).

In health center 2, patients who had contact with a CHW experienced a significant decrease in HbA1c (0.43 mmol/mol; 95% CI = –0.70, –0.17; $P = .002$); BMI (–0.08; 95% CI = –0.14, –0.02; $P = .005$); and triglycerides (–22.50 mg/dL; 95% CI = –38.98, –6.01; $P = .008$). There was no evidence of changes in diastolic blood pressure (0.09 mmHg; 95% CI = –0.16, 0.34; $P = .47$) or low-density lipoprotein cholesterol (4.96 mg/dL; 95% CI = –0.57, 10.49; $P = .08$).

Between-Group Analyses

The propensity score–matched between-group analysis for health center 1 showed a statistically significant decrease in total cholesterol between the CHW and non-CHW groups (3.62 mg/dL; 95% CI = –6.64, –0.59; $P = .019$; Table 4). All other outcomes, with the exception of systolic blood pressure, had an observed decrease between the CHW and non-CHW groups, but these decreases were not significant. Systolic blood pressure increased slightly, but also not significantly.

For the between-group analysis at health center 2, the only observed significant difference between CHW and non-CHW groups was for the diastolic blood pressure outcome (0.38 mmHg; 95% CI = 0.09, 0.67; $P = .01$). There was also a nonsignificant increase in triglycerides. For all other outcomes, the estimated difference between the CHW and non-CHW groups was an insignificant decrease.

Sensitivity and Subgroup Analyses

We tested the sensitivity of these analyses to the choice of inclusion cutoffs for BMI, total cholesterol, and triglycerides by expanding the criteria for inclusion by 10% and 20%. For instance, the primary analysis included patients with a BMI between 15.0 and 60.0, whereas the 10% expansion would result in patients with BMI between 13.5 and 66.0 being included. Expanding the inclusion cutoff values by as much as 50% did not change any of the conclusions in the within-group analysis.

In the between-group analysis, the estimate for total cholesterol became statistically insignificant (difference = –2.4; 95% CI = –5.4, 0.6; $P = .12$) with a 10% expansion in inclusion criteria, whereas the remaining conclusions were unchanged. Similarly, conclusions remained the same when we

TABLE 3—Within-CHW Group Difference Estimates, Pre–Post-CHW Contact With 3-Mo Lag Time for Post-CHW Visit: United States, 2012–2015

	FQHC1			FQHC2		
Outcome	Pre-CHW	Post-CHW	Difference[a] (95% CI)	Pre-CHW	Post-CHW	Difference[a] (95% CI)
HbA1c, %, mmol/mol	7.56	7.41	−0.15 (−0.24, −0.06)	8.02	7.58	−0.43 (−0.70, −0.17)
BMI, kg/m^2	33.1	32.8	−0.29 (−0.39, −0.20)	31.2	31.1	−0.08 (−0.14, −0.02)
Systolic BP, mmHg	130.5	129.3	−1.24 (−2.03, −0.46)	133.2	133.1	−0.07 (−0.52, 0.39)
Diastolic BP, mmHg	75.6	74.6	−1.02 (−1.46, −0.59)	80.0	80.1	0.09 (−0.16, 0.34)
LDL, mg/dL	114.9	105.5	−9.45 (−10.85, −8.04)	99.4	104.4	4.96 (−0.57, 10.49)
Cholesterol, mg/dL	197.2	185.3	−11.90 (−13.51, −10.29)	186.0	185.9	−0.15 (−6.57, 6.28)
TChol/HDL, mg/dL	4.48	4.18	−0.31 (−0.36, −0.27)	4.20	4.15	−0.05 (−0.26, 0.16)
Triglycerides, mg/dL	187.1	176.4	−10.66 (−14.78, −6.55)	196.0	173.5	−22.50 (−38.98, −6.01)

Note. BMI = body mass index; BP = blood pressure; CHW = community health worker; CI = confidence interval; FQHC1 = federally qualified health center 1; FQHC2 = federally qualified health center 2; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein; LDL = low-density lipoprotein; TChol = total cholesterol.

[a]Difference is defined as post-CHW – pre-CHW.

adjusted for insurance status. A subgroup analysis restricted to patients with diabetes did not result in a change in HbA1c effect across either health center or analysis method.

DISCUSSION

FQHCs are being encouraged and incentivized to incorporate the PCMH concept into care delivery, and EHRs are increasingly used to improve patient management. Our practice-based research study illustrates an effort to use EHRs to discern the impact of CHWs in a PCMH approach on indicators of risk and control for chronic disease and, more specifically, on the contribution of the CHW workforce in 2 health care settings on these outcomes. In our study of chronic disease risk drawn from EHRs, we found that patients of the FQHCs in our study experienced sustained health improvements.

Health center 1 demonstrated significant improvements across all risk indicators and clinically meaningful changes in lipids, and both health centers saw significant decreases in HbA1c, triglycerides, and BMI. Our ability to discern the effect of CHWs in the PCMH model is less conclusive. The between-group analysis detected minimal impact from our most basic coding of whether an individual patient had CHW contact or not. Thus, although the patients showed consistent improvement in chronic disease risk through engagement in their primary care systems over time, there was no evidence that CHW exposure provided additional benefit.

One explanation is that CHW involvement in patient care teams did not improve chronic disease risk; however, we believe limitations on our ability to use EHRs to delineate the dose, type, or quality of CHW contact render this interpretation premature. Furthermore, these findings are counter to numerous CHW intervention studies documenting an effect on indicators of cardiovascular health and diabetes control.[9,27,28]

It is also plausible that the effectiveness of CHWs' role in the PCMH is not clearly demonstrated in the health outcomes that we focused on. In interacting with patients, for example, CHWs may encourage patients to seek regular care who might not otherwise be engaged and monitored in EHRs. In this case, the actual contribution of CHWs is to ensure that at-risk patients receive regular care. These patients then experience benefits similar to those of patients who did not see a CHW. Considering the track record of CHWs in increasing access to medical care in marginalized communities,[29] it would be worthwhile to determine the relative value of this CHW role in the FQHCs.

In addition to the limitations in differentiating the quality of CHW interactions from EHRs, we were unable to capture the fluid and adaptive nature in CHW roles in response to changes in broader organizational strategies to provide patient-centered care.[24] Although there is evidence that CHWs help clients with chronic disease to address mental health issues, we were also unable to assess this contribution through the medical record.[30] Delineating

TABLE 4—Between-Group Difference Estimates, Propensity Score Matched With 3-Month Lag on Post-CHW Visits: United States, 2012–2015

	FQHC1			FQHC2		
Outcome	No CHW	CHW	Difference[a] (95% CI)	No CHW	CHW	Difference[a] (95% CI)
HbA1c, %, mmol/mol	7.45	7.15	−0.31 (−0.66, 0.04)	7.75	7.75	−0.01 (−0.16, 0.18)
BMI, kg/m^2	32.8	32.8	−0.02 (−0.20, 0.17)	31.1	31.1	−0.08 (−0.17, 0.01)
Systolic BP, mm/Hg	129.0	129.1	0.10 (−1.02, 1.22)	132.5	132.5	−0.02 (−0.53, 0.48)
Diastolic BP, mm/Hg	75.2	74.9	−0.30 (−0.92, 0.32)	79.5	79.9	0.38 (0.09, 0.67)
LDL, mg/dL	109.4	106.9	−2.51 (−5.17, 0.16)	105.2	101.0	−4.16 (−11.47, 3.15)
Cholesterol, mg/dL	190.5	186.9	−3.62 (−6.64, −0.59)	186.5	182.2	−4.25 (−12.54, 4.05)
TChol/HDL, mg/dL	4.19	4.12	−0.06 (−0.15, 0.02)	4.19	4.19	−0.00 (−0.23, 0.23)
Triglycerides, mg/dL	176.3	172.0	−4.30 (−11.72, 3.13)	177.6	181.5	3.87 (−16.81, 24.56)

Note. BMI = body mass index; BP = blood pressure; CHW = community health worker; CI = confidence interval; FQHC1 = federally qualified health center 1; FQHC2 = federally qualified health center 2; HbA1c = glycated hemoglobin; HDL = high-density lipoprotein; LDL = low-density lipoprotein; TChol = total cholesterol. Matched on age, gender, insurance status (commercial, Medicaid, Medicare, self-pay), race, diagnoses (diabetes, cardiovascular disease, cardiovascular disease risk), and BMI category (underweight, normal, overweight, obese, morbidly obese).

[a]Difference is defined as CHW – no CHW.

the contribution of various CHW activities on health outcomes would help clarify the CHW role in the holistic PCMH approach in providing "accessible, continuous, comprehensive, compassionate, and culturally effective care."[9(pe28)] Although not all patients interact directly with CHWs, the providers and other health care professionals are ideally benefiting from the perspective of CHWs, who are recognized for their ability to represent the values and priorities of communities in integrated health care teams.

To the extent that the between-group analysis did not document an additional benefit on health outcomes, the clinical environment may present challenges for CHWs in achieving the health benefits for patients demonstrated in intervention studies.[15] As CHWs become increasingly integrated into the delivery of health care, they are confronted with barriers related to clinical practice. Providers may lack understanding of CHWs' role or fail to recognize their value, resulting in underuse or misuse of the CHW workforce.[25,31] CHWs may also experience less autonomy and flexibility in clinical settings than in community organizations, which may also diminish the CHWs' impact.[32]

As FQHCs continue to initiate innovative models for CHW integration, more detailed documentation of their activities with patients would contribute to understanding effective clinical CHW roles for specific populations and health conditions.[15] Some FQHCs, for example, anticipate that the CHW workforce can address burgeoning health care costs by focusing on high utilizers of health care services. There is evidence that CHWs can have a positive effect on issues such as hospital readmission, and practice-based research can provide timely feedback on new strategies, including more upstream CHW efforts to help patients self-manage chronic conditions. The evolution of EHRs to include indicators of the social determinants of health by partner FQHCs and other health centers may make CHW contributions more evident moving forward.

Limitations

The findings of this study must be considered in light of a number of limitations. The lack of consistent documentation in EHRs on the duration, type, and quality of CHW contact restricted its potential to fully capture the application of the CHW workforce in the current, evolving health care landscape. Sustained and iterative feedback between the research partners and clinical partners is necessary to optimize future use of these data to test research hypotheses and improve health services delivery.

Furthermore, the method we used for between-group analysis propensity score matching does not control for unmeasured confounders. We do not know, for example, whether there were explicit or implicit processes by medical providers that may result in different execution of protocols for referral to CHWs. Although we used a wide range of potential confounders available in EHRs and our propensity score matching samples were highly similar, there are no statistical tests to determine whether there are unmeasured confounders (e.g., whether some providers were more likely to refer less adherent patients to CHWs). Designs such as cluster-randomized trials (in which some health care teams are randomly assigned to include CHWs and others are not) or analysis adjusting for instrumental variables (we have yet to identify viable instruments in these data) would be required to adjust for such confounders.[33,34]

Conclusions

We sought to quantitatively assess the impact of CHWs in 2 primary care health centers serving underserved populations at risk for chronic disease. The within-group findings consistently showed that patients improved in clinical outcomes after exposure to CHWs in both partnering health centers. However, the between-group findings did not show significant improvements that could be specifically tied to our broad measure of CHW exposure.

Our research illustrates many distinctions in extracting exposure and outcome data from EHRs with the aim of evaluating the contributions of a specific type of health professional or a specific intervention conducted in a natural clinical setting. Progress in this type of evaluation research requires iteration and feedback between researchers with specific evaluation aims and institutions whose primary mission is to serve individual health needs. AJPH

CONTRIBUTORS

M. Ingram led the writing of the article. M. Ingram, J. Blackburn, and S. Sabo assisted in research conceptualization. M. Ingram and M. L. Bell assisted in research design. M. Ingram and A. Lohr collaborated with community partners in data interpretation. K. J. Doubleday, M. L. Bell, and S. C. Carvajal analyzed the data. K. J. Doubleday, M. L. Bell, A. Lohr, and S. C. Carvajal assisted in writing the article. M. L. Bell, L. Murrieta, M. Velasco, J. Blackburn, S. Sabo, J. Guernsey de Zapien, and S. C. Carvajal assisted in data interpretation. S. C. Carvajal conceptualized and designed the research.

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HUMAN PARTICIPANT PROTECTION

This study was conducted under the guidance and approval of the University of Arizona human subjects internal review board.

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