Integrating Population Health Strategies into Primary Care: Impact on Outcomes and Hospital Use for Low-Income Adults

Heather Kitzman, PhD[1], Kristen Tecson, PhD[2], Abdullah Mamun, PhD[1], Briget da Graca, JD, MS[3], Samrat Yeramaneni, PhD[4], Kenneth Halloran, MPH[1], Donald Wesson, MD[1]

Objective: Our objectives were two-fold: 1) To evaluate the benefits of population health strategies focused on social determinants of health and integrated into the primary care medical home (PCMH) and 2) to determine how these strategies impact diabetes and cardiovascular disease outcomes among a low-income, primarily minority community. We also investigated associations between these outcomes and emergency department (ED) and inpatient (IP) use and costs.

Design: Retrospective cohort.

Setting: Community-based PCMH: Baylor Scott & White Health and Wellness Center (BSW HWC).

Patients/Participants: All patients who attended at least two primary care visits at BSW HWC within a 12-month time span from 2011-2015.

Methods: Outcomes for patients participating in PCMH only (PCMH) as compared to PCMH plus population health services (PCMH+PoPH) were compared using electronic health record data.

Main Outcomes: Diastolic and systolic blood pressure, hemoglobin A1c, ED visits and costs, and IP hospitalizations and costs were examined.

Results: From 2011-2015, 445 patients (age=46±12 years, 63% African American, 61% female, 69.5% uninsured) were included. Adjusted regression analyses indicated PCMH+PoPH had greater improvement in diabetes outcomes (prediabetes HbA1c= -.65[SE=.32], P=.04; diabetes HbA1c= -.74 [SE=.37], P<.05) and 37% lower ED costs than the PCMH group (P=.01). Worsening chronic disease risk factors was associated with 39% higher expected ED visits (P<.01), whereas improved chronic disease risk was associated with 32% fewer ED visits (P=.04).

Conclusions: Integrating population health services into the PCMH can improve chronic disease outcomes, and impact hospital utilization and cost in un- or under-insured populations. *Ethn Dis*. 2022;32(2):91-100; doi:10.18865/ed.32.2.91

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Introduction

There is increasing recognition that population health approaches, such as evidence-based wellness and prevention services and addressing social determinants of health (SDOH), can reduce emergency department (ED) and inpatient (IP) hospital utilization.[1-3] However, evidence as to which strategies lead to improved health outcomes and reductions in hospital use is limited.[4-6] Filling this gap in the evidence is important for improving the health of and care provided to all segments of the population, but is needed most urgently for uninsured populations, as their lack of health insurance carries a significantly elevated risk of mortality.[7,8] Additionally, from the perspective of health care systems left to cover the cost of uncompensated hospital care for uninsured patients, low-cost population health interventions that prevent the need for such hospital care hold substantial value: nationally, costs of uncompensated care for the uninsured in the United States average $42.4 billion per year.[9]

In 2019, almost 30 million predominantly low-income, non-White, working-age adults in the United States lacked health insurance.[10] Uninsured adults use fewer health services in a given year than covered adults, and the use of fewer

[1] Baylor Scott & White Health and Wellness Center, Baylor Scott & White Health, Dallas, TX; Robbins Institute for Health Policy & Leadership, Baylor University, Waco, TX
[2] Baylor Scott & White Heart and Vascular Institute, Baylor Scott & White Health, Dallas, TX
[3] Baylor Scott & White Research Institute, Dallas, TX
[4] Sarah Cannon Research Institute, Nashville, TN

Address correspondence to Heather Kitzman, PhD; Baylor Scott & White Health and Wellness Center; Heather.kitzmancarmichael@bswhealth.org

and less appropriate services is associated with higher morbidity and mortality.[8] Data also show that the uninsured are admitted to hospitals for more serious conditions,[11] and that low-income, racial/ethnic minorities, and un- or underinsured patients have higher rates of preventable hospitalizations.[12]

Health care systems must transition from a reactionary model that focuses on acute conditions to one that proactively prevents disease and improves overall population health and counters current health disparities.[13,14] The primary care medical home (PCMH) is designed to improve population health through integrated medical and social care, and has reduced ED use in select studies.[15] Some studies focusing on uninsured and/or low-income populations report success of the PCMH model in these groups, including reductions in all-cause or nonurgent ED visits,[16,17] and hospitalization costs,[18] while others report little impact[19] or even exacerbation of some health disparities.[20]

This study evaluated the benefits of integrating population health strategies into a primary care medical home (PCMH) serving a low-income, primarily ethnic minority community.

Overall, there is a lack of evidence to guide population health initiatives to improve health and reduce costs,[5,6] particularly in uninsured, low-income populations. [21] The Baylor Scott & White Health and Wellness Center (BSW HWC) previously reported that its innovative population health model significantly reduced ED and IP use and costs; however, the impact of program components on patient outcomes and associated hospital use was not evaluated.[3] To build population health evidence for uninsured and low-income populations, this study estimated the differential effects of the BSW HWC model: access to primary care at a designated PCMH with and without participation in population health strategies. The study aim was to determine which components of the model were associated with improvements in type 2 diabetes mellitus (DM) and cardiovascular disease (CVD) outcomes, and associated patterns of hospital use in a primarily uninsured adult ethnic minority population.

Methods

This retrospective cohort study included participants who visited the ED or IP at any Baylor Scott & White Health hospital in North Texas and attended at least two primary care visits at BSW HWC within a 12-month time span from 2011-2015. BSW HWC is a community-based health center comprising a level 3 PCMH clinic that conducts extramural grant-supported research and medical education, housed within a City of Dallas Parks and Recreational Center through a private/public partnership. A detailed description of BSW HWC has previously been published.[3] In addition to primary care and adjunct clinical and behavioral health services, BSW HWC offers patients opportunities to participate in "population health programs" that focus on wellness, prevention, and social determinants of health (SDOH), defined by the Centers for Disease Control and Prevention as the "conditions in the environments in which people are born, live, learn, work, play, worship and age that affect a wide range of health, functioning, and quality-of-life outcomes and risks."[22] Participation in any service is voluntary.

The enrollment date for individuals meeting study criteria (ie, ED or IP visit in the past 12 months and two primary care visits) was taken as the time of first BSW HWC service, ie the index event. Electronic health records were examined for up to 12 months following the index event to group patients into those who had participated in 'PCMH only' (PCMH) services or 'PCMH + Population Health' (PCMH+PoPH) services. Those with less than 30 days of follow-up were excluded from analyses. This study was considered IRB exempt by the Baylor Scott & White Research Institute.

Study Groups

PCMH Only (PCMH)

Participants in the PCMH group received at least two primary care visits at the BSW HWC PCMH over 12 months. BSW HWC PCMH services include medical care as well as options for a variety of adjunct clinical or "wrap-around" services including appointments with a licensed clinical social worker, pharmacist, and nutritionist.[2] Community health workers were also available for patient navigation, care coordination, and chronic disease education.

PCMH + Population Health (PCMH+PoPH)

Participants in the PCMH+PoPH group received at least two primary care visits at the BSW HWC PCMH and attended at least one Population Health wellness, prevention, or SDOH program over 12 months. Programs and services were free of charge and included the National Diabetes Prevention Program (DPP), Diabetes Self-Management Education (DSME), Group Lifestyle Balance (GLB), nutrition seminars, cooking demonstrations, physical activity classes (eg, Zumba, Praise and Flow, Aerobics), Walk with a Doc, Bible Study, Crafting for Health, weekly farm stands providing local access to affordable produce, and support programs for seniors. Program participation was tracked in a relational database from class attendance and sign-in logs. Program participation was classified in three categories:1) Evidence-Based Education (DPP, DSME, GLB); 2) General Wellness/SDOH (nutrition seminars, farm stand, lunch and learn, cooking demonstrations, Bible Study, physical activity and senior programming); and 3) All (participation in both types of programs).

Measures

Biomarkers were collected during routine visits to the BSW HWC primary care clinic by trained medical assistants. Systolic blood pressure (SBP), diastolic blood pressure (DBP), glycated hemoglobin (HbA1C), and body weight were obtained from electronic health records. A clinically significant improvement in CVD/DM was defined as a reduction of 10 mm Hg systolic BP or 5 mm Hg diastolic BP and/or .5% of HbA1c by the end of the follow-up period.[23,24] A worsening in CVD/DM outcomes was defined as an increase of 10 mm Hg systolic BP or 5 mm Hg diastolic BP and/or .5% of HbA1c by the end of the follow-up period. Biomarkers measured at the index event (± 30 days) were used as the baseline and those recorded closest to 12 months (± 90 days) following the index event were used as the post-measure. Participants lacking a baseline and/or post measure for a particular biometric marker were removed from that corresponding analysis.

Hospital utilization was evaluated based on the number of visits and direct cost incurred during IP hospitalizations and/or ED visits obtained from electronic health records. Number of visits and associated direct costs in the 12 months prior and 12 months post the index BSW HWC visit were taken as baseline and follow-up measures, respectively. Direct costs of ED and IP services were adjusted for inflation based on the 2015 Consumer Price Index for medical care services. Hospital visits with primary diagnosis codes for trauma, pregnancy, and/or newborns were excluded from analyses.

Statistical Analyses

Continuous variables are presented as mean ± standard deviation or median [quartile 1, quartile 3], if skewed. Categorical variables are presented as frequencies (percentages). Differences between study groups in baseline demographics (self-reported gender, age, ethnicity, race), socioeconomics (self-reported zip code, health insurance status), biometrics, and utilization were evaluated using two sample t-tests, Wilcoxon Rank Sum tests, or Chi-Square tests, as appropriate. Along with assessing the overall changes in CVD and DM, subgroup analyses were conducted for patients who were prediabetic/diabetic or pre-hypertensive/hypertensive (HbA1C > 5.6 mmol/mol; systolic BP ≥120 mm Hg; and diastolic BP ≥80 mm Hg), and diabetic or hypertensive only patients (HbA1C > 6.4 mmol/mol; or systolic BP ≥140 mm Hg; and diastolic BP ≥90 mm Hg, hypertension stage 2 or greater).[25,26]

Multiple linear regression models were constructed to evaluate the effect of Population Health programs in addition to clinic services on CVD and DM outcomes (systolic BP, diastolic BP, and HbA1c), adjusting for socio-

economic and demographic variables. Further, to estimate the effect of the type of Population Health program in which individuals in the PCMH+PoPH group participated (Evidence-based Education, General Wellness/SDOH, All), stratified analyses were performed with paired biometric changes using paired t-tests and Wilcoxon Signed Rank tests, as appropriate.

Additionally, multivariable zero-inflated Poisson or negative binomial models were constructed to estimate the effects of improvement or worsening of CVD/DM on hospital utilization while controlling for baseline diabetes status, demographic factors, and socioeconomic variables. Zero-inflated Gamma models were used to estimate the impact of BSW HWC programs and improvement or worsening of CVD/DM outcomes on ED and IP costs after adjusting for baseline diabetes status, demographic factors and socioeconomic variables. Each of the adjusted models was assessed for goodness of fit using the likelihood ratio test and Pearson chi-square test as appropriate. Variables significantly different at baseline between groups, such as sex, baseline diabetic status, and residential location, were included in the model to adjust for confounding effects. Age, ethnicity, and insurance status were cited in the literature as differential factors for hospital utilizations and therefore included in the model.[27,28]

Results

Of 666 records from 2011 to 2015 screened, 445 were eligible for analyses. The average age was 46±12 years and 61% were female (Table 1). The PCMH+PoPH group had significantly more participants with diabetes (77% vs 36%, P<.001) and, therefore, diabetes status was adjusted in the regression model. Only 126 (29%) participants were non-hypertensive; baseline hypertension rates did not differ between groups. Most participants were uninsured (69.5%) and insurance status did not differ between groups. Those in the PCMH+PoPH group were more likely to live in a local ZIP code than those in the PCMH group

Table 1. Patient characteristics at baseline

Variable	All, N=445	PCMH+PoPH Group, n=259	PCMH Group, n=186	P
Age, years mean (SD)	46.2 (11.6)	46.2 (11.6)	46.2 (11.7)	.99
Male, n (%)	174 (39.1)	89 (34.4)	85 (45.7)	.02
Ethnicity, n (%)				.51
African American	273 (63.3)	167 (65.5)	106 (60.2)	
White	48 (11.1)	27 (10.6)	21 (11.9)	
Hispanic or Latino	94 (21.8)	54 (21.2)	40 (22.7)	
Other	16 (3.7)	7 (2.8)	9 (5.1)	
Diabetes (HbA1c >6.4 mmol/mol), n (%)	224 (61.9)	175 (77.1)	49 (36.3)	<.01
HbA1c, mean (SD)	9.37 (2.68)	9.56 (2.70)	8.64 (2.50)	<.001
Hypertension status, n (%)				.39
Non-hypertensive (SBP<120 and DBP<80)	126 (29.0)	79 (31.6)	47 (25.5)	
Pre-hypertensive (140>SBP≥120 or 90>DBP≥80)	208 (47.9)	116 (46.4)	92 (50.0)	
Hypertensive (SBP≥140 or DBP≥90)	100 (23.04)	55 (22.00)	45 (24.46)	
Systolic BP, mm Hg, mean (SD)	131.5 (23.8)	130.6 (22.9)	132.6 (24.6)	.38
Diastolic BP, mm Hg, mean (SD)	81.2 (14.6)	80.2 (13.9)	82.7 (15.4)	.07
Weight (lbs), mean (SD)	206.8 (54.7)	208.5 (56.0)	204.6 (53.1)	.47
Insurance status, n (%)				.12
Private	81 (18.3)	43 (16.7)	38 (20.5)	
Medicare/Medicaid	54 (12.2)	38 (14.7)	16 (8.7)	
Uninsured	308 (69.5)	177 (68.6)	131 (70.8)	
Local ZIP code, n (%)	208 (47.3)	136 (52.7)	72 (39.6)	<.01

SBP, systolic blood pressure; DBP, diastolic blood pressure; HbA1c, hemoglobin A1c

Table 2. Adjusted estimates of CVD and DM at post-intervention for PCMH+PoPH as compared to PCMH group

Outcomes	Adjusted additional effect of PCMH+PoPH group compared to PCMH group [a, b, c]	
All participants	Estimate (SE)	P
HbA1c, mmol/mol	-.48 (.35)	.17
Weight, lbs	.11 (1.80)	.95
Systolic BP, mm Hg	2.95 (2.28)	.20
Diastolic BP, mm Hg	1.23 (1.61)	.44
Pre-hypertensive or hypertensive, and pre-diabetic or diabetic at baseline		
HbA1c (>5.6 mmol/mol)	-.65 (.32)	.04
Systolic BP (≥120 mm Hg)	5.34 (3.09)	.09
Diastolic BP (≥80 mm Hg)	3.98 (2.24)	.08
Hypertensive/diabetic only at baseline		
HbA1c (>6.4 mmol/mol)	-.74 (.37)	.05
Systolic BP (≥140 mm Hg)	2.23 (5.48)	.68
Diastolic BP (≥90 mm Hg)	2.85 (3.02)	.35

a. A positive estimate was an indication of an increase at post-intervention for PCMH+PoPH group compared to PCMH group
b. Model for HbA1C at post-intervention was adjusted for baseline HbA1c, sex, age, ethnicity, baseline measure, insurance status, and residence location
c. Models for systolic BP, diastolic BP, and weight at post-intervention were adjusted for the baseline value of the corresponding outcome variable, sex, age, ethnicity, insurance status, residence location, and diabetes status at baseline

(53% vs 40%, P=.01). The average follow-up time did not differ significantly between groups (321±115 vs 303±130 days for PCMH+PoPH group and PCMH group, respectively, P=.13, data not shown).

CVD and DM Outcomes

There were significant reductions in both SBP and DBP for all participants using services at the BSW HWC (-3.6±23.4 mm Hg, P =.002; -2.3±14.9 mm Hg, P=.002, respectively). Further, participants who were pre-hypertensive or hypertensive experienced even greater decreases in blood pressure (SBP: -10.0±24.1 mm Hg and -21.0±27.4 mm Hg; DBP: -9.3±14.4 mm Hg and -15±13.5 mm Hg, Ps<.0001, respectively). A significant decrease in HbA1c was also observed (-1.3±2.6 mmol/mol, P<.0001). Participants gained an average of 2.1±14.2 pounds by the end of the follow-up period (P<.01) (data not shown).

Table 2 summarizes the comparisons of changes in CVD and DM outcomes from baseline to follow-up between the study groups overall and by baseline CVD/DM status after adjusting for covariates. There were no significant differences in the groups' SBP, DBP, weight, or HbA1c changes at post-intervention. However, for the subgroup of participants with prediabetes or diabetes at baseline, the PCMH+PoPH group had greater reductions in HbA1c than those in the PCMH group (adjusted mean differences between PCMH+PoPH and PCMH groups: -.65 (prediabetes) and -.74 (diabetes); P=.04 and P<.05, respectively).

PCMH+PoPH Participation in Education, Wellness, and SDOH Programs

Approximately 21% of patients participated only in "Evidence-based Education" programs, 10% participated only in "General wellness/SDOH" programs, and 69% in a mixture of the two program types. Patients participating only in "Evidence-based Education" programs had significant reductions in SBP, DBP, and HbA1c (Ps=.08, .04, <.01, respectively). Patients who participated only in "General wellness/SDOH" programs had a significant reduction in DBP (P=.02) and patients who participated in both types of programs had significant reductions in HbA1c (P<.01).

The median number of Evidence-based Education classes attended per program was 2.0 (range 1 to 11 class visits per program). PCMH+PoPH patients who participated only in Evidence-based Education programs had significant reductions in SBP and DBP when they attended more than two classes (-7.37 mm Hg and -5.84 mm Hg,

Table 3. Adjusted effect of groups, improvement or worsening in CVD/DM on hospital utilizations

		Adjusted effect (SE) on number of ED or IP after index date[a]	P	Adjusted effect (SE) on ED or IP costs after index date[b]	P
Emergency Department (ED)					
Model 1	Group: PCMH+PoPH vs PCMH	-.13 (0.17)	.46	-.46 (.16)	.01
	Improvement in CVD/DM outcomes: yes vs no	-.39 (0.19)	.04	-.25 (.15)	.10
Model 2	Group: PCMH+PoPH vs PCMH	-.12 (0.17)	.49	-.42 (.17)	.01
	Worsened in CVD/DM outcomes: yes vs no	.33 (0.19)	.07	-.06 (.14)	.69
Inpatient Department (IP)					
Model 1	Group: PCMH+PoPH vs PCMH	-.26 (0.32)	.42	-.13 (.23)	.59
	Improvement in CVD/DM outcomes: yes vs no	.39 (0.43)	.37	-.02 (.23)	.93
Model 2	Group: PCMH+PoPH vs PCMH	-.25 (0.31)	.43	-.19 (.23)	.43
	Worsened in CVD/DM outcomes: yes vs no	-.05 (0.42)	.90	.31 (.21)	.14

a. Models were adjusted for age, sex, race/ethnicity, type of insurance, baseline diabetes status, residential location, and number of hospital visits in baseline. Estimates were in logarithmic scale and were estimated from two-parts model to account for the mixture distribution of the response variable (number of hospital visits in a year following the index date) due to excess zeros and count of hospital visits. Each model had P>.05 from the goodness of fit test

b. Models were adjusted for age, sex, race/ethnicity, type of insurance, baseline diabetes status, residential location, and total costs incurred in baseline. Estimates were in logarithmic scale and were estimated from two-parts model to account for the mixture distribution of the response variable (total cost incurred in a year following the index date) due to zero costs corresponding to no ED/IP visits and costs due to ED/IP visits. All four models had P>.05 from the goodness of fit test

respectively). Further, those who were pre-hypertensive or hypertensive at baseline and attended at least two classes had a greater reduction in SBP and DBP than those who attended less than two classes with the same risk profile. Similarly, participants with diabetes who attended more than two education classes had greater reductions in HbA1c than those who attended less than two. The General Wellness/SDOH programs did not show a clear dose-response relationship.

ED and IP Use and Cost Patterns

In the year prior to using BSW HWC services, there were 531 ED visits among the 445 individuals included in our cohort, while in the year following the initial visit at BSW HWC, there were 456 ED visits (a 14% reduction (P=.003)). Additionally, a total of 178 IP visits occurred in 162 patients in the 12 months prior to the index BSW HWC service and IP visits were reduced by 43% after the index BSW HWC service (102 total visits, P<.0001).

At least one CVD/DM outcome measure had improved for approximately 65% of patients (and worsened for approximately 44% of patients) by the end of the follow-up period. After adjusting for exposure group, age, sex, ethnicity, insurance status, residence location, baseline DM status, and number of ED visits prior to using BSW HWC services, the expected number of ED visits was 32% (=1 - exp[-.3928]) lower for patients who had a clinical improvement in CVD/DM outcomes than those who did not improve (P=.04) (Table 3, ED, Model 1). The expected number of ED visits per patient per year was 1.5 for those who had a clinical improvement in CVD/DM outcomes, vs 2.1 visits per patient per year for those who had no improvement. Similarly, the expected number of ED visits was 39% (= exp [.3319] - 1) higher for patients who had clinically worsened CVD/DM outcomes compared to patients who did not (P=.07). The marginal number of ED visits were 1.9 per patient per year for the patients who had clinically worsened CVD/DM outcomes and 1.4 per patient per year who did not, respectively. Improvement or worsening in CVD/DM outcomes did not have a significant effect on the expected number of IP visits after adjusting for the baseline IP visits, demographic, socioeconomic, and baseline diabetes status.

Overall, ED costs were reduced by 23.2% and IP costs by 49.5% after using BSW HWC services (P=.0007 and P<.0001, respectively). After adjusting for baseline ED

costs, baseline diabetes status, and demographic and socioeconomic factors, improvement in CVD/DM outcomes accounted for a 22% (=1 – exp[-.25]) (P=.10) reduction in average ED cost in the post-intervention period while conditional on having incurred an ED cost (Table 3). The marginal average ED cost was $424.3 lower per patient per year for those who had a clinical improvement in CVD/DM outcomes compared to those who had not.

In comparing the study groups from the adjusted analyses, the average ED cost in the post-intervention period for the patients in the PCMH+PoPH group was approximately 37% (=1 - exp[-.46]) lower (P=.01) than those in the PCMH group when accounting for improvements in CVD/DM outcomes. The average ED cost per patient per year was $441 lower for the PCMH+PoPH group than the PCMH group. Worsening of CVD/DM outcomes was not statistically significant in ED cost (P=.69). The findings were similar for average IP cost (12% lower for PCMH+PoPH than PCMH for the model with improvement in CVD/DM and 19% lower for PCMH+PoPH than PCMH for the model with worsening in CVD/DM), but were non-significant (Table 3).

Discussion

This study evaluated a multifaceted innovative population health model to improve chronic disease and reduce ED and IP use and costs. The overall BSW HWC model demonstrated significant reductions in blood pressure and HbA1c that were associated with decreased ED and IP use and costs. This study supports previous findings that the BSW HWC population health model reduces ED and IP use and costs in a primarily uninsured population and extends these findings by evaluating patient outcomes and comparing the additive value of Population Health programs to primary care.[3]

Our findings indicate that integrating population health into primary care has the potential to enhance patient outcomes in a predominantly uninsured, low-income population and reduce uncompensated hospital costs.

Individuals who accessed the BSW HWC PCMH demonstrated significant improvements in CVD and DM outcomes. These findings were clinically significant for those with elevated blood pressure. Further, the large standard deviations related to changes in CVD and DM outcomes indicate some had even greater improvements, whereas others benefitted less. This could be due to sociodemographic or other factors not collected in this study. Clinic patients who attended additional population health services had a significantly greater reduction in DM and a greater reduction in ED costs than those who only accessed the PCMH. These findings are promising for the integration of wrap-around wellness, prevention, and SDOH services and are consistent with a recent study in a large urban safety-net health system that also found that wraparound services integrated into a PCMH led to reductions in hospitalizations and ED visits along with significant cost savings.[2] Further, individuals who lived close to the center were more likely to engage in services that improved diabetes outcomes providing support for place based initiatives to address health disparities.

Overall, the impact of PCMH on health care resource utilization and costs in lower-income populations[16-20] has been less consistent than in insured or Medicare populations.[15] The effectiveness of the PCMH is impacted by SDOH and other upstream factors outside of the medical setting.[5] Although many health care systems are beginning to address individual social needs such as transportation, meals, housing, or mental health, few are addressing community-level SDOH, or underlying factors, that perpetuate high social needs and health disparities.[29] The BSW HWC actively addresses SDOH and in-

tegrates community health workers into its care model, which may explain the positive outcomes on hospital use and costs in this study.

This study also demonstrated a significant relationship between CVD/DM outcomes and patterns in EP and IP use and costs. Clinically significant reductions in blood pressure, such as a 10 mm Hg reduction in SBP, can reduce the risk of CVD events by 20%.[23] Uninsured individuals are more likely to have undiagnosed and uncontrolled hypertension, contributing to a higher risk for stroke and death than insured individuals.[30-32] Similarly, uninsured individuals are more likely to have undocumented and untreated diabetes, yet even modest reductions in HbA1c of 1% have been associated with long-term reductions in diabetes complications,[33] which could provide substantial savings as diabetes health care costs are more than $300 billion annually.[34] In our study, worsening CVD/DM outcomes were associated with a 39% greater chance of an ED visit and 36% higher IP costs. Conversely, participants with an improvement in CVD/DM outcomes were 32% less likely to visit the ED and incurred 22% less in ED costs. These findings indicate that small changes in CVD and DM outcomes are associated with use of emergency services, and programs to manage CVD and DM outcomes at the population level could provide cost savings and improved health in low-income, uninsured populations.

Our findings indicate that integrating population health into primary care has the potential to enhance patient outcomes in a predominantly uninsured, low-income population and reduce uncompensated hospital costs. In this study, evidence-based education programs showed the strongest beneficial impact on health outcomes, but more research is needed to determine which services lead to the greatest improvements in health and reductions in hospital utilization for situations that are primary care-preventable. Identifying the most effective, and cost-effective, programs to offer in conjunction with primary care can reduce costs, improve population health, and inform value-based care models. Since the provision of services to the uninsured seldom generates much, if any, reimbursement, developing sustainable population health models for this population depends largely on cost savings to hospitals through the avoidance of resource intensive, uncompensated acute care.

Study Limitations

Limitations of this study include the retrospective design, lack of randomization and a control group, and data from only one health care system. Further, this study evaluated how services improved ED and IP use and costs for individuals who had previous hospital use. Therefore, it may not be generalizable to individuals without a prior history of hospital use where preventing unnecessary visits would be the objective. While we cannot eliminate the possibility that some unmeasured factor may have made patients in the PCMH+PoPH group more likely to participate in Population Health programs and more likely to comply with medication regimens and recommendations for healthy living that impact the outcomes measured, comparable groups were approximated by accounting for participant demographic and clinical characteristics in statistical models. These study results may not be generalizable to other payer groups such as Medicare Advantage or private insurance.

Conclusion

The BSW HWC model addresses SDOH through population health services integrated into a PCMH and reduces patient-level chronic disease risk factors and use of expensive hospital utilization. These findings provide much-needed support for the role of SDOH and prevention in population health models for low-income, uninsured populations. Future work should identify specific cost-effective services that provide the greatest impact on patient health and health care outcomes.

Conflict of Interest

Wesson: Paid consultant for Tricida, Inc (San Francisco) regarding metabolic acidosis (not related to this study)

Author Contributions

Research concept and design: Kitzman, Tecson, Mamun, Yeramaneni, Halloran, Wesson; Acquisition of data: Kitzman, Yeramaneni, Halloran, Wesson; Data analysis and interpretation: Kitzman, Tecson, Mamun, da Graca, Yeramaneni, Wesson; Manuscript draft: Kitzman, Mamun, da Graca, Yeramaneni, Halloran, Wesson; Statistical expertise: Tecson, Mamun; Acquisi-

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