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RESEARCH ARTICLE

High Blood Pressure Reduction, Health Insurance Status, and Social Deprivation Index in U.S. Community Health Centers

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Introduction: Lack of health insurance is a risk factor for uncontrolled hypertension, but it is unknown whether health insurance or neighborhood-level social deprivation is associated with greater reductions in blood pressure over time.

Methods: We estimated the association of health insurance and social deprivation index on blood pressure reduction over time using electronic health record data from 2012 to 2017. We included patients aged 19−64 years with an initial systolic blood pressure ≥150 mmHg or diastolic blood pressure ≥100 mmHg and ≥1 additional visit from 93 community health centers in states that expanded Medicaid in 2014.

Results: We included 66,207 patients: 20.1% uninsured, 64.8% publicly insured, and 15.1% privately insured. Adjusting for patient characteristics and baseline blood pressure, systolic blood pressure/diastolic blood pressure declined over the study period by 21.3/11.2 mmHg, 22.0/11.4 mmHg, and 21.1/10.7 mmHg among uninsured, publicly insured, and privately insured individuals, respectively. There were small but significantly greater reductions in systolic blood pressure among patients with public insurance than among those who were uninsured (difference= −1.3, 95% CI= −1.6, −1.0) but none associated with social deprivation index. There were no differences in diastolic blood pressure reductions over time by insurance status or social deprivation index. Blood pressure control (systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg) was significantly greater among publicly or commercially insured individuals than among uninsured individuals (51.7%, 51.5%, 44.6% respectively, both comparisons $p<0.001$), with no associations between blood pressure control and social deprivation index.

Conclusions: Reductions in blood pressure were large but mostly not associated with insurance type or social deprivation index. Additional research is needed to understand the factors that lead to blood pressure reduction in community health center settings.

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2773-0654/$36.00
https://doi.org/10.1016/j.focus.2022.100018

INTRODUCTION

Uncontrolled hypertension is the largest single contributor to all-cause and cardiovascular death. For each 10 mmHg reduction in a population's blood pressure (BP), there is 20%−30% reduction in major cardiovascular disease (CVD) events.[1,2] *Individuals with very high BP*, defined as those with systolic BP (SBP) ≥150 mmHg or diastolic BP (DBP) ≥100 mmHg, have greater CVD risk than those with lower BP.[3] Lack of health insurance is a risk factor for uncontrolled hypertension,[4] but it is unknown whether having (versus not having) health insurance leads to greater reductions in BP over time. A previous study showed that hypertension diagnosis rates were higher among patients receiving care in states that expanded Medicaid in 2014 after the Affordable Care Act than among those receiving care in states that did not.[5] Another study showed that within expansion states, those newly gaining health insurance had greater increases in BP control than those continuously insured, continuously uninsured, and discontinuously insured (particularly among individuals living in the most deprived neighborhoods).[6]

Numerous studies have shown that lower individual SES is associated with higher incidence and lack of BP control.[7] There is also increasing evidence that in addition to individual social determinants of health, the neighborhood environment plays a role in hypertension prevalence and treatment and BP reduction.[8] The 2020 Surgeon General's Call to Action to Control Hypertension stated that communities are the primary level at which social determinants of health operate.[1] Access to health insurance and ongoing clinical care may not be sufficient if neighborhoods lack access to healthy food, transportation, and safe places to be active. A recently published study found that individuals living in more deprived neighborhoods had a higher prevalence of hypertension even after controlling for age, race/ethnicity, education, and income.[9] No studies have looked at the relationship between insurance status, neighborhood deprivation, and BP changes and control over time. However, definitions of BP control have been changing. Between 2014 and 2017,[10] *hypertension control* was defined as a BP<150/90 mmHg for individuals aged ≥60 years. Therefore, in this study, we evaluated the association of health insurance and neighborhood-level social deprivation index (SDI)[11] on change in BP from 2012 to 2017 among low-income racially diverse patients seeking care at community health centers (CHCs) with very high BP. Among individuals with systolic BP>150 mmHg or diastolic BP>100 mmHg, there is no debate as to whether BP should be reduced further.

METHODS

Study Population

Electronic health record data were obtained from OCHIN (not an acronym), a multistate collaboration of CHCs.[12] Eligible clinics (n=93) were primary care clinics or local health departments that were live on OCHIN's electronic health record between January 1, 2012 and December 31, 2017 and were in Medicaid expansion states. States included in the analysis were Alaska, California, Hawaii, Indiana, Massachusetts, Maryland, Minnesota, Montana, New Mexico, Nevada, Ohio, Oregon, Rhode Island, and Washington.

Patients were aged 19−64 years throughout the study period, had ≥1 SBP≥150 and/or DBP≥100, and had ≥1 additional visit. For patients with ≥1 BP reading on the same day, BP readings on that day were averaged.[13] We excluded patients who were pregnant at any point during the study period, were diagnosed with end-stage renal disease, or had ≥1 Medicare-financed visit because patients aged <65 years with Medicare differ medically from those with other types of insurance.[14]

Measures

The main independent variables of interest were health insurance (uninsured, publicly insured, and privately insured) and neighborhood-level SDI quartiles.[15] Insurance was assigned using the insurance type recorded at most encounters after the patients' first very high BP. Publicly insured visits included Medicaid (99% of publicly insured visits) and Tricare and Indian Health Services (1% of publicly insured visits). Privately insured visits included both employer-provided insurance and insurance purchased through state and federal marketplaces. SDI was assigned using the patient's census tract on record at their first very high BP reading. The national percentile-ranked SDI is a validated, composite measure that includes the proportion of single-parent families, poverty, population with less than a high-school diploma, unemployment, renter-occupied units, crowded living, high-needs populations, and car ownership in a geographic area.[11,15] As an exploratory analysis, we examined *BP control*, defined as BP<140/90 at the last visit.

We adjusted for potential confounders, including age at visit, sex, diabetes diagnosis on or before the visit, baseline SBP or DBP, presence of BP medication before each visit, number of CHC visits during the study period, rurality assigned using U.S. Department of Agriculture Rural-Urban Commuting Area ZIP-code approximation codes, and state. In addition, we adjusted for race and ethnicity, as recorded in the patient's medical record, to control for systemic disparities in accessing health care among communities of color.[16]

Statistical Analysis

The patient population is stratified by insurance type. We estimated the association of health insurance and SDI on change in SBP and DBP using linear mixed models. Models adjusted for all covariates and corrected for clustering at the patient level through random intercept and slopes for patients. To test whether the association of insurance or SDI on the change in SBP or DBP varied over time, we modeled (1) an interaction effect between insurance and time and (2) an interaction between SDI and time on

SBP or DBP. Furthermore, these models were stratified by insurance type to test whether a change in SBP and DBP varied by insurance across SDI. Finally, we assessed the association of insurance and SDI with BP control at the last visit using a multivariable logistic regression model, adjusting for all covariates and estimating predicted probabilities. All statistical analyses were performed using Stata, Version 15.1. This study was approved by the Oregon Health & Science University IRB.

RESULTS

Between 2012 and 2017, there were 66,207 patients who met the study eligibility criteria. Of those, 20.1% were uninsured, 64.8% were publicly insured, and 15.1% were privately insured (Table 1). SDI scores varied by insurance status, with higher SDI scores among the uninsured than among the publicly or privately insured. Uninsured patients had higher baseline SBP and DBP than insured patients. Publicly and privately insured patients were more frequently White race. Uninsured patients were more frequently of Hispanic ethnicity. Uninsured patients also had lower numbers of clinic visits over the observation period.

Adjusting for patient characteristics and baseline BP, SBP/DBP declined by 21.3/11.2 mmHg, 22.0/11.4 mmHg, and 21.1/10.7 mmHg over the study period among uninsured, publicly insured, and privately insured individuals, respectively (Table 2). There were clinically small but statistically significantly greater reductions in SBP among patients with public insurance than among those uninsured (net difference= −1.3; 95% CI= −1.6, −1.0). There was no statistically significant difference in DBP reductions by insurance type. There

Table 1. Patient Demographics Among Those With at Least 1 Very High BP Reading (Systolic ≥150 mmHg or Diastolic ≥100 mmHg) by Insurance

Patient characteristics at baseline	Uninsured *n*=13,336 (20.1%)	Publicly insured *n*=42,870 (64.8%)	Privately insured *n*=10,001 (15.1%)
Systolic BP mmHg, mean (SD)	158.2 (14.5)	156.7 (13.1)	156.6 (12.9)
Diastolic BP mmHg, mean (SD)	95.6 (11.6)	94.9 (11.3)	94.5 (11.1)
Social Deprivation Index, mean (SD)[a]	67.3 (23.5)	67.6 (23.1)	61.8 (21.9)
Age, mean (SD)	46.0 (9.6)	46.5 (10.2)	47.1 (10.3)
Sex, *n* (%)			
Female	5,850 (43.9)	20,718 (48.3)	4,719 (47.2)
Male	7,486 (56.1)	22,152 (51.7)	5,282 (52.8)
Race, *n* (%)			
White	9,537 (71.5)	33,138 (77.3)	8,548 (85.5)
Black	2,247 (16.9)	5,845 (13.6)	620 (6.2)
AI/AIN, NH/PI, Asian, or other race	638 (4.8)	2,390 (5.6)	477 (4.8)
Unknown race	914 (6.9)	1,497 (3.5)	356 (3.6)
Ethnicity, *n* (%)			
Non-Hispanic	8,384 (62.9)	34,211 (79.8)	8,082 (80.8)
Hispanic	4,677 (35.1)	7,292 (17.0)	1,633 (16.3)
Unknown ethnicity	275 (2.1)	1,367 (3.2)	286 (2.9)
Urbanicity, *n* (%)			
Urban	10,504 (78.8)	31,022 (72.4)	4,971 (49.7)
Urban cluster	1,533 (11.5)	8,786 (20.5)	3,401 (34.0)
Rural	1,175 (8.8)	2,581 (6.0)	1,487 (14.9)
Missing	124 (0.9)	481 (1.1)	142 (1.4)
Hypertension diagnosis, *n* (%)	9,526 (71.4)	30,131 (70.3)	6,738 (67.4)
Hypertension prescription, *n* (%)	8,789 (65.9)	27,758 (64.8)	6,059 (60.6)
Diabetes diagnosis, *n* (%)	3,259 (24.4)	10,396 (24.3)	2,025 (20.3)
Patient characteristics from baseline to follow-up			
Number of visits with at least 1 BP, mean (SD)	7.2 (7.2)	11.8 (12.2)	8.9 (8.8)

Note: In cases where there was a 2-way tie (*n*=9,999), insurance was assigned over uninsurance. (There were no instances where both insurance types tied.) In the few instances where there was a tie between all 3 insurance types (*n*=5), insurance from the first visit was assigned.
[a]Social deprivation index was calculated on the basis of census tract and address at index BP >150 and/or 100 BP mmHg visit. Scores range from 0 to 100, with higher numbers indicating greater levels of social deprivation.
AI/AIN, American Indian or Alaskan Native; BP, blood pressure; NH/PI, Native Hawaiian or Pacific Islander.

Table 2. Average Total Change Over the Study Period in Systolic and Diastolic BP From First High BP Reading Among Patients With Baseline Very High BP (Systolic ≥150 mmHg or Diastolic ≥100 mmHg)

Measures	Avg. BP at first high BP, unadjusted (SD)	Avg. total change in BP[a]	95% CI
Systolic BP			
Insurance			
Uninsured	157.8 (14.4)	−21.3	−21.8, −20.9
Public insurance	156.3 (13.0)	−22.0	−22.8, −22.3
Private insurance	156.2 (12.7)	−21.1	−20.6, −21.5
SDI[b]			
SDI first quartile (0−52)	156.3 (14.1)	−21.8	−22.2, −21.4
SDI second quartile (53−70)	156.1 (12.3)	−21.7	−22.1, −21.4
SDI third quartile (71−85)	156.2 (13.6)	−21.5	−21.9, −21.1
SDI fourth quartile (86+)	157.4 (13.1)	−22.2	−22.6, −21.8
SDI missing	156.4 (13.3)	−21.4	−21.9, −20.9
Diastolic BP			
Insurance			
Uninsured	95.5 (11.4)	−11.2	−11.5, −10.9
Public insurance	94.6 (11.2)	−11.4	−11.5, −11.2
Private insurance	93.6 (11.2)	−10.7	−11.0, −10.4
SDI			
SDI first quartile (0−52)	95.1 (11.4)	−11.5	−11.7, −11.2
SDI second quartile (53−70)	94.4 (11.2)	−11.1	−11.3, −10.8
SDI third quartile (71−85)	94.8 (11.4)	−11.2	−11.4, −10.9
SDI fourth quartile (86+)	94.6 (11.3)	−10.9	−11.2, −10.7
SDI missing	94.1 (10.9)	−10.8	−11.1, −10.4

[a]Models corrected for clustering at the individual level and adjusted for facility state, age, race, ethnicity, sex, rurality, presence of a diabetes diagnosis, prescription for hypertension medication, number of visits with a BP measurement during the study period, time, and baseline systolic and diastolic BP.
[b]SDI was based on baseline address census tracts, with higher numbers indicating greater levels of social deprivation.
Avg., average; BP, blood pressure; SDI, social deprivation index.

was also no difference in SBP and DBP reductions by SDI score.

BP control (SBP<140 mmHg and SBP<90 mmHg) by study end was statistically significantly greater among publicly and privately insured patients than among uninsured patients (predicted probability: public insurance=51.7%; 95% CI=51.2, 52.1 and commercial insurance=51.5%; 95% CI=50.5, 52.4 vs uninsured=44.6%; 95% CI=43.8, 45.4), whereas there was a minimal association between SDI and control (Table 3).

DISCUSSION

The American Heart Association published a statement calling for broadening the causes of CVD from lifestyle, physiologic, and genetic factors to include social determinants of health.[17] The Surgeon General's Call to Action to Control Hypertension[1] emphasized the importance of social context in controlling hypertension, including SES (e.g., education, employment, income), neighborhood factors (such as poverty, segregation, and access to care), and policies (availability of health insurance).

Although we hypothesized that insurance status would have a significant impact on BP reduction over time among a group of CHC patients with an initial SBP≥150 mmHg or DBP≥100, we found that differences in SBP reduction by insurance type were very small and unlikely to be clinically significant and no differences for DBP. We also found that there was no difference in BP reductions by SDI. Although BP control was greater among public and private insured patients than among uninsured patients, this translated into only modestly greater reductions in SBP and no reductions in DBP over time. This may have been because BP control was based on the last visit only, and BP control as a dichotomous outcome may not reflect overall BP reduction among individuals with very high BP at baseline.

Muntner et al.[4] recently reported that *BP control* (defined as SBP<140 mmHg and DBP<90 mmHg) declined in the U.S. from 2013−2014 (53.8%) to 2017−2018 (43.7%). Insurance status was strongly associated with BP control (uninsured 22.4% vs Medicaid insured

Table 3. Predicted Probability of Blood Pressure Control at Last Visit by Insurance and Social Deprivation Among Patients With Baseline High Blood Pressure (Systolic >150 mmHg or Diastolic >100 mmHg)[a]

Measures	Predicted probability, %	95% CI	*p*-value
Insurance			
Uninsured	44.6	43.8, 45.4	ref
Public insurance	51.7	51.2, 52.1	<0.001
Private insurance	51.5	50.5, 52.4	<0.001
Social deprivation[b]			
Q1: <53	49.8	49.0, 50.6	ref
Q2: 53–70	50.4	49.6, 51.1	0.357
Q3: 71–85	50.2	49.4, 51.1	0.491
Q4: 86+	51.0	50.2, 51.9	0.043
Missing	49.3	48.3, 50.3	0.445

Q, quartile.
[a]Models were adjusted for facility state, age, race, ethnicity, sex, rurality, presence of a diabetes diagnosis, prescription for hypertension medication, number of visits with a blood pressure measurement during the study period, time from first to the last visit, and baseline systolic blood pressure.
[b]Social Deprivation Index was based on baseline address census tracts, with higher numbers indicating greater levels of social deprivation.

41.1%, Medicare insured 53.4%, and private 48.2%). Other factors associated with worse BP control included not having a usual source of care (26.5%) and not having had a health visit in the past year (8.0%). Egan and colleagues[18] reported that worsening BP control was attenuated by having health insurance, a usual source of care, and ≥1 healthcare visit annually. Our study suggests that among individuals with very high BP receiving ongoing care at CHCs, large reductions in BP occurred regardless of insurance type or SDI.

Many studies have shown that lower individual SES is associated with higher incidence and lack of BP control.[7,8] Less is known about neighborhood-level SES and hypertension and BP control. Xu et al.[9] and Claudel and colleagues[19] in 2 separate studies found that higher levels of neighborhood deprivation were associated with a higher incidence of hypertension. However, neither study reported BP control or reduction[9,19] by level of neighborhood deprivation. In a previous study, we found that gaining health insurance after the Affordable Care Act Medicaid expansion led to improved hypertension control, especially among those living in the most deprived neighborhoods.[6] We found no interaction between insurance and SDI and BP reduction or control in this study. CHCs were created to provide high-quality preventive and primary healthcare to underserved populations regardless of their ability to pay.[20] The most important finding from our study was that all patients with very high BP receiving care at CHCs had marked reductions in BP over time regardless of insurance type or SDI. SDI includes many contextual factors such as percent poverty, education, housing, and unemployment. Our study provides some evidence that care received at CHCs may overcome these barriers, with only a modest effect of lack of health insurance.

Limitations

This study had several limitations. We attempted to include random effects for clinics in our models, but the models would not converge. To help account for this in part, state-fixed effects were included. It was not possible to explore other social context factors such as segregation, structural racism, and other neighborhood characteristics such as access to healthy foods and safe places for physical activity. Access to these measures and person-level socioeconomic indicators may have led to different outcomes. In addition, race and ethnicity were controlled for in the analyses, but not explored further. Future research should examine the impact of race and ethnicity on BP reduction. In addition, BP reductions might be, in part, because of regression to the mean, with individuals with very high BP at a single visit being more likely to have lower BP in subsequent ambulatory visits (and those with lower BPs likely to have higher BP) regardless of changes in treatment.[21]

CONCLUSIONS

Overall, in CHCs among people with markedly elevated BP at a clinic visit, subsequent reductions in BP were large but were mostly not associated with insurance type and not associated with SDI. Access to care and having repeated visits may be more important than insurance type or SDI in lowering BP in CHCs and need further study.

ACKNOWLEDGMENTS

The authors would like to acknowledge Treasure Allen, MPH, Department of Family Medicine, Oregon Health and Science University and Laura Moreno, MPH, Department of Family Medicine, Oregon Health and Science University for their assistance in completing this manuscript.

The views presented in this article are solely the responsibility of the authors and do not necessarily represent the views of the funding agencies.

This work was supported by the National Heart, Lung, and Blood Institute grant number R01HL136575. This work was conducted with the Accelerating Data Value Across a National Community Health Center Network (ADVANCE) Clinical Research Network. OCHIN leads the ADVANCE network in partnership with Health Choice Network, Fenway Health, Oregon Health & Science University, and the Robert Graham Center HealthLandscape. ADVANCE is funded through the Patient-

Centered Outcomes Research Institute, contract number RI-CRN-2020-001.

This study was presented at the North American Primary Care Research Group Annual Meeting on November 19–23, 2021, "High systolic blood pressure reduction and health insurance status in community health centers."

Declarations of interest: none.

CREDIT AUTHOR STATEMENT

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