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Disparities in Biomarkers for Patients With Diabetes After the Affordable Care Act

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Abstract

Background—Racial and ethnic minorities are disproportionately affected by diabetes and at greater risk of experiencing poor diabetes-related outcomes compared with non-Hispanic whites. The Affordable Care Act (ACA) was implemented to increase health insurance coverage and reduce health disparities.

Objective—Assess changes in diabetes-associated biomarkers [hemoglobin Alc (HbAlc) and low-density lipoprotein] 24 months pre-ACA to 24 months post-ACA Medicaid expansion by race/ethnicity and insurance group.

Research Design—Retrospective cohort study of community health center (CHC) patients.

Subjects—Patients aged 19–64 with diabetes living in 1 of 10 Medicaid expansion states with ≥ 1 CHC visit and ≥ 1 HbAlc measurement in both the pre-ACA and the post-ACA time periods (N = 13,342).

Methods—Linear mixed effects and Cox regression modeled outcome measures.

Results—Overall, 33.5% of patients were non-Hispanic white, 51.2% Hispanic, and 15.3% non-Hispanic black. Newly insured Hispanics and non-Hispanic whites post-ACA exhibited modest reductions in HbAlc levels, similar benefit was not observed among non-Hispanic black patients. The largest reduction was among newly insured Hispanics versus newly insured non-Hispanic whites ($P < 0.05$). For the subset of patients who had uncontrolled HbAlc (HbAlc ≥ 9%) within 3 months of the ACA Medicaid expansion, non-Hispanic black patients who were newly insured gained the highest rate of controlled HbAlc (hazard ratio = 2.21: 95% confidence interval, 1.10—4.66) relative to the continuously insured group.

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Conclusions—The impact of the ACA Medicaid expansion on health disparities is multifaceted and may differ across racial/ethnic groups. This study highlights the importance of CHCs for the health of minority populations.

Keywords

Affordable Care Act; diabetes; health policy; Medicaid; health outcomes; health insurance; natural experiment

Diabetes is a leading cause of morbidity and mortality[1,2]; thus, it is important for all patients with diabetes to receive secondary preventive services shown to improve diabetes control and limit complications.[3,4] For example, patients with diabetes should receive regular glycosylated hemoglobin Ale (HbA1c) screening to monitor and maintain glycemic control as well as low-density lipoprotein (LDL) to prevent cardiovascular disease.[5] Racial/ethnic minorities are disproportionately affected by diabetes and are at significantly greater risk of experiencing poor diabetes-related outcomes.[6–10] The percentage of US adults with diagnosed diabetes among Hispanics (12.1%) and non-Hispanic blacks (12.7%) is nearly twice that of non-Hispanic whites (7.4%).[11] Receipt of secondary diabetes preventive care also varies by race/ethnicity; for example, Hispanics are less likely to receive HbA1c screening tests, foot exams or eye exams, relative to whites and blacks.[6] In addition, certain racial/ethnic minorities are significantly more likely to have poorly controlled diabetes.[12]

Disparities in diabetes detection, treatment, and control have also been linked to socioeconomic factors, care quality. and health insurance coverage.[13] In addition, uninsured patients are more likely to have undiagnosed diabetes and less likely to receive recommended diabetes care.[14–25] With historically lower health insurance rates than non-Hispanic whites, racial/ethnic minorities are more likely to have experienced the negative consequences of being uninsured.[4] Gaining health insurance improves access to care and increases disease diagnosis and management. For example, studies found that patients who gained Oregon Medicaid coverage had increased rates of diabetes diagnosis and use of appropriate medication prescription levels[26] and were more likely to achieve HbA1c control than those who were uninsured.[27]

Owing to the relationship between health insurance, and diabetes detection and care, the Affordable Care Act (ACA), which sought to increase health insurance coverage and reduce health disparities,[28] provided an opportunity to use a natural experiment to understand the impact of health insurance on diabetes-related health outcomes. Several studies showed a positive impact of the ACA in reducing racial/ ethnic disparities.[29–31] In addition, 1 study post-ACA Medicaid expansion found a 23% increase in Medicaid-enrolled patients with newly diagnosed diabetes and that mean patient HbAlc levels were lower in Medicaid expansion states compared with nonexpansion states.[32] We know of no studies, however, that have directly assessed the impact of ACA Medicaid expansion on reducing racial/ethnic disparities in diabetes biomarker outcomes.[33]

In this study, we evaluated within-group and betweengroup changes in diabetes-related biomarkers (HbA1c and LDL) across 4 insurance groups (continuously uninsured, and discontinuously, newly and continuously insured, described below), stratified by race/

ethnicity. The 4 insurance groups allowed us to leverage the ACA Medicaid expansion natural experiment, as the newly insured patients likely gained coverage due to this policy change. Thus, we hypothesized that the improvements in diabetes biomarkers among patients who gained insurance post-ACA (the newly insured group) relative to those who remained uninsured or were continuously insured would be greater among Hispanic and non-Hispanic black patients than their non-Hispanic white counterparts. In other words, we expected that health insurance gains due to the ACA would narrow disparities in diabetes biomarker outcomes.

MATERIALS AND METHODS

Data Source

We used the multistate Accelerating Data Value Across a National Community Health Center (ADVANCE) clinical data research network (CDRN), a member of PCORnet that includes electronic health record (EHR) data from 1200 community health centers (CHCs) across 26 states.[34] CHCs are an ideal setting to study the impact of Medicaid expansion on diabetes biomarkers and disparities as they provide care to millions of low-income, uninsured patients,[35] a population likely to be eligible for Medicaid coverage via the ACA. In addition, CHCs care for a high volume of patients with diabetes (21% in CHCs vs. 11% nationally in a 2018 report) and 62% of their patients are racial/ethnic minorities.[36] Lastly, CHCs consistently assist their patients with insurance enrollment and retention, thus they have robust insurance data to allow for understanding the impact of Medicaid expansion.[37,38]

The current analysis considered 10 states that expanded Medicaid on January 1, 2014: California, Hawaii, Maryland, Minnesota, New Mexico, Ohio, Oregon, Rhode Island, Washington, and Wisconsin. Although Wisconsin did not expand Medicaid up to 138% of the federal poverty level when the ACA took effect, it did open enrollment to adults up to 100% federal poverty level simultaneously and, therefore, was treated as an expansion state in this study. We focus our approach on expansion states, as the large number of CHC patients who were eligible for Medicaid would only have the option to apply in states that expanded Medicaid.

The study captured a pre-ACA and post-AC A period, covering, respectively, the 24 months before Medicaid expansion (January 1, 2012 to December 31, 2013) and the 24 months following expansion (January 1, 2014 to December 31, 2015). Clinics must have had an EHR in place by the start of the study period (January 1, 2012) to ensure that baseline biomarker measurements were available. Health systems in the ADVANCE CDRN collect comprehensive patient demographics and follow patients longitudinally from each encounter to patient-level laboratory results, diagnoses, prescriptions, and other outcomes.[39] These EHR data also allow for measurement of health outcomes during periods of uninsurance.

Patient Population

We selected patients between the ages of 19 and 64 with an existing diabetes diagnoses before Medicaid expansion (January 1, 2014). An existing diagnosis of diabetes was based

on a modified SUPREME-DM (surveillance, prevention, and management of diabetes mellitus) definition.[40] A patient must have experienced 2 related diagnostic events within 730 days, such as: (1) 2 or more visits with an outpatient diagnosis of diabetes according to associated International Classification of Diseases—9th Revision (ICD-9) codes; (2) at least 1 visit with the presence of an ICD-9 code and 1 with a positive HbA1c or glucose test for diabetes, based on American Diabetes Association thresholds; (3) a ICD-9 coded visit and prescription of a diabetes-related medication; and (4) a positive HbA1c or glucose test and a diabetes-related medication order. Our methodology did not allow for us to differentiate between type I and type II diabetes diagnoses. To capture longitudinal trends, patients must have had ≥ 1 ambulatory visit and ≥ 1 valid biomarker measurement in the preperiod and ≥ 1 ambulatory visit and ≥ 1 valid biomarker measurement in the postperiod.

Patients who were pregnant at any time during the study period were excluded as guidelines for maternal care and gestational diabetes differ from standard care of the larger adult population. Finally, any patient who used Medicare at any visit was excluded as Medicare eligibility was unrelated to the ACA Medicaid expansion under study.

Outcomes

The diabetes-related biomarkers were continuous measures of HbA1c and LDL cholesterol at preperiod and postperiod visits. Nonmissing values of HbA1c ≥ 0%and l0 mg/dL ≥LDL ≥300 mg/dL represented valid biomarker measurement.[41,42] Biomarker values were obtained from ADVANCE which uses PCORnet's Common Data Model.[43] These data are routinely assessed for completeness and quality following PCORnet's standard analytic queries and data quality check process.[43] As such, they have low missingness on relevant variables and a high proportion of labs mapped to Logical Observation Identifiers Names and Codes.[34]

As elevated levels of HbA1c should be addressed quickly, we also conducted a secondary analysis that identified a subset of patients with an uncontrolled HbA1c result (≥ 9% regardless of treatment or comorbidities)[27,44] within 3 months before the ACA Medicaid expansion date (January 1, 2014) and considered a time-to-event outcome where we estimated the time from ACA expansion (January 1, 2014) until the time when the patient was able to achieve a controlled measurement (<9%).

Independent Variables

The primary independent variables of interest were race/ethnicity and insurance group. Three mutually exclusive race/ethnicity groups were considered: Hispanic, non-Hispanic white, and non-Hispanic black. Participants were classified as Hispanic through self-identification of ethnicity in the EHR or if their reported primary language was Spanish; otherwise, the classification relied on self-identification of race. Races other than white or black were excluded as they represent <5% of the patient population.

Patients were categorized into 1 of 4 insurance groups: (1) *continuously uninsured* patients were uninsured at all of their visits during the pre-ACA and post-ACA periods; (2) *continuously insured* patients had insurance (except Medicare) at all visits in the study period; (3) *newly insured* patients were always uninsured at visits pre-ACA and always

insured at visits post-ACA; and (4) *discontinuously insured* patients who presented as both insured and uninsured sporadically.

Covariates

To describe the study population and account for their differential impact on cardiometabolic biomarkers, we considered the following EHR-derived pre-ACA expansion (ie, baseline) patient-level covariates in our analyses: sex, age at the start of the study (January 1, 2012), rural versus urban status, total number of patient visits during the preperiod, number of comorbidities, smoking status (current smoker vs. former/never/missing smoker status) before Medicaid expansion, and state.

Statistical Analyses

Patient characteristics before implementation of the ACA Medicaid expansion were summarized among each race/ethnicity group for the 4 insurance groups. For each continuous biomarker outcome (HbA1c and LDL), utilizing linear mixed effects modeling, we performed a difference-indifference (DD) analyses estimating change in biomarker levels pre-ACA (January 1, 2012 to December 31, 2013) to post-ACA (January 1, 2014 to December 31, 2015) by insurance group *within race/ethnicity groups*. The DD analysis can estimate the differences in mean biomarker outcomes between insurance groups for each race/ethnicity group. In addition, utilizing the same model, we tested if the differences in biomarker levels between insurance groups from pre-ACA to post-ACA were similar *between race/ethnicity groups* through difference-in-difference-in-differences (DDD) analyses. The linear mixed effects modeling included the following fixed effects terms: indicators for race/ethnicity groups, indicators for insurance groups, indicator for ACA period (post vs. pre) and the 3-way and 2-way indicators for race/ethnicity, insurance and ACA period groups. We also included fixed effects for covariates listed above. Random effects for patients accounted for temporal observations of biomarker measurements within patients and random effects for CHCs accounted for clustering of patients within clinics. Clustering at the state level was accounted for by including state fixed effects in the regression models. DD and DDD estimates were obtained through linear combinations of the regression parameters from the linear mixed effects models.

As a secondary analysis, among a subset of patients with uncontrolled HbA1c within 3 months before the ACA Medicaid expansion, management of uncontrolled HbAlc levels by insurance group and race/ethnicity were examined. Within each race/ethnicity group, we performed state-stratified Cox proportional hazards modeling with main effects for insurance groups, accounting for the aforementioned covariates. Among race/ethnicity groups, covariate-adjusted hazard ratios (HRs) were calculated for insurance groups (comparing to the reference group of continuously uninsured). A robust sandwich estimator was used to construct 95% confidence intervals for the HRs, accounting for the clustering of patients within CHCs. The assumption of proportional hazards was assessed using Schoenfeld residuals and was deemed suitable.

All statistical tests were performed with a 2-sided type I error of 5%. Analyses were conducted in R version 3.4.0. The Oregon Health & Science University Institutional Review Board approved this study (IRB#00011858).

RESULTS

Patient Characteristics

Patient characteristics stratified by race/ethnicity differed by insurance status (Table 1). A total of N = 13,342 patients with diabetes had ≥ 1 HbA1c measurements at both the pre-ACA and the post-ACA time periods. The sample was predominately urban with mean patient age between 40 and 50 years old; about half were Hispanic (51.2%), 15.3% were non-Hispanic black, and 33.5% were non-Hispanic white. Having at least 2 comorbidities was common in this patient population, and smoking prevalence was high for black (37.3%) and white patients (34.7%), whereas low for Hispanic patients (8.5%). Hispanic patients were more likely to be continuously uninsured (30.1%) than other race/ethnicity groups, whereas non-Hispanic white patients were most frequently continuously insured (44.3%) and non-Hispanic black patients were often discontinuously insured (50.6%). Among the sample of N = 9808 patients with ≥ 1 LDL measurements at both the pre-ACA and the post-ACA time periods (Appendix Table 1, Supplemental Digital Content 1, http://links.lww.com/MLR/B930), the distribution of the insurance groups by race/ethnicity was similar. In addition, qualitatively similar distributions of patient characteristics were observed among the subset of N = 1790 patients with uncontrolled HbA1c within 3 months before the ACA Medicaid expansion (Appendix Table 2, Supplemental Digital Content 1, http://links.lww.com/MLR/B930).

Overall Pre-ACA to Post-ACA Change in HbA1c and LDL by Race/Ethnicity

Overall (Table 2), HbA1c values were close to 8% before ACA expansion for all race/ethnic groups: non-Hispanic black (8.22%), Hispanic (8.08%), and non-Hispanic white (7.94%). Post-ACA, all groups showed an increase in HbA1c. Average pre-ACA LDL for race/ethnicity groups were ≤ 110 mg/dL: non-Hispanic black (108.99 mg/dL), Hispanic (107.35 mg/dL), and non-Hispanic white (109.89 mg/dL). Post-ACA, all groups showed a decrease in LDL.

Pre-ACA to Post-ACA Change in HbA1c and LDL by Insurance Group Stratified by Race/Ethnicity

Changes from pre-ACA to post-ACA were relatively similar across race/ethnicity groups; however, there were some differences in the direction and slope of the trend by insurance subgroup (Fig. 1A). For example, newly insured Hispanics observed the largest decline in mean HbAlc (absolute change from pre-ACA to post-ACA = −0.12%). Conversely, HbAlc levels rose slightly among the discontinuously and continuously insured subgroups in all 3 racial/ethnic groups. LDL levels improved from pre-ACA to post-ACA in all groups (Fig. 1B), except for the continuously uninsured non-Hispanic white patients.

DD and DDD Estimates of Pre-ACA to Post-ACA HbA1c and LDL

Within race/ethnic groups, significant DD estimates of pre-ACA to post-ACA between insurance groups were found only among the Hispanic patients (Table 3). Newly insured Hispanics had greater improvement in HbA1c levels from pre-ACA to post-ACA than continuously uninsured Hispanics (DD = −0.32%). Continuously insured Hispanic patients had a slight improvement when compared with continuously uninsured Hispanic patients (DD = −0.08%). In the DDD assessments, the improvement in mean HbA1c between newly insured and continuously uninsured was significantly greater for Hispanics than non-Hispanic whites (Hispanics DD = −0.32%, non-Hispanic whites DD = −0.08%; DDD = [−0.32%+0.08%] = −0.24%, $P = 0.0199$). The DDD estimates comparing non-Hispanic black and non-Hispanic whites were not significantly different.

Some DD estimates of pre-ACA to post-ACA LDL change by insurance status within race/ethnicity groups were also significant (Table 3). Newly insured Hispanics and non-Hispanic whites reduced their LDL more than the continuously uninsured (DD = −2.52; −10.83 mg/dL, respectively). The results also showed that non-Hispanic whites in all insurance groups had better improvement in LDL from pre-ACA to post-ACA compared with Hispanic and non-Hispanic black patients (DDD P values <0.05 for all insurance groups).

Time From an Uncontrolled HbA1c Measurement to Control

Table 4 displays the results of the adjusted Cox proportional hazards model for time to control of HbA1c among a subset of N = 1790 patients with elevated HbAlc (≥ 9%) at the time of the Medicaid expansion. The results show that non-Hispanic black patients who were newly insured gained the highest rate of controlled HbA1c (HR = 2.27; 95% confidence interval, 1.10–4.66) relative to the continuously insured group. For non-Hispanic white and Hispanic patients, the newly insured showed a similar, although not significant, likelihood of having controlled HbA1c.

DISCUSSION

This study investigated whether gaining insurance following the ACA Medicaid expansion contributed to improvement in diabetes-related biomarkers (HbA1c and LDL) and whether or not gains in coverage led to a narrowing of disparities for racial/ethnic minorities served by CHCs. Overall, HbA1c and LDL levels among racial/ethnic minorities were similar in both the pre-ACA and post-ACA time periods. Further, we did not see a significant difference in the magnitude of change when comparing the racial/ethnic subgroups with regards to HbA1c and LDL levels pre-ACA versus post-ACA. We did, however, find that the largest reduction in HbA1c was among newly insured Hispanics versus newly insured non-Hispanic whites and for patients who had uncontrolled HbA1c, newly insured non-Hispanic black patients experienced the highest rate of controlled HbAlc relative to the continuously insured group. Thus, the impact of the ACA Medicaid expansion on changes in health disparities for this population of patients with diabetes was multifaceted.

Newly insured non-Hispanic whites and Hispanics experienced a decrease in HbAlc measurements post-AC A, whereas non-Hispanic blacks did not. In fact, newly insured

Hispanic patients showed the greatest improvement in HbAlc. Given the evidence showing that small improvements in HbA1c can contribute to large reductions in risk for diabetes-related complications, these changes could have a large impact on reducing long-term health disparities.[45] Of concern, however, was the finding that Hispanics were the most likely minority subgroup to remain uninsured or discontinuously insured post-ACA Medicaid expansion. As Hispanic patients have a higher lifetime risk for diabetes and higher risk for costly complications than non-Hispanic whites, continuous health insurance that enables access to preventive health care services and treatment are essential.[46] Thus, finding solutions to improve coverage for Hispanics is critical to improve the health of Hispanics with diabetes and reduce disparities. In other words, Hispanics in our study who gained coverage experienced the largest reduction in HbA1c; yet, they gained it at a lower rate than non-Hispanics suggesting that more work to provide coverage for Hispanics is needed.

The differences we observed in average HbA1c both pre-ACA and post-ACA across racial/ethnic groups were smaller in this study compared with previously reported disparities. For instance, in their review, Kirk et al,[46] highlighted that most studies comparing HbA1c between non-Hispanic whites and Hispanics found a difference of 0.5%. In this study, the HbA1c difference between non-Hispanic whites and Hispanics was about 0.1%. The values of HbA1c for our patient population were similar within insurance groups despite race/ethnicity, which is not necessarily surprising given the excellent care provided by CHCs. The similarity of HbA1c values reinforces the critical role CHCs play in caring for medically underserved low-income and minority patients before and after the ACA Medicaid expansion. Previous studies found increased insured visits to CHCs after the ACA Medicaid expansion, especially in states that chose to expand.[47] The additional overall revenue may have allowed CHCs to provide more equitable care for all, regardless of insurance group. However, it is notable that those with continuous health insurance had lower HbA1c measurements in all racial/ethnic groups in both the pre-ACA and post-ACA time periods suggesting that consistent coverage is important for HbA1c control. It is also interesting that newly insured non-Hispanic blacks with uncontrolled HbA1c achieved HbA1c control more quickly than continuously uninsured non-Hispanic blacks which highlights the importance of gaining health insurance after the ACA Medicaid expansion for this group.

With regard to LDL measurements, all groups experienced a decrease except for continuously uninsured non-Hispanic whites. Notably, non-Hispanic blacks started and ended with higher measurements than Hispanics or non-Hispanic whites. In addition, newly insured Hispanics experienced a significantly smaller decrease in LDL post-ACA compared with non-Hispanic whites suggesting that Hispanics may not have benefited as much from the ACA Medicaid expansion as non-Hispanic whites. Indeed, previous studies have shown despite much improvement in health insurance coverage, disparities remain.[47] It is possible that the 2013 guideline changes for treating LDL[48] brought this issue to the forefront of CHC providers' care leading to a substantial decrease for all groups.

The improvement in many of the subgroups, most notably the newly insured, in both HbA1c and LDL is encouraging. As there is evidence that joint occurrence between multiple cardiometabolic risk factors is associated with higher HbA1c, improvement in or control of

cholesterol, as well as blood pressure, smoking cessation, and body mass index are important as well.[49] We found CHCs helped patients with diabetes improve their health and kept health disparities to a minimum. Therefore, the care CHCs provide to patients with chronic disease, regardless of insurance status, is outstanding. We also found that having health insurance was helpful for the health of patients. Additional efforts (eg, patient education) are also likely to improve the overall cardiometabolic health of vulnerable patients seen in CHCs. Thus, we recommend funds continue to be allocated to CHCs for providing high-quality primary care for low-income and minority patients and the continuation of health insurance access for all.

This study had limitations. Although we controlled for important confounders, including comorbidities, unmeasured confounding may still exist. For example, patients with Medicaid coverage before the ACA are likely different from those who are uninsured or newly insured in ways we could not capture through available EHR data. Also, because gaining insurance was not assigned randomly, DD and DDD methods can potentially suffer from unobserved confounding of contemporaneous factors that differentially impact insurance groups. As this study was limited to patients who received care at CHCs, our conclusions may not generalize to individuals outside of CHC settings. In addition, it is possible that patients in this study received care outside of the ADVANCE network; however, prior studies suggest that patients who visit CHCs continue to do so even after gaining insurance.[50]

CONCLUSIONS

This study assessed changes in diabetes biomarkers pre-ACA versus post-ACA in CHCs by race/ethnicity and insurance status. There was no evidence of significant disparities in diabetes-related biomarkers pre-ACA or post-ACA in CHCs. Newly insured Hispanic patients had the greatest improvement in HbAlc and newly insured non-Hispanic blacks with high HbAlc before the ACA gained control faster than non-Hispanic whites post-ACA. Therefore, the impact of the ACA Medicaid expansion on health disparities is multifaceted and may differ across racial/ethnic groups; the study highlights the importance of CHCs for the health of minority populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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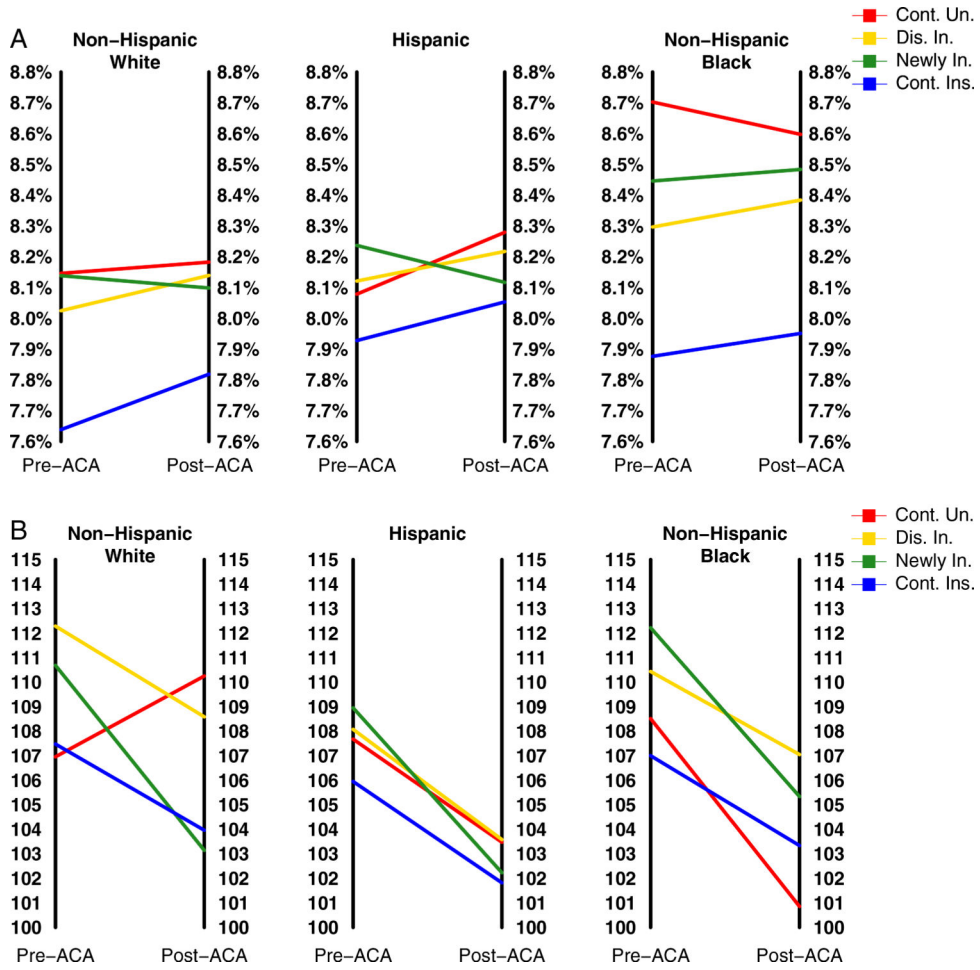

FIGURE 1.

A, Adjusted mean hemoglobin A1c measurements from diabetic adult patients before and after 2014 Affordable Care Act (ACA) Medicaid expansion by race/ethnicity and insurance coverage group. B, Adjusted mean low-density lipoprotein measurements from diabetic adult patients before and after the ACA Medicaid expansion by race/ethnicity and insurance coverage group.

TABLE 1.

Baseline Characteristics of N = 13,342 Study Patients With Diabetes Who Had At Least 1 HbA1c Measurement in Boththe Pre-ACA and the Post-ACATime Periods by Insurance Status, Stratified by Race/Ethnicity

		Insurance Status			
Characteristic	**Overall**	**Continuously Uninsured**	**Discontinuously Insured**	**Newly Insured**	**Continuously Insured**
Hispanic, N (row %)	6831 (100)	2053 (30.1)	2280 (33.4)	905 (13.2)	1593 (23.3)
Male (%)	41.0	43.7	38.6	44.9	38.9
Age (y) (mean) *	46.5	44.1	47.2	48.1	47.5
No. comorbidities (%) †					
1	11.1	12.2	10.3	12.9	9.7
2–4	54.6	61.1	52.6	54.9	49.1
5–6	17.9	15.3	19.7	15.4	20.2
7 or more	9.6	5.7	9.8	7.6	15.3
Unknown	6.8	5.7	7.6	9.2	5.8
No. visits (mean) ‡	8.4	7.6	9.3	6.3	9.6
Current smoker (%) §	8.5	5.9	8.7	8.0	11.7
Urban (%) ‖	94.3	94.4	93.5	93.4	95.7
Non-Hispanic black, N (row %)	2047 (100)	159 (7.8)	1036 (50.6)	216 (10.5)	636 (31.1)
Male (%)	50.3	57.2	51.1	58.3	44.5
Age (y) (mean) *	47.1	44.8	47.3	46.3	47.5
No. comorbidities (%) †					
1	10.4	16.4	9.9	13.9	8.5
2–4	41.3	54.1	43.6	44.0	33.5
5–6	19.6	13.8	19.9	21.3	20.1
7 or more	24.0	10.7	22.1	15.7	33.3
Unknown	4.6	5.0	4.4	5.1	4.6
No. visits (mean) ‡	9.3	6.1	10.2	6.3	9.7
Current smoker (%) §	37.3	28.3	37.6	45.8	36.2
Urban (%) ‖	99.2	100.0	99.1	99.5	98.9

Characteristic	Overall	Insurance Status			
		Continuously Uninsured	Discontinuously Insured	Newly Insured	Continuously Insured
Non-Hispanic white, N (row %)	4464 (100)	190 (4.3)	1520 (34.0)	775 (17.4)	1979 (44.3)
Male (%)	45.9	54.7	44.7	49.0	44.7
Age (y) (mean) *	47.2	47.2	47.5	47.4	46.8
No. comorbidities (%) †					
1	4.7	8.4	5.3	5.0	3.8
2–4	32.9	50.0	32.0	42.5	28.2
5–6	24.8	17.4	25.1	28.6	23.7
7 or more	35.1	19.5	34.3	22.3	42.2
Unknown	2.5	4.7	3.3	1.5	2.0
No. visits (mean) ‡	10.6	6.7	12.2	8.1	10.7
Current smoker (%) §	34.7	25.3	33.0	34.5	36.8
Urban (%) ‖	92.2	91.6	91.9	90.3	93.2

Column percentages are reported unless otherwise noted.

Sex, age, number of comorbidities, number of pre-ACA visits, smoking status, and urbanity, respectively, significantly differed between race/ethnicity-insurance status groups with *P*-values <0.001 from either ANOVA for continuous variables—age and number of visits—χ^2 tests for all other categorical variables. The initial study sample included N = 34,723patients from expansion states who had diabetes before Medicaid expansion and who had at least 1 HbAlc biomarker measurement during the study period. Inclusion criteria requiredat least 1 valid HbAlc measurement and visit pre-ACA and post-ACA, restricting the sample to N = 14,336. Finally, after excluding patients who were not non-Hispanic white, non-Hispanic black or Hispanic, our final study sample for HbA1c analyses was N = 13,342.

*Baseline patient age at the start of the study (January 1, 2012). Patients must have been between the ages of 19 and 64 during the entire study period to be included in the sample.

†There were 54 chronic disease and comorbidities (including diabetes), before the study period and to the end of the preperiod. The total number of comorbidities per patientranged from 0 to 22.

‡Total number of visits per patient in the preperiod.

§Binary category creation of current smoker versus former/never/missing smoker status before the ACA.

‖Urban setting was created by collapsing Rural Urban Commuting Area (RUCA) codes “Urban Area” and “Urban Cluster.” Rural consists of “Rural” and “Small Town.” MissingRUCA code was indicated as “Unknown.”

ACA indicates Affordable Care Act; ANOVA, analysis of variance; HbA1c, hemoglobin A1c.

TABLE 2.

Adjusted Mean Measurements and Changes inDiabetes-related Biomarkers Before and After ACA MedicaidExpansión by Race/Ethnicity

Biomarker	Race/Ethnicity	Pre-ACA, Adjusted Mean	Post-ACA, Adjusted Mean	Change from Pre to Post
Glycosylated hemoglobin (HbA1c) (%) *	Hispanic	8.077	8.185	**+0.108**
	Non-Hispanic black	8.222	8.290	**+0.068**
	Non-Hispanic white	7.944	8.063	**+0.119**
LDL cholesterol (mg/dL) †	Hispanic	107.35	102.79	**−4.56**
	Non-Hispanic black	108.99	105.04	**−3.95**
	Non-Hispanic white	109.89	105.92	**−3.97**

Bold values denotes statistically significant difference ($P < 0.05$) in within-race/ethnicity group change from pre-ACA to post-ACA.

Models were adjusted for patient sex, age, number of comorbidities, total number ofvisits pre-ACA (January 1, 2012 to December 31, 2013), smoking status, and urbanity.

*Among patients with at least 1 HbA1c measurement in both the pre-ACA and thepost-ACA Medicaid expansion time periods (N = 13,342).

†Among patients with at least 1 LDL measurement in both the pre-ACA and thepost-ACA Medicaid expansion time periods (N = 9808).

ACA indicates Affordable Care Act; HbA1c, hemoglobin A1c; LDL, low-density lipoprotein.

TABLE 3.

Adjusted Insurance Coverage Group DD Estimates in Diabetes-related Biomarkers Before and After ACA Medicaid Expansion by Race/Ethnicity

		Insurance Group			
Biomarker	**Race/Ethnicity Group**	**Continuously Uninsured (Ref. for DD)**	**Discontinuously Insured**	**Newly Insured**	**Continuously Insured**
Glycosylated hemoglobin (HbA1c) (%)†	Hispanic	Ref.	**−0.105**	**−0.321***	**−0.075***
	Non-Hispanic black	Ref.	+0.192	+0.143	+0.179
	Non-Hispanic white (Ref. for DDD)	Ref.	+0.078	−0.080	+0.144
LDLcholesterol (mg/dL)‡	Hispanic	Ref.	−0.29*	**−2.52***	+0.07*
	Non-Hispanic black	Ref.	+4.27*	+0.78*	+3.99*
	Non-Hispanic white (Ref. for DDD)	Ref.	**−6.99**	**−10.83**	**−6.81**

Numeric estimates denote DD comparing pre-post change between insurance group (ie, discontinuously insured, newly insured, continuously insured) versus continuouslyuninsured (reference) within each race/ethnicity group. Bold denotes statistically significant difference ($P < 0.05$) for DD comparisons with race/ethnicity groups.

Models were adjusted for patient sex, age, number of comorbidities, total number of visits pre-ACA (January 1, 2012 to December 31, 2013), smoking status, and urbanity.

*Statistically significant differences ($P < 0.05$) comparing DDD between race/ethnicity groups. In the DDD comparisons, non-Hispanic whites serve as the reference group. Forexample, comparing DD of newly insured for Hispanics (DD = −0.321) to the DD of newly insured for non-Hispanic whites (DD = −0.080) we observe a significantly different DDbetween these 2 race/ethnicity groups.

†Among patients with at least 1 HbA1c measurement in both the pre-ACA and the post-ACA Medicaid expansion time periods (N = 13,342).

‡Among patients with at least 1 LDL measurement in both the pre-ACA and the post-ACA Medicaid expansion time periods (N = 9808).

ACA indicates Affordable Care Act; DD, difference-in-difference; DDD, difference-in-difference-in-differences; HbA1c, hemoglobin A1c; LDL, low-density lipoprotein; Ref.,reference.

TABLE 4.

Hazard Ratios and 95% Confidence Intervals of HbA1c Control After Elevated Level (≥ 9%) by Race/ Ethnicityand Insurance Coverage Group

	Race/Ethnicity Group					
Insurance Group	**Hispanic**		**Non-Hispanic Black**		**Non-Hispanic White**	
Continuously uninsured	Ref.		Ref.		Ref.	
Discontinuously insured	0.97	0.79–1.20	1.73	0.95–3.16	0.91	0.52–1.61
Newly insured	1.27	0.95–1.70	**2.27**	**1.10–4.66**	1.12	0.63–2.00
Continuously insured	1.20	0.94–1.51	1.56	0.74–3.24	0.80	0.43–1.47

Among a subset of patients with uncontrolled HbAlc (≥ 9%) within 3 monthsbefore the ACA Medicaid expansion (N = 1790).

Bold values denote statistically significant difference ($P < 0.05$). Hazard ratios wereestimated using state-stratified Cox proportional hazards models adjusted forpatient sex, age, number of comorbidities, total number of visits pre-ACA (January 1,2012 to December 31, 2013), smoking status, and urbanity.

ACA indicates Affordable Care Act; HbA1c, hemoglobin A1c; Ref., reference.