The Affordable Care Act: Effects of Insurance on Diabetes Biomarkers

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OBJECTIVE

We sought to understand how Affordable Care Act (ACA) Medicaid expansion insurance coverage gains are associated with changes in diabetes-related biomarkers.

RESEARCH DESIGN AND METHODS

This was a retrospective observational cohort study using electronic health record data from 178 community health centers (CHCs) in the ADVANCE (Accelerating Data Value Across a National Community Health Center Network) network. We assessed changes in diabetes-related biomarkers among adult patients with diabetes in 10 Medicaid expansion states ($n = 25{,}279$), comparing newly insured with continuously insured, discontinuously insured, and continuously uninsured patients pre– to post–ACA expansion. Primary outcomes included changes from 24 months pre- to 24 months post-ACA in glycosylated hemoglobin (HbA_{1c}), systolic (SBP) and diastolic (DBP) blood pressure, and LDL cholesterol levels.

RESULTS

Newly insured patients exhibited a reduction in adjusted mean HbA_{1c} levels (8.24% [67 mmol/mol] to 8.17% [66 mmol/mol]), which was significantly different from continuously uninsured patients, whose HbA_{1c} levels increased (8.12% [65 mmol/mol] to 8.29% [67 mmol/mol]; difference-in-differences [DID] −0.24%; $P < 0.001$). Newly insured patients showed greater reductions than continuously uninsured patients in adjusted mean SBP (DID −1.8 mmHg; $P < 0.001$), DBP (DID −1.0 mmHg; $P < 0.001$), and LDL (DID −3.3 mg/dL; $P < 0.001$). Among patients with elevated HbA_{1c} in the 3 months prior to expansion, newly insured patients were more likely than continuously uninsured patients to have a controlled HbA_{1c} measurement by 24 months post-ACA (hazard ratio 1.25; 95% CI 1.02–1.54].

CONCLUSIONS

Post-ACA, newly insured patients had greater improvements in diabetes-related biomarkers than continuously uninsured, discontinuously insured, or continuously insured patients. Findings suggest that health insurance gain via ACA facilitates access to appropriate diabetes care, leading to improvements in diabetes-related biomarkers.

Diabetes is a leading cause of morbidity and mortality in the U.S. (1,2). Secondary preventive services for patients with diabetes, such as screening for and addressing glycosylated hemoglobin (HbA_{1c}) and lipid levels, limit complications and improve health outcomes (3–5). Uninsured patients have higher average HbA_{1c} levels than do those with health insurance (4) and yet are less likely to receive secondary prevention (6–8). Prior research showed that even when uninsured patients with diabetes visited community health centers (CHCs), "safety net" clinics that provide care regardless of patients' ability

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to pay, they received fewer preventive services and had poorer diabetes control than insured patients (9,10). Thus, increased health insurance access may improve diabetes-related treatment and care. Indeed, results from the Oregon Experiment (an earlier Medicaid expansion in one state) showed that Medicaid coverage gains were associated with higher rates of diagnosis and treatment of diabetes (11), as well as a greater proportion of diagnosed patients with controlled HbA_{1c} (12).

Due to the association of health insurance coverage with receipt of recommended screenings and HbA_{1c} control, it is important to evaluate how the Affordable Care Act (ACA) Medicaid expansion impacted diabetes-related biomarkers (an intermediate measure of long-term health outcomes) (13). Between 2014 and 2016, 30 states (and the District of Columbia) implemented the ACA Medicaid expansion (14), which extended eligibility to individuals in households earning ≤138% of the federal poverty level (FPL) and resulted in ~12 million people newly Medicaid insured by the end of 2016 (15). One study found that among Medicaid enrollees, there was a 23% increase in new diabetes diagnoses pre- to-post ACA and that, additionally, patients with diabetes in expansion states had lower mean HbA_{1c} levels than those in nonexpansion states (16). We know of no studies, however, that directly assessed the impact of the ACA Medicaid expansion on diabetes-related biomarkers (17).

To address this gap in the literature, we leveraged a large CHC electronic health record (EHR) data network, which provided data from 10 states that expanded Medicaid on 1 January 2014, to evaluate the impact of the ACA Medicaid expansion on objectively measured diabetes-related biomarkers. Specifically, we assessed the following biomarkers associated with complications for patients with diabetes: HbA_{1c}, LDL cholesterol, systolic (SBP) and diastolic (DBP) blood pressure, and BMI (18). CHCs are an ideal setting to study the effects of Medicaid expansions, as they provide primary care to millions of uninsured patients who have low incomes (69% have incomes at or below 100% FPL) (19) and thus were likely eligible for gaining Medicaid coverage with the ACA. The prevalence of diabetes in patients seen at CHCs is also considerably higher than the national average (21% vs. 11% in 2016) (19). Additionally, because CHCs routinely assist patients with Medicaid insurance enrollment and retention, they have robust data available relevant to understanding the impact of Medicaid expansions (20,21).

In this study, we evaluated within- and between-group changes in diabetes-related biomarkers in four insurance cohorts of patients with diabetes, comparing newly insured patients with the other three insurance groups pre– to post–ACA expansion. We evaluated whether biomarker improvement among the newly insured was significantly greater and whether the newly insured experienced biomarker control sooner than *1*) the continuously uninsured, *2*) the discontinuously insured, and *3*) the continuously insured. We were interested in comparing biomarker control in the newly insured with the other three insurance groups because previous research showed that Medicaid enrollees with coverage gaps and those who had stable enrollment pre-ACA exhibited distinct health care use patterns (22,23). As secondary analyses, we compared within- and between-group changes in diabetes-related prescription rates, comparing newly insured patients with the other three insurance groups pre– to post–ACA expansion.

RESEARCH DESIGN AND METHODS

Data Source

Patient-level EHR data were derived from the ADVANCE (Accelerating Data Value Across a National Community Health Center Network) clinical data research network (CDRN) of PCORnet, which contains data from CHCs in 10 states that expanded Medicaid. Further details of the ADVANCE CDRN have previously been described (24). The ADVANCE CDRN data set uniquely positions us to assess diabetes-related biomarkers immediately following the ACA Medicaid expansion. The ADVANCE EHR data set contains information on payer types at each visit (from billing information) and has been validated to show reliable insurance information for visit-level analyses and for characterizing longitudinal patterns (23). Diabetes-related biomarker values were obtained from clinical results in the VITAL and LAB_RESULT_CM tables of PCORnet's Common Data Model. ADVANCE clinical data are routinely assessed for completeness and quality following PCORnet's standard analytic queries and data quality check process and have low missingness on relevant variables and a high proportion of laboratories mapped to LOINC. Prescribing information was obtained from ADVANCE prescribing data that are linked to concept identifier codes that unambiguously identify brand name and generic drugs using RxNorm, an open-source program created by the National Library of Medicine (25).

The study period included 24 months prior to Medicaid expansion (1 January 2012–31 December 2013) and 24 months after Medicaid expansion (1 January 2014–31 December 2015). To reliably capture preperiod diabetes-related biomarker measurements, we included all ADVANCE CHCs that implemented EHR by 1 January 2012 (the start of the study period) in 10 states that expanded Medicaid as of 1 January 2014 (California, Hawaii, Maryland, Minnesota, New Mexico, Ohio, Oregon, Rhode Island, Washington, and Wisconsin), limiting our sample to 178 CHCs. Wisconsin was treated as an expansion state even though the state did not expand Medicaid up to 138% FPL; rather, Wisconsin expanded enrollment to adults up to 100% FPL on the same date as the ACA Medicaid expansion, thus behaving more like an expansion state than not (26). Included CHCs have demographics similar to those of health centers across the nation (19).

Patient Population

We identified all patients aged 19–64 years who were diagnosed with diabetes prior to the Medicaid expansion (1 January 2014) using the modified Surveillance, PREvention, and ManagEment of Diabetes Mellitus (SUPREME-DM) definition (27). By this definition, the presence of any combination of two "events" from outpatient diagnoses, diagnostic-level laboratory results, or dispensation of antihyperglycemic agents no more than 730 days apart is required for diabetes classification. For example: *1*) at least two visits with a diabetes-related ICD-9 code; *2*) one ICD-9–coded visit and one HbA_{1c} or glucose test positive for diabetes, according to American Diabetes Association thresholds; *3*) one ICD-9–coded visit and a diabetes-related medication order, or *4*) a diabetes-related medication order and a positive HbA_{1c} or glucose test. We also required patients to have at least one valid preperiod diabetes-related biomarker measurement and primary care visit (24 months prior to Medicaid expansion [1 January 2012–31

December 2013), as well as one valid postperiod biomarker and primary care visit (24 months after Medicaid expansion [1 January 2014–31 December 2015) to characterize longitudinal trends.

Patients were excluded if they were pregnant at any time during the study, as pregnant patients with gestational diabetes mellitus typically have different visit behavior and care than the rest of the adult population. Additional exclusions included patients with >138% FPL, as they were not eligible for Medicaid via expansion, and patients with no zip code, as we could not verify that they lived in an expansion state. Lastly, we excluded any patients with an ambulatory visit with Medicare as the payer, since eligibility was unrelated to ACA Medicaid expansion.

Dependent Variables

Our primary outcomes of interest were continuous variables of HbA_{1c}, LDL cholesterol, SBP and DBP, and BMI values over time. Based on prior research (28,29), we considered valid biomarker values to be nonmissing measurements that fall within the following ranges: $HbA_{1c} \geq 0\%$, 10 mg/dL $\leq$ LDL $\leq$ 300 mg/dL, 50 mmHg $\leq$ SBP $\leq$ 260 mmHg, 0 mmHg $\leq$ DBP $\leq$ 200 mmHg, and 8.8 kg/m^2 $\leq$ BMI $\leq$ 104.3 kg/m^2. We also considered a separate set of secondary analyses that evaluated time from an uncontrolled HbA_{1c} measurement 3 months prior to the ACA Medicaid expansion start date (1 January 2014) to a controlled measurement. Diabetes was considered uncontrolled if $HbA_{1c} \geq 9\%$ (75 mmol/mol) (12). Additionally, a separate secondary analysis was performed to evaluate changes in diabetes-related prescription rates between insurance groups. We considered two medication prescription outcomes in each period (pre-ACA, post-ACA): *1*) the total number of diabetes-related prescriptions (both insulin and noninsulin medications) and *2*) the total number of insulin prescriptions. We used standard methodology to identify medications listed on the Oregon Medicaid preferred drug list that are used to treat diabetes and categorized them as insulin or noninsulin medications. (See Supplementary Table 1.) The preferred list links the drugs covered by the Oregon Medicaid program to their associated RxNorm concept identifier codes (30). All orders issued during the study period for medications with the corresponding RxNorm concept identifier codes were pulled from the EHR.

Independent Variables

The primary independent variable was a set of indicators denoting which insurance cohort a patient belonged to. We considered four mutually exclusive cohorts: *1*) newly insured, patients with all uninsured visits in the pre-ACA period and all insured visits in the post-ACA period; *2*) continuously uninsured, patients who were uninsured at all visits in both the pre- and post-ACA periods; *3*) continuously insured, patients with insurance (except Medicare) recorded at all pre- and post-ACA visits; and *4*) discontinuously insured, patients with any combination of visit coverage that did not follow the definitions above (i.e., patients who went on and off insurance) (31).

Covariates

To describe insurance cohorts and control for potential differences between cohorts, we considered the following EHR-derived pre-ACA (baseline) covariates in our analyses: sex, age at the start of the study period, race/ethnicity, indicator for average pre-ACA FPL of $\leq$138%, number of comorbidities, number of visits pre-ACA, smoking status pre-ACA, urban/rural status, and state.

Statistical Analyses

We examined differences in pre-ACA (baseline) patient-level characteristics between the insurance cohorts using χ^2 and ANOVA tests. For each diabetes-related biomarker (HbA_{1c}, SBP/DBP, LDL, and BMI), we performed a difference-in-differences (DID) analysis modeling change in level from pre- to post-ACA. We produced unadjusted and covariate-adjusted means for pre- and post-ACA periods for each insurance group and estimated both within- and between-group diabetes-related biomarker changes with the newly insured as the referent group. We estimated adjusted diabetes-related biomarker means using a linear mixed-effects model that included the following fixed effects: a set of three indicators representing the four insurance cohorts, an indicator for period (pre-ACA serving as the reference group), the interaction terms between the insurance cohort indicators and the indicator for time period, and finally a set of variables for the covariates listed above. As patients could have multiple biomarker measures in both the pre- and post-ACA periods, we used random effects for patients to account for temporal observations of diabetes-related biomarker measurements within patients and we also used random effects for CHCs to account for patients nested with CHCs. To evaluate the robustness of our biomarker results to imbalance in patient characteristics between insurance groups, we performed a sensitivity analysis using inverse probability of treatment weighting (IPTW) to adjust for observable differences between the insurance groups in lieu of covariate adjustment. A generalized boosted model that included the covariates listed above was used to produce a separate set of weights for each biomarker cohort using the twang (tool kit for weighting and analysis of nonequivalent groups) package in R (version 3.6.0). DID linear mixed-effects modeling was performed using inverse probability of treatment weighting for each diabetes-related biomarker.

We also performed a time-to-event analysis modeling time from an uncontrolled HbA_{1c} measurement to a controlled HbA_{1c} measurement. Among a subset of patients with an uncontrolled ($HbA_{1c} \geq 9\%$ [75 mmol/mol]) measurement within 3 months pre-ACA, we fitted a state-stratified Cox proportional hazards model to assess time to a controlled ($HbA_{1c} < 9\%$ [75 mmol/mol]) measurement by insurance cohort adjusted for confounders listed above and the addition of patient's out-of-control HbA_{1c} values at baseline. Hazard ratios (HRs) were calculated, and a robust sandwich estimator was used to construct 95% CIs of the HRs, accounting for clustering of patients within CHCs. The assumption of proportional hazards was assessed using Schoenfeld residuals and was deemed suitable. Using the proposed Cox model, we then computed and plotted survival probability estimates of the proportion of patients without a controlled measurement throughout the 24 months post-ACA by insurance group.

For the secondary analyses evaluating changes in total diabetes-related prescription and insulin prescription rates, we implemented similar linear mixed-effects DID models as the ones used for the primary diabetes-related biomarker analyses.

All statistical testing was two sided with a type I error set to 5%. All analyses were completed using R, version 3.4.0. The study was approved by the Oregon Health & Science University Institutional Review Board.

RESULTS

Participant Characteristics

The insurance groups differed on multiple baseline (pre-ACA) patient-level

characteristics (Table 1). Compared with the other insurance groups, the newly insured ($n = 2,483$) had the highest mean age (47.4 years) and highest proportion of males (46.8%). Pre-ACA, the continuously uninsured ($n = 2,888$) had the lowest mean age (44.4 years) and were most likely of the groups to be Hispanic (80.4%); they were also less than half as likely as the others to be documented smokers pre-ACA. The continuously insured ($n = 5,442$) were least likely to be Hispanic (32.5%), most likely to be documented smokers pre-ACA, and most likely to have multiple comorbidities; in particular, they were substantially more likely than the other groups to have seven or more comorbidities (29.9%). The discontinuously insured ($n = 5,770$) had the highest number of pre-ACA visits (10.3) and were second-most likely to have seven or more comorbidities (19.7%). Similar distributions were observed in biomarker-specific cohorts (Supplementary Table 2).

DID Analysis: Change in HbA_{1c} Values Pre- to Post-ACA Between Insurance Groups

Unadjusted means over ACA implementation by insurance cohort are presented in Supplementary Table 3, while covariate-adjusted means are presented in Table 2. Newly insured patients exhibited minimal reductions in adjusted mean HbA_{1c} levels pre- to post-ACA (8.24% [67 mmol/mol] to 8.17% [66 mmol/mol]); however, this change was significantly different from the change in continuously uninsured patients, whose HbA_{1c} levels increased (8.12% [65 mmol/mol] to 8.29% [67 mmol/mol]; DID 0.24%, 95% CI 0.17–0.30%, $P < 0.001$). Pre- to post-ACA mean HbA_{1c} in the discontinuously insured also increased slightly (8.14% [65 mmol/mol] to 8.23% [66 mmol/mol]). HbA_{1c} change from pre- to post-ACA in the continuously insured also increased (7.81% [62 mmol/mol] to 7.96% [63 mmol/mol]).

Subset Analysis: Time to a Controlled HbA_{1c} Measurement

Among 1,925 patients with elevated HbA_{1c} at baseline, based on unadjusted Kaplan-Meier estimates, the percentage of patients with controlled HbA_{1c} at 24 months post-ACA was highest among the newly insured (70.5%, 95% CI 63.8–76.0) followed by continuously insured (66.3%, 95% CI 61.7–70.3), discontinuously insured (63.4%, 95% CI 60.0–67.5), and, lastly, continuously uninsured (58.5%, 95% CI 53.0–63.4).

In the adjusted stratified Cox model (Fig. 1), the newly insured and continuously uninsured were not significantly different in their likelihood of having a controlled measurement by 24 months post-ACA. Cox-adjusted Kaplan-Meier survival curves showed faster time to control for the newly insured compared with the continuously uninsured (HR 0.80, 95% CI 0.65–0.98) and discontinuously insured (HR 0.81, 95% CI 0.68–0.95).

DID Analysis: Differences Between Insurance Groups in Changes in LDL, SBP/DBP, and BMI Values Pre- to Post-ACA

Table 2 shows that newly insured patients had the greatest improvement pre- to post-ACA in adjusted mean LDL (108.5–101.5 mg/dL), a 7.0-point drop compared with the 3.8-point drop (107.2–103.5 mg/dL) seen in continuously uninsured patients (DID 3.26, 95% CI 1.45–5.07, $P < 0.001$). The continuously insured and the discontinuously insured exhibited changes in LDL values that were also lower than seen in the newly insured: a 3.2 decrease in the continuously insured (105.0–101.2 mg/dL) (DID 3.19, 95% CI 1.59–4.78, $P < 0.001$) and a 2.9 decrease in the discontinuously insured (108.6–104.5 mg/dL) (DID 2.88, 95% CI = 1.30–4.45, $P < 0.001$).

Overall changes in SBP from pre- to post-ACA were small for all four insurance cohorts. Adjusted mean SBP values decreased for newly insured (130.1–129.0 mmHg) while rising for continuously

Table 1—Characteristics of patients with diabetes by insurance cohort

Characteristic	Continuously uninsured ($n = 2,888$)	Discontinuously insured ($n = 5,770$)	Continuously insured ($n = 5,442$)	Newly insured ($n = 2,483$)	P
Male sex (%)	45.7	43.2	41.5	46.8	<0.001
Age, years (mean)*	44.4	47.0	46.7	47.4	<0.001
Race/ethnicity group (%)					<0.001
Hispanic	80.4	43.7	32.5	43.5	
Non-Hispanic white	9.4	30.2	43.6	38.2	
Non-Hispanic black	6.8	19.9	14.0	10.7	
Non-Hispanic other	2.3	3.9	6.8	4.2	
Unknown	1.0	2.4	3.1	3.5	
No. of comorbidities (%)†					<0.001
One	12.7	8.9	7.3	10.1	
Two to four	58.6	44.3	36.3	49.1	
Five to six	14.8	20.9	21.5	20.8	
Seven or more	6.9	19.7	29.9	13.6	
Unknown	7.1	6.1	5.0	6.4	
No. of visits before ACA (mean)	7.2	10.3	9.9	6.8	<0.001
Current smoker prior to ACA (%)‡	9.5	22.9	27.6	23.2	<0.001
Urban setting (%)§	94.4	93.8	93.8	92.9	0.147

This table includes all patients included in any of the specific biomarker analyses. For specific sample sizes and distributions used for each biomarker analysis, please refer to the footnote of Supplementary Table 2. χ^2 tests for categorical variables and ANOVA tests for continuous variables were used to test for differences between insurance groups. *Patient age was the age as of 1 January 2012 (the beginning of the study period). The study sample was restricted to patients aged 19–64 years during the entire study period. †We considered 54 chronic diseases and comorbidities. See footnote of Supplementary Table 2 for the full list. ‡Binary category creation of current smoker vs. former smoker/never smoker/missing status. §Urban setting category was created by collapsing RUCA (rural-urban commuting area) codes "urban area" and "urban cluster." Rural consists of "rural" and "small town." Missing RUCA code was indicated as "unknown."

Table 2—Adjusted mean changes in biomarkers from pre- to post-ACA between insurance groups

Measure	Continuously uninsured	Discontinuously insured	Continuously insured	Newly insured
HbA_{1c}, %				
Pre-ACA, mean	8.12	8.14	7.81	8.24
Post-ACA, mean	8.29	8.23	7.96	8.17
Change pre- to post-ACA	+0.17	+0.09	+0.15	−0.07
DID	**+0.24**	**+0.16**	**+0.22**	Ref
95% CI	**0.17–0.30**	**0.11–0.22**	**0.16–0.27**	Ref
P value	**<0.001**	**<0.001**	**<0.001**	Ref
LDL cholesterol, mg/dL				
Pre-ACA, mean	107.22	108.62	105.03	108.52
Post-ACA, mean	103.45	104.47	101.19	101.49
Change pre- to post-ACA	−3.77	−4.15	−3.84	−7.03
DID	**+3.26**	**+2.88**	**+3.19**	Ref
95% CI	**1.45–5.07**	**1.30–4.45**	**1.59–4.78**	Ref
P value	**<0.001**	**<0.001**	**<0.001**	Ref
SBP, mmHg				
Pre-ACA, mean	128.10	129.09	127.87	130.07
Post-ACA, mean	128.80	129.26	128.30	129.01
Change pre- to post-ACA	+0.70	+0.17	+0.43	−1.06
DID	**+1.76**	**+1.23**	**+1.49**	Ref
95% CI	**1.34–2.19**	**0.89–1.58**	**1.14–1.84**	Ref
P value	**<0.001**	**<0.001**	**<0.001**	Ref
DBP, mmHg				
Pre-ACA, mean	78.65	79.26	78.86	80.06
Post-ACA, mean	78.19	78.71	78.37	78.56
Change pre- to post-ACA	−0.46	−0.55	−0.49	−1.50
DID	**+1.04**	**+0.95**	**+1.00**	Ref
95% CI	**0.77–1.30**	**0.73–1.17**	**0.78–1.22**	Ref
P value	**<0.001**	**<0.001**	**<0.001**	Ref
BMI, kg/m^2				
Pre-ACA, mean	31.98	32.79	33.21	32.70
Post-ACA, mean	31.84	32.58	32.84	32.58
Change pre- to post-ACA	−0.14	−0.21	−0.37	−0.12
DID	−0.02	**−0.09**	**−0.24**	Ref
95% CI	−0.08 to 0.04	**−0.13 to −0.03**	**−0.29 to −0.19**	Ref
P value	0.510	**<0.001**	**<0.001**	Ref

Biomarker-adjusted means at each period (pre- and post-ACA) and for each insurance group were estimated using a linear mixed-effects model. Random effects for patients and CHCs accounted for temporal observations of biomarkers within patients as well as for patients nested with CHCs. Boldface type denotes statistical significace (i.e., $P < 0.05$). Ref, reference.

uninsured (128.1–128.8 mmHg) (DID 1.76, 95% CI 1.34–2.19), discontinuously uninsured (129.1–129.3 mmHg) (DID 1.23, 95% CI 0.89–1.58), and continuously insured (127.9–128.3) (DID 1.49, 95% CI 1.14–1.84) patients. Adjusted mean DBP values also decreased only a small amount for all insurance cohorts pre- to post-ACA: slightly more in the newly insured (80.1–78.6 mmHg) than in the continuously uninsured (78.7–78.2 mmHg) (DID 1.04, 95% CI 0.77–1.30), the discontinuously uninsured (79.3–78.7 mmHg) (DID 0.95, 95% CI 0.73–1.17), and the continuously insured (78.9–78.4 mmHg) (DID 1.00, 95% CI 0.78–1.22).

Adjusted mean BMI values decreased slightly for all insurance cohorts pre- to post-ACA. Compared with the decrease in the newly insured (32.7–32.6 kg/m^2) of ~0.1 kg/m^2, the change in the discontinuously insured was similar (32.0–31.8 kg/m^2). The other groups showed slightly more change: a decrease of 0.2 kg/m^2 for the discontinuously uninsured (32.8–32.6 kg/m^2) (DID −0.09, $P < 0.001$) and ~0.4 kg/m^2 for the continuously insured (33.2–32.8 kg/m^2) (DID −0.24, $P < 0.001$).

DID Analysis: Changes in Total Antidiabetes Medication and Insulin-Only Prescriptions

Table 3 shows that newly insured patients had the greatest increase in the mean number of total antidiabetes medication prescriptions (22.2–33.4) relative to the other insurance groups, with a positive increase of 11.2 prescriptions from pre- to post-ACA. Specifically, the newly insured saw a change of close to 10 more prescriptions from pre- to post-ACA, on average, as compared with the continuously uninsured (DID −9.7, 95% CI −11.4 to −8.0).

In evaluation of the average change in insulin prescriptions pre- to post-ACA, the newly insured patients (pre-ACA 6.4, post-ACA 11.0) and discontinuously insured patients (pre-ACA 7.3, post-ACA 11.9) showed a similar increase from pre- to post-ACA by an average of 4.6 insulin prescriptions. The other insurance groups experienced smaller changes. Compared with the newly insured, the continuously uninsured had the lowest increase (pre-ACA 6.5, post-ACA 7.4) (DID −3.7, 95% CI −4.8 to −2.5).

Sensitivity Analyses: IPTW DID Modeling Evaluating Differences Between Insurance Groups in Changes in HbA_{1c}, LDL, SBP/DBP, and BMI Values Pre- to Post-ACA

DID results for each biomarker cohort based on IPTW linear mixed-effects models are qualitatively similar to results obtained

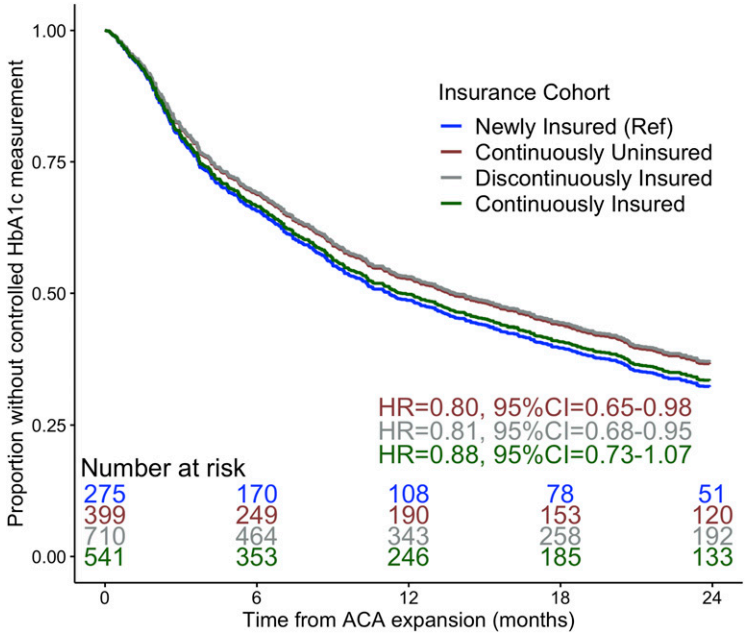

Figure 1—Adjusted Cox survival curves: time from baseline elevated HbA_{1c} measurement around the ACA expansion to a controlled measurement by insurance cohort. This subset analysis identified patients with an uncontrolled HbA_{1c} ($HbA_{1c} \geq 9\%$) measurement within 3 months prior to ACA Medicaid expansion start date (1 January 2014). We followed these patients 24 months post–Medicaid expansion until their time to a controlled measurement ($<9\%$ HbA_{1c}). Ref, reference.

from covariate-adjusted linear mixed-effects models (Supplementary Table 4).

CONCLUSIONS

This study compared changes in diabetes-related biomarkers from pre- to post-ACA among newly insured compared with continuously uninsured, continuously insured, and discontinuously insured patients with diabetes seen at CHCs. The findings revealed that those who gained insurance following the ACA (newly insured) experienced greater improvements in HbA_{1c}, blood pressure, and lipid levels as compared with the other insurance groups. BMI changes were small for all insurance groups. The improvements experienced by the newly insured over the continuously uninsured and discontinuously insured groups are likely due to increased access to health care services and thus adequate coverage for diabetes secondary screenings. It could also be due to access to medications to help control chronic conditions. To understand if this was the case, we conducted an analysis to see whether there was a drastic change in access to medications pre- to post-ACA by insurance group. We found the mean number of antidiabetes medication and insulin prescriptions increased for all insurance groups, with the greatest number in the newly insured group. This increase in mean number of prescriptions may be due to changes in the medication regimen based on negative side effects or lack of effectiveness. Therefore, we cannot say for certainty whether the improvements for the newly insured patients were due to access to care or change in medication regimen or both. Additional research is needed to fully understand the mechanism by which the newly insured were able to achieve greater biomarker control.

With regard to the continuously insured group, they are likely a sicker and lower-income population than the newly insured, since Medicaid eligibility options prior to the ACA were very narrow; this difference would explain why the newly insured saw greater improvements than those who were continuously insured. Indeed, 30% of those in our study sample in the continuously insured group had seven or more comorbidities compared with only 14% of those in the newly insured group. Of note, these prescription differences were still observed after we controlled for number of comorbidities

Table 3—Adjusted mean changes in total antidiabetes medication prescriptions and total insulin prescriptions from pre- to post-ACA between insurance groups

Measure	Continuously uninsured	Discontinuously insured	Continuously insured	Newly insured
Total antidiabetes medication prescriptions				
Pre-ACA, mean	25.3	25.7	24.5	22.2
Post-ACA, mean	26.8	34.8	30.0	33.4
Change pre- to post-ACA	+1.5	+9.1	+5.5	+11.2
DID	**−9.7**	**−2.0**	**−5.7**	Ref
95% CI	**−11.4 to −8.0**	**−3.4 to −0.5**	**−7.2 to −4.2**	Ref
P value	**<0.001**	**0.009**	**<0.001**	Ref
Insulin prescriptions				
Pre-ACA, mean	6.5	7.3	6.5	6.4
Post-ACA, mean	7.4	11.9	9.0	11.0
Change pre- to post-ACA	+0.9	+4.6	+2.5	+4.6
DID	**−3.7**	−0.0	**−2.1**	Ref
95% CI	**−4.8 to −2.5**	−1.0 to 1.0	**−3.1 to −1.1**	Ref
P value	**<0.001**	0.944	**<0.001**	Ref

Prescription-adjusted means at each period (pre- and post-ACA) and for each insurance group were estimated using a linear mixed-effects model. Random effects for patients and CHCs accounted for temporal observations of biomarkers within patients as well as for patients nested with CHCs. Boldface type denotes statistical significance (i.e., $P < 0.05$). Ref, reference.

and number of pre-ACA visits using either covariate-adjusted modeling or IPTW modeling.

Though some of the changes might seem relatively small at the individual patient level, this study included a large number of patients, so the population-level health impacts are worth noting. For example, the relative mean reduction in HbA_{1c} from pre- to post-ACA was 0.24% in those who were newly insured compared with those who were continuously uninsured (a group that the newly insured would have been a part of if not for the ACA). Previous research found that a 1% reduction in the level of HbA_{1c} in patients with diabetes was associated with a 21% relative decrease in diabetes-related morbidity or mortality (32,33). These findings are consistent with other studies that established an association between access to Medicaid coverage and positive health outcomes among individuals who suffer from chronic conditions (12). Additionally, unlike the groups with new or consistent insurance post-ACA, continuously uninsured and discontinuously insured patients showed worsening HbA_{1c} levels post-ACA, highlighting the adverse effects of lack of access to health insurance and the importance of keeping patients with diabetes insured. Future research is needed to evaluate whether these improvements are sustained beyond 24 months.

Newly insured patients also experienced a 7 mg/dL decrease in LDL (6% change from baseline), which was larger than the decline seen in the other insurance groups. A change of this size has been shown in other studies to be associated with a reduction in risk of coronary heart disease by 6% (34). Such LDL changes in an individual patient affect not only overall cardiovascular disease risk but also whether a patient meets recommended risk thresholds for cholesterol-lowering medications (35).

There is a large body of work establishing the importance of CHCs in providing timely health care to at-risk populations (12,36) and assisting patients with insurance enrollment and retention (37); this study highlights the effectiveness of CHCs in helping patients with diabetes receive access to care, resulting in improved diabetes-related biomarkers. Our results extend and confirm analyses of the effects of previous research by showing that gain of health insurance from the 2014 ACA Medicaid expansion was associated with improved diabetes-related biomarkers (HbA_{1c}, LDL, SBP, and DBP).

Our study had limitations. Though we adjusted for a number of baseline covariates, including comorbidity level, unmeasured confounding may still exist: patients with Medicaid coverage prior to the ACA are likely substantially different from uninsured and newly insured enrollees in ways we could not fully capture. Because our EHR data were limited to patients who received care at CHCs, our conclusions may not necessarily extend to individuals who did not visit CHCs. It is also possible that patients in our sample received care outside of our EHR networks; however, prior studies suggest that patients who visit CHCs continue to do so post–insurance gain (36). Additionally, previous studies showed that CHCs were more likely to accept patients with Medicaid than other primary care providers (19,38), so it is unlikely that the patients from this study received a significant amount of ambulatory care outside of the CHCs. Though we found an increase in the number of medications prescribed, especially among newly insured, we have no information about patient adherence to these medications. The small improvement in HbA_{1c} may reflect poor adherence to diabetes medication. Additionally, we did not formally adjust for the number of biomarker measurements in the analysis because we conceptualized visits (and measurements) to be in the causal pathway from gaining insurance to improved diabetes-related biomarkers. Future studies could consider mediation analyses to evaluate this hypothesis. Finally, our study focused on intermediate outcomes and did not examine the impact of Medicaid access on long-term diabetes outcomes such as cardiovascular disease and mortality.

Conclusion

Compared with uninsured and discontinuously or continuously insured, newly insured patients seeking care at CHCs had greater pre- to post-ACA improvement in diabetes-related biomarkers. These findings highlight the importance of the ACA Medicaid expansion for patients with diabetes.

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