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# The Impact of Nurse Practitioner-Led Primary Care on Quality and Cost for Medicaid-Enrolled Patients in States With Pay Parity

**Jordan M. Harrison, PhD[1], Ashley M. Kranz, PhD[2], Annie Yu-An Chen, DDS, MS[3], Harry H. Liu, PhD[4], Grant R. Martsolf, PhD[1,5], Catherine C. Cohen, PhD[6], and Michael Dworsky, PhD[6]**

**Abstract**

Studies have established that nurse practitioners (NPs) deliver primary care comparable to physicians in quality and cost, but most focus on Medicare, a program that reimburses NPs less than physicians. In this retrospective cohort study, we evaluated the quality and cost implications of receiving primary care from NPs compared to physicians in 14 states that reimburse NPs at the Medicaid fee-for-service (FFS) physician rate (i.e., pay parity). We linked national provider and practice data with Medicaid data for adults with diabetes and children with asthma (2012-2013). We attributed patients to primary care NPs and physicians based on 2012 evaluation & management claims. Using 2013 data, we constructed claims-based primary care quality measures and condition-specific costs of care for FFS enrollees. We estimated the effect of NP-led care on quality and costs using: (1) weighting to balance observable confounders and (2) an instrumental variable (IV) analysis using differential distance from patients' residences to primary care practices. Adults with diabetes received comparable quality of care from NPs and physicians at similar cost. Weighted results showed no differences between NP- and physician-attributed patients in receipt of recommended care or diabetes-related hospitalizations. For children with asthma, costs of NP-led care were lower but quality findings were mixed: NP-led care was associated with lower use of appropriate medications and higher rates of asthma-related emergency department visits but similar rates of asthma-related hospitalization. IV analyses revealed no evidence of differences in quality between NP- and physician-led care. Our findings suggest that in states with Medicaid pay parity, NP-led care is comparable to physician-led care for adults with diabetes, while associations between NP-led care and quality were mixed for children with asthma. Increased use of NP-led primary care may be cost-neutral or cost-saving, even under pay parity.

**Keywords**

nurse practitioners, primary care, health care quality, health care costs, Medicaid

**What do we already know about this topic?**
Studies have established that nurse practitioners (NPs) deliver primary care comparable to that of physicians in quality and cost, but most focus on Medicare, a program that reimburses NPs less than physicians.

**How does your research contribute to the field?**
In this retrospective cohort study, we evaluated the quality and cost implications of receiving primary care from NPs compared to physicians in 14 states that reimburse NPs at the Medicaid fee-for-service physician rate (i.e., Medicaid pay parity).

**What are your research's implications toward theory, practice, or policy?**
Our findings suggest NP-led primary care in Medicaid could help address primary care shortages without sacrificing quality or raising costs for adults, even under pay parity, but further research is needed to understand the outcomes of NP-led care for children.

## Introduction

High-quality primary care is important to prevent and manage chronic disease, avoid acute illness, and control health care costs, yet many Americans with chronic conditions such as diabetes and asthma lack access to a primary care provider.[1,2] The Association of American Medical Colleges has projected a shortage of 17,800 to 48,000 primary care physicians by 2034.[3] Growing primary care shortages in many areas contribute to challenges with access to care, particularly for underserved populations such as Medicaid enrollees. Medicaid-enrolled patients have historically faced lower appointment availability and longer wait times, largely due to lower Medicaid reimbursement rates relative to other payers.[4] Ensuring access to care for Medicaid enrollees is an ongoing challenge for states, and Medicaid expansion in many states has led to increased demand.[5] As the supply of primary care physicians continues to decline, nurse practitioners (NPs) play a growing role in meeting demands for care.[6]

NPs are advanced practice registered nurses trained at the masters or doctoral level and licensed by states to assess patients, order and interpret diagnostic tests, make diagnoses, initiate and manage treatment plans, and prescribe medications.[7,8] NPs practice independently or as part of interprofessional teams with physicians. The NP workforce has grown rapidly in recent years, more than doubling between 2010 and 2017.[9] Among the 355,000 licensed NPs in the US, 89% are credentialed to deliver primary care and 70% practice in primary care.[10] Previous studies suggest primary care NPs are more likely than primary care physicians to practice in rural, underserved, and socioeconomically disadvantaged areas and accept Medicaid-enrolled patients.[11-13]

Numerous studies have established that NPs deliver high-quality primary care comparable to physicians,[14-20] and previous studies have found similar or lower costs of primary care delivered by NPs versus physicians.[14-18] However, these previous studies have focused primarily on the Medicare population, and there is little evidence on the impact of NP-led care among younger populations. Similarly, there is little evidence on the effects of NP-led care on health care costs when NPs and physicians are reimbursed at the same rate (i.e., pay parity). Some state Medicaid programs reimburse NPs at the Medicaid fee-for-service (FFS) physician rate, but in many states Medicaid reimbursement for NPs is up to 25% less than reimbursement for physicians.[19] Total patient costs may be similar for NPs and physicians under pay parity if the services received are similar. Under pay parity, impacts of NP-led care on costs should be driven by impacts on service use: total patient costs may be lower for NPs than physicians if NP-led care lowers overall service use, or vice versa.

Scope of practice laws may also have implications for the quality of care provided by NPs and total costs of care. In many states scope of practice laws limit NPs' abilities to practice without physician oversight or collaboration.[20] Studies suggest that quality of NP-led care in states with full practice authority for NPs (FPA states) is similar or better compared to non-FPA states.[21-24] Findings regarding FPA and health care spending have been mixed. Some studies suggest FPA is associated with cost savings due to greater efficiency of care delivery,[21,25-27] while others suggest expanded access to care under FPA may generate higher costs due to increased service use.[28,29] Thus it remains unknown how patient costs may vary for NP-led care in states with Medicaid pay parity with and without FPA.

To address these gaps in the literature, our objective was to evaluate the quality and cost implications of receiving primary care from NPs compared to physicians in 14 states that reimburse NPs at the Medicaid fee-for-service physician rate (i.e., Medicaid pay parity), including five FPA states and nine non-FPA states. We conducted a retrospective cohort study focused on Medicaid-enrolled patients from 2012 to 2013 with two of the most prevalent chronic conditions: adults with diabetes and children with asthma. We used a validated method to attribute primary care patients to NPs and physicians and then used two complementary empirical strategies to estimate the effect of NP-led care on quality and costs: (1) entropy balancing to derive weights to adjust for observed differences in patients attributed to NPs and physicians, and (2) an instrumental variables analysis using differential distance from patients' residences to primary care practices with NPs on staff to adjust for unobserved differences in patients attributed to NPs and physicians.

## Methods

This study was approved with a waiver of consent by the lead author's Human Subjects Protection Committee.

### Data Sources

We obtained data on health care service use and costs from the 2012 and 2013 Medicaid Analytic Extract (MAX) files. Developed by the Centers for Medicare & Medicaid Services

[1]RAND Corporation, Pittsburgh, PA, USA
[2]RAND Corporation, Arlington, VA, USA
[3]RAND Corporation, Boston, MA, USA
[4]Independent Researcher, Boston, MA, USA
[5]University of Pittsburgh School of Nursing, Pittsburgh, PA, USA
[6]RAND Corporation, Santa Monica, CA, USA

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**Corresponding Author:**
Jordan M. Harrison, RAND Corporation, 4570 Fifth Avenue #600, Pittsburgh, PA 15213, USA.
Email: jharriso@rand.org

(CMS) to support research and policy analysis for Medicaid populations, MAX files include person-level information on Medicaid eligibility, service utilization, and payments.[30] MAX files include National Provider Identifiers (NPI) but do not include Tax Identification Numbers (TIN) or clinician addresses or ZIP codes. Though more recent data is available from the T-MSIS Analytic File (TAF), the new generation of Medicaid data available for all states from 2016 onward, further work is needed to understand usability of the TAF data for policy analyses, including the extent of quality issues common in Medicaid claims such as missingness and variability across states.[31]

We sampled primary care practices and providers using national health care provider and practice data from the 2012 and 2013 SK&A files (now called OneKey by IQVIA).[32] The SK&A files contain data on office-based physician practices across the U.S., including practice specialty, number and type of providers within the practice, provider specialties, NPIs, and practice location (ZIP code and latitude/longitude). This information allowed us to identify NPs working in primary care, an advantage over other data sources.[33]

## Sample Construction

To select the sample of states, we reviewed 2012 and 2013 MAX data validation reports for the 27 states with Medicaid pay parity in 2012 (Appendix Table A1) to identify those with the most complete NPI data. We also considered usability of MAX encounter data for managed care enrollees.[34] Based on these criteria, we included 5 FPA states (Iowa, Maine, Oregon, Washington, Wyoming) and 10 non-FPA states (California, Delaware, Michigan, Missouri,[i] New Jersey, New York, Ohio, Tennessee, Utah, and Virginia).

We used 2012 to 2013 SK&A data to identify primary care practices in the states of interest. We defined the following practice specialties as primary care: adolescent medicine, family practice, general practice, general preventative medicine, geriatric medicine, internal medicine, internal medicine/pediatrics, multi-specialty, and pediatrics.[35] We characterized the provider mix in each practice as the percentage of providers (including physicians, NPs, and physician assistants) that were NPs. To ensure adequate representation of practices with a large share of NPs, we included in our sample all primary care practices in which at least 80% of providers were NPs. From the remaining pool of primary care practices, we sampled 100% of practices in small states and 33 or 67% of practices in mid- and large-sized states (Appendix Table A1). This was to ensure the size of the patient cohort was not intractably large. We generated a deduplicated list of NPIs for all providers in the sampled primary care practices in 2012 or 2013, resulting in a sample of approximately 60,000 NPIs. Any patient with one or more outpatient claims from any of the NPIs on our list was included in the final cohort of approximately 12 million Medicaid enrollees.

Next, we identified adults with diabetes and children with persistent asthma who were continuously enrolled in Medicaid during 2012 to 2013 (inclusive of both enrollees in FFS and comprehensive managed care) and had one or more primary care visits in 2012. We excluded individuals dually enrolled in Medicaid and Medicare because we did not have information on care paid by Medicare. The diabetes sample included adults ages 18 to 64 with diagnoses of diabetes reported in the Medicaid Enrollee Supplemental File (MESF) chronic conditions file. The pediatric asthma sample included children ages 5 to 17 who met claims-based criteria for persistent asthma.[36]

## Patient Attribution

We used a validated method to attribute patients to providers.[37] To ensure an established relationship with the attributed primary care provider, patient attribution was based on 2012 evaluation and management (E&M) services from the Berenson-Eggers Type of Services Codes for new (M1A: 99201-99205) and established office visits (M1B: 99211-99215). Patients were attributed to the provider who delivered the plurality of E&M visits paid by Medicaid (at least 30% of visits). We excluded E&M services from inpatient, emergency, or specialty care settings so that attribution would be based on primary care. After applying these criteria, no patients in Missouri were attributed to NPs, therefore we excluded Missouri from our analytic sample. We caution that, under typical coding practices, billing data cannot identify care delivered by NPs under indirect billing (when an NP performs services but bills under a physician's name). Some care delivered by NPs may consequently be inaccurately attributed to physicians (see Discussion for details). The final patient sample included 49,907 adults with diabetes and 39,765 children with asthma (Appendix Figures A1 and A2).

## Control Variables

Our analyses adjusted for patient demographic and clinical characteristics including age, sex, race/ethnicity, county rural/urban residence (metropolitan, non-metropolitan—adjacent to metropolitan areas, non-metropolitan—not adjacent to metropolitan areas),[38] state of residence, Medicaid enrollment type (FFS or comprehensive managed care), Medicaid eligibility category,[ii] and chronic condition count.

## Dependent Variables

*Quality measures.* We constructed claims-based quality measures using 2013 data based on specifications from the Healthcare Effectiveness Data and Information Set (HEDIS) and the Agency for Healthcare Research and Quality (AHRQ). For adults with diabetes, we constructed the following indicators of comprehensive diabetes care (CDC): receipt of hemoglobin A1c testing, annual low density lipoprotein (LDL) screening, and medical attention for nephropathy.[36] We also constructed indicators of having all three CDC measures and having zero CDC measures. We did not examine receipt of a retinal eye exam, another indicator of comprehensive diabetes care, because we could not reliably identify provider specialty in the MAX data. We also identified adults having any preventable hospitalizations for complications of diabetes.[39] For children with persistent asthma, we constructed a measure of receipt of appropriate medications,[36] an indicator of having one or more emergency department (ED) visits for asthma,[40] and an indicator of having one or more hospital admissions for asthma.[39]

*Costs.* Our cost analyses were limited to FFS enrollees (<10% of our patient sample) in a subset of states with available data.[iii] Among the patients in our sample with FFS enrollment, we evaluated diabetes- and asthma-related Medicaid costs in 2013. We identified FFS claims with a principal diagnosis or second listed diagnosis for diabetes or asthma, respectively, and summed total annualized costs for inpatient visits, outpatient visits, and prescription drugs. Costs in each category were winsorized at the 99th percentile for those with non-zero spending. We calculated total costs per patient as the sum of inpatient, outpatient, and prescription costs. Due to documented issues with incomplete and inaccurate cost data for Medicaid managed care payments,[41-43] including missing encounters, inappropriate zeros, and negative values, we were unable to measure costs for managed care enrollees.

## Statistical Analysis

We used two approaches to address observable and unobservable differences between patients receiving primary care from NPs and those receiving primary care from physicians. Analyses were estimated using data from all states and then for groups of states stratified by FPA versus non-FPA status. Analyses were performed in Stata version 16 and SAS version 9.4. For all analyses we used two-sided tests with alpha level of 0.05.

*Weighting estimates of the effects of NP-led care.* We used entropy balancing[44] to derive weights that balance differences in observable patient characteristics between those attributed to NPs and those attributed to physicians, including age, sex, race/ethnicity, rural/urban residence, state of residence, Medicaid enrollment type, and Medicaid eligibility category. Entropy balancing was chosen over propensity score methods for ease of use and computational speed. We evaluated outcomes before and after weighting to examine whether differences in quality and cost outcomes associated with NP attribution are driven by observable differences between patient groups.

*Instrumental variables (IV) estimates of the effects of NP-led care.* To avoid confounding due to unobservable differences between NP- and physician-attributed patients (i.e., due to self-selection into NP-led care based on unobservable factors affecting quality or cost of care), we also conducted an IV analysis.

In addition to examining provider-level attribution to an NP (which is the explanatory variable of interest in our weighting estimates), we constructed a practice-level attribution measure intended to capture whether patients were attributed to providers at a practice with one or more NPs on staff. Practice-level exposure to NPs is of interest because the presence of NPs in a practice may affect quality of care even if the patient's attributed provider is a physician. Practice-level attribution may also help address mismeasurement of NP-led care due to indirect billing.

We followed previous studies in using differential distance as an instrument,[45-48] where differential distance is defined as the additional distance beyond the nearest primary care practice that a patient needs to travel to reach a practice that has one or more NPs on staff. We counted a practice as having NPs on staff if one or more NPs were linked to that practice in the SK&A data. Our differential distance calculations included the universe of primary care practices in the states of interest in SK&A. We used Google Maps Application Programming Interfaces to calculate the driving distance between patient ZIP code centroids and practice coordinates (latitude and longitude) obtained from SK&A (Appendix B-1).

We report estimates from linear regression models of quality measures on an indicator for NP attribution, patient demographic and clinical characteristics, and state fixed effects. Heteroskedasticity-robust variance estimates were used for statistical inference.[49] Linear regression models that do not use the instrument were estimated using ordinary least squares (OLS), while the IV models were estimated using two-stage least squares (2SLS). We also estimated nonlinear IV models using two-stage residual inclusion (2SRI).[50] Nonlinear models (logistic regression for binary patient-level quality measures, and Poisson regression for a count outcome) may be more efficient for the outcomes considered here, but in practice both sets of IV models were imprecisely estimated and yield similar findings: we therefore do not report the 2SRI estimates in this paper.

Differential distance to an NP practice is a strong predictor of NP attribution. The first-stage F-statistics on the differential distance instruments are 116 for adults with diabetes and 50 for children with asthma, both well above the threshold of 10 customarily viewed as a warning sign of weak instruments. First-stage F-statistics for practice-level attribution were even higher: 289 for children with asthma and 540 for adults with diabetes. Reduced-form and first stage estimates are reported in the Appendix (Tables A6 and A7), where we also discuss why additional assumptions required for IV to identify causal effects are likely to be met in this setting (Appendix B-2).

We also used our IV specification to estimate effects of provider-level and practice-level attribution on costs for

**Table 1.** Standardized Differences in Quality Outcomes for Patients Attributed to Nurse Practitioners and Physicians, Overall and by FPA and Non-FPA States.

| | Overall | | Non-FPA states | | FPA states | |
|---|---|---|---|---|---|---|
| | Standardized difference[a] | | Standardized difference[a] | | Standardized difference[a] | |
| | Unweighted | Weighted | Unweighted | Weighted | Unweighted | Weighted |
| Adults with diabetes | | | | | | |
| Hemoglobin A1c testing performed | −0.04* | 0.02 | −0.07** | 0.02 | −0.06 | 0.01 |
| LDL-C screening | −0.11*** | 0.02 | −0.12*** | 0.03 | −0.09 | −0.01 |
| Medical attention for nephropathy | −0.05* | 0 | −0.05* | −0.01 | −0.03 | 0 |
| All 3 performed | −0.12*** | 0 | −0.13*** | 0.02 | −0.13* | −0.06 |
| None performed | 0 | −0.03 | 0.01 | −0.02 | −0.04 | −0.1 |
| Has one or more claims for diabetes-related admissions | −0.01 | 0.01 | 0 | 0.02 | −0.05 | −0.06 |
| Children with asthma | | | | | | |
| Use of appropriate medications for children with asthma | −0.14*** | −0.10** | −0.17*** | −0.11** | −0.02 | −0.03 |
| Has one or more claims for asthma-related emergency department visits | 0.02 | 0.06* | 0.02 | 0.06 | 0.06 | 0.06 |
| Has one or more claims for asthma-related admissions | −0.04 | 0 | −0.05 | 0 | 0 | 0.01 |

[a]Standardized difference calculated as average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients.
*$P < .05$. **$P < .01$. ***$P < .001$.

the subsample of FFS patients for whom costs could be measured reliably. However, these IV estimates were too imprecise to be informative, and we do not report them.

## Results

### Rates and Correlates of NP-Led Care

Patient attribution to an NP was somewhat rare; 3.51% of children with asthma and 4.55% of adults with diabetes were attributed to an NP as their primary care provider, with the remainder attributed to a physician. Among adults with diabetes (Appendix Table A2), those attributed to NPs were slightly younger, more likely to be female, non-Hispanic White, and live in rural areas, and had differences in Medicaid eligibility category: more likely to be blind/disabled, more likely to qualify through Section 1931, less likely to qualify through Section 1115, less likely to be medically needy. Among children with asthma (Appendix Table A3), those attributed to NPs were slightly older, more likely to be non-Hispanic White and live in rural areas, and had differences in Medicaid eligibility category: less likely to be blind/disabled, more likely to qualify through Section 1115, less likely to be medically needy. Entropy balancing weights achieved balance on all characteristics (Appendix Tables A2 and A3).

### Estimates of the Effects of NP-Led Care

*Quality outcomes: Adults with diabetes.* After weighting, adult patients with diabetes attributed to NPs had no significant differences in performance on hemoglobin A1c testing, LDL cholesterol screening, or medical attention for nephropathy compared to those attributed to physicians (Table 1; Figure 1A). Though patients attributed to NPs had significantly lower unadjusted performance on these outcomes, there were no significant differences after weighting for patient characteristics. The proportion of patients with diabetes-related hospital admissions did not differ significantly between patients attributed to NPs and physicians before or after weighting (Table 1; Figure 1B). Findings were similar in FPA and non-FPA states; there were no significant differences in weighted outcomes between NPs and physicians. Performance on diabetes quality measures was slightly better overall in FPA states (Appendix Table A4).

All regression models (OLS and IV) indicated that receiving NP-led primary care (measured via provider-level attribution) was not associated with any differences in quality of care for adults with diabetes (Table 2). While the IV point estimates for the effects of NP attribution were large, they were imprecisely estimated, having large standard errors, and none are statistically significant at 5%. Receiving care from a practice that had one or more NPs on staff was also not associated with any differences in quality of care across all IV models. Instrumental variables estimates for the effects of NP care in FPA versus non-FPA states were statistically insignificant at both the provider level and the practice level in both groups of states (Appendix Table A8).

*Quality outcomes: Children with asthma.* Children with asthma who were attributed to NPs had lower unadjusted

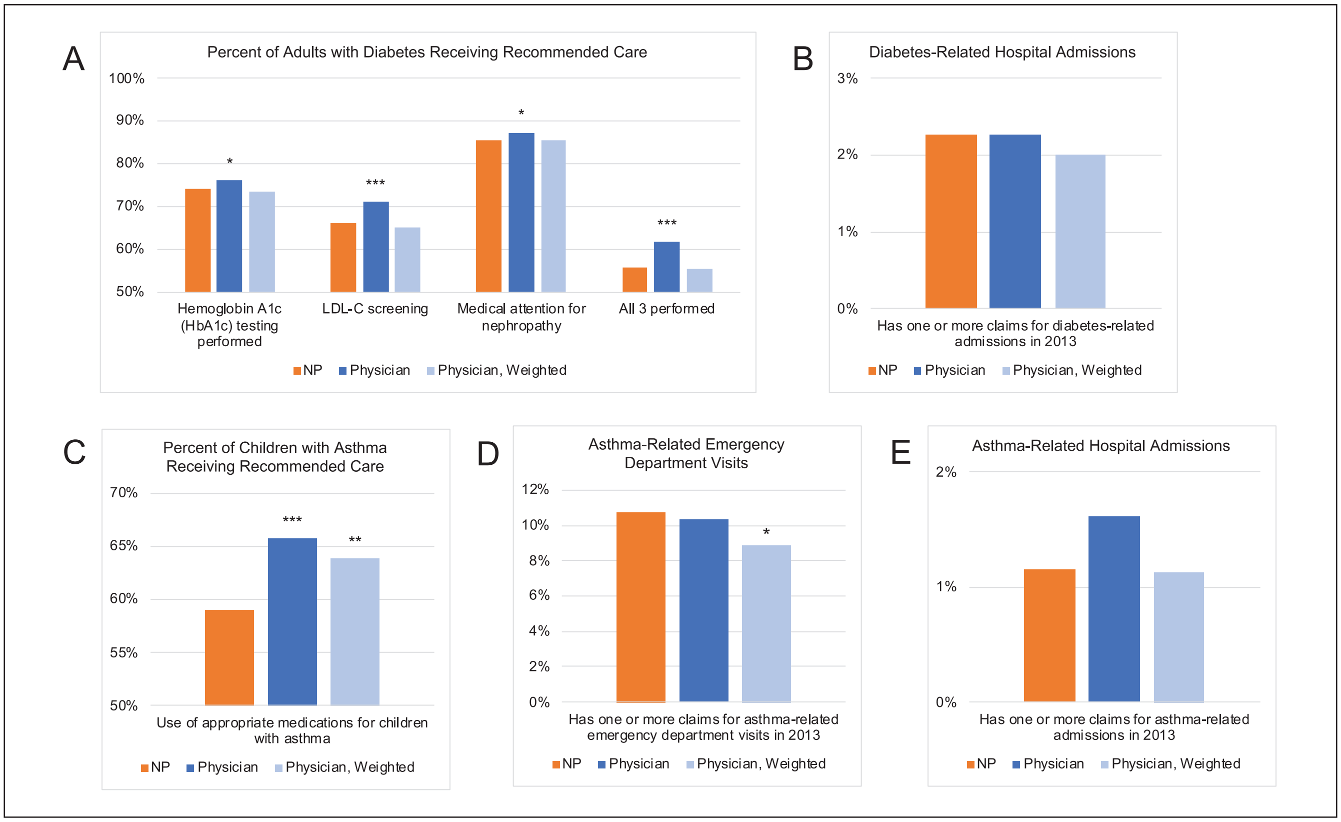


**Figure 1.** Quality outcomes for adults with diabetes and children with asthma. A. Percent of Adults with Diabetes Receiving Recommended Care; B. Diabetes-Related Hospital Admissions; C. Percent of Children with Asthma Receiving Recommended Care; D. Asthma-Related Emergency Department Visits; E. Asthma-Related Hospital Admissions.

*Note. P*-values represent standardized differences in quality measure performance between (1) NP versus Physician and (2) NP versus Physician, Weighted. NP = nurse practitioner.

**P* < .05. ***P* < .01. ****P* < .001.

performance on use of appropriate medications for people with asthma (59.0 vs 65.7%, $P < .001$) (Table 1; Figure 1C). After weighting, this difference was reduced, but not eliminated (59.0 vs 63.8%, $P < .001$). NP-physician differences in performance on the asthma medication measure were driven by non-FPA states; we did not observe a significant difference in FPA states (Appendix Table A5). Children with asthma attributed to NPs had a similar unadjusted rate of asthma-related ED visits compared to those attributed to physicians (10.7 vs 10.3%, $P = .567$) (Table 1; Figure 1D). However, after weighting, children with asthma attributed to NPs had a higher rate of asthma-related ED visits compared to those attributed to physicians (10.7 vs 8.9%, $P = .033$), with similar findings in FPA and non-FPA states. The proportion of patients with asthma-related hospital admissions did not differ significantly between patients attributed to NPs and physicians before or after weighting (Table 1; Figure 1E), and findings were similar in FPA and non-FPA states.

In IV models, NP-led primary care (measured via provider-level attribution) was not associated with any differences in use of appropriate medications, ED visits, or hospital admissions for children with asthma (Table 3). Results were similar in the IV models examining receipt of care from a practice that had one or more NPs on staff. IV estimates for the effects of NP-led care in FPA versus non-FPA states were also statistically insignificant at both the provider level and the practice level in both groups of states (Appendix Table A9).

*Cost outcomes: Adults with diabetes.* Among adults with diabetes, there were no statistically significant differences in FFS costs for NP- and physician-attributed patients (Figure 2A). Although unadjusted annual mean costs were lower for NP-attributed patients ($5525) than for physician-attributed patients ($8123, $P = .065$), the difference shrunk after weighting to achieve balance on observable characteristics (weighted annual mean cost for physician-attributed patients = $5815, $P = .74$). Findings with regard to NP-physician cost differences were similar in FPA and non-FPA states (Appendix Table A10).

*Cost outcomes: Children with asthma.* Among children with asthma, those attributed to NPs had lower total FFS costs compared to those attributed to physicians (Figure 2B). Unadjusted annual mean costs were lower for NP-attributed patients ($588) than physician-attributed patients ($1586,

**Table 2.** Linear Regression and Instrumental Variables Analysis of Quality for Adults With Diabetes.

| Outcomes | Hemoglobin A1c testing performed | LDL-C screening | Medical attention for nephropathy | All 3 procedures performed | None performed | Has one or more claims for diabetes-related admissions in 2013 |
|---|---|---|---|---|---|---|
| Explanatory variable: Provider-level attribution to NP | | | | | | |
| OLS estimate (standard error [SE]) | 0.012 (0.010) | 0.009 (0.011) | −0.003 (0.008) | 0.003 (0.011) | −0.005 (0.005) | 0.001 (0.003) |
| 2SLS (IV) estimate (SE) | −0.393 (0.249) | −0.420 (0.265) | −0.335 (0.193) | −0.454 (0.285) | 0.209 (0.131) | −0.117 (0.089) |
| Mean of outcome | 0.759 | 0.709 | 0.873 | 0.615 | 0.055 | 0.023 |
| N | 49855 | 49855 | 49855 | 49855 | 49855 | 49855 |
| Explanatory variable: Practice-level attribution to practice with NP(s) on staff | | | | | | |
| OLS estimate (SE) | 0.025*** (0.005) | −0.002 (0.005) | 0.008* (0.004) | 0.005 (0.005) | −0.009*** (0.003) | −0.001 (0.002) |
| 2SLS (IV) estimate (SE) | −0.077 (0.048) | −0.082 (0.051) | −0.065 (0.037) | −0.089 (0.055) | 0.041 (0.025) | −0.023 (0.017) |
| Mean of outcome | 0.759 | 0.709 | 0.873 | 0.615 | 0.055 | 0.023 |
| N | 49855 | 49855 | 49855 | 49855 | 49855 | 49855 |

*Note*. Standard errors are heteroskedasticity-robust. Instrument is differential distance from nearest primary care practice to nearest primary care practice with one or more NPs on staff. First-stage *F*-statistic for individual-level NP attribution was 116.1. First-stage *F*-statistic for practice-level NP attribution was 540.3. All models control for state fixed effects and all covariates listed in Appendix Table A2. OLS estimate = coefficient on indicator for patient attribution to NP from OLS regression of quality measure on attribution indicator and covariates; 2SLS (IV) estimate = coefficient on indicator for patient attribution to NP from OLS regression of quality measure on attribution indicator and covariates; N = sample size for 2SLS model.
$^{*}P < .05$. $^{***}P < .001$.

**Table 3.** Linear Regression and Instrumental Variables Analysis of Quality for Children With Asthma.

| Outcomes | Use of appropriate medications for children with asthma | Has one or more claims for asthma-related emergency department visits in 2013 | Has one or more claims for asthma-related admissions in 2013 |
|---|---|---|---|
| Explanatory variable: Provider-level attribution to NP | | | |
| OLS estimate (SE) | –0.047*** (0.013) | 0.0180* (0.00853) | –0.000115 (0.003) |
| 2SLS (IV) estimate (SE) | 0.012 (0.460) | 0.247 (0.298) | 0.002 (0.122) |
| Mean of outcome | 0.655 | 0.103 | 0.016 |
| N | 39744 | 39744 | 39744 |
| Explanatory variable: Practice-level attribution to practice with NP(s) on staff | | | |
| OLS estimate (SE) | –0.012* (0.006) | 0.00151 (0.00376) | –0.003 (0.001) |
| 2SLS (IV) estimate (SE) | 0.002 (0.072) | 0.0386 (0.0464) | 0.000 (0.019) |
| Mean of outcome | 0.655 | 0.103 | 0.016 |
| N | 39744 | 39744 | 39744 |

*Note*. Standard errors are heteroskedasticity-robust. Instrument is differential distance from nearest primary care practice to nearest primary care practice with one or more NPs on staff. First-stage *F*-statistic for individual-level NP attribution was 49.95. First-stage *F*-statistic for practice-level NP attribution was 289.11. All models control for state fixed effects and all covariates listed in Appendix Table A3.
OLS estimate = coefficient on indicator for patient attribution to NP from OLS regression of quality measure on attribution indicator and covariates; 2SLS (IV) estimate = coefficient on indicator for patient attribution to NP from OLS regression of quality measure on attribution indicator and covariates; N = sample size for 2SLS model.
*$P<.05$.***$P<.001$.

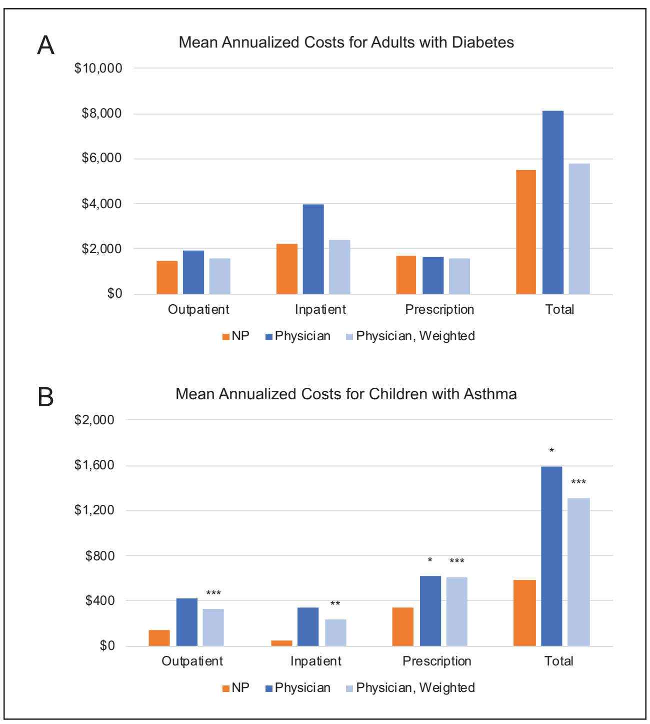


**Figure 2.** Fee-for-service cost outcomes for adults with diabetes and children with asthma. A. Mean Annualized Cost for Adults with Diabetes; B. Mean Annualized Costs for Children with Asthma.
*Note. P*-values represent standardized differences in mean annualized costs between (1) NP versus Physician and (2) NP versus Physician, Weighted. Total costs are the sum of inpatient, outpatient, and prescription costs.
NP = nurse practitioner.
*$P<.05$. **$P<.01$. ***$P<.001$.

$P=.02$). After weighting, costs remained significantly lower among children attributed to NPs (weighted annual mean cost for physician-attributed patients = $1306, $P<.01$). Findings with regard to NP-physician cost differences were similar in FPA and non-FPA states (Appendix Table A11).

## Discussion

To our knowledge, no previous studies have evaluated the cost and quality outcomes of NP-led primary care in a context with pay parity. Examining states with Medicaid pay parity, we found that NP-attributed adults with diabetes received comparable quality of care at similar cost to physician-attributed patients. Quality findings were mixed for children with asthma: NP-led care was associated with lower use of appropriate medications and a higher rate of asthma-related ED visits. However, rates of asthma-related hospitalization were not associated with NP-led care, and children with asthma had lower FFS costs under NP-led care. The association between NP-led care and health care quality or cost did not differ substantially in FPA states versus non-FPA states.

We observed notable demographic, geographic, and eligibility category differences among the population of Medicaid enrollees served by primary care NPs compared to those served by primary care physicians. These characteristics may be associated with quality and cost outcomes. For example, rural patients may face barriers with access to care, which could lead to lower rates of hemoglobin A1c testing and LDL cholesterol screening. In both populations examined here (adults with diabetes and children with asthma), patients attributed to NPs were more likely to live in rural areas. We also found that adults with diabetes who were attributed to NPs had differences in Medicaid eligibility category (i.e., more likely to qualify through Section 1931) that may suggest greater poverty compared to patients attributed to physicians. These findings are consistent with previous studies that suggest NPs are more likely than physicians to deliver primary care in rural and socioeconomically disadvantaged areas.[11-13]

Our findings for adults with diabetes suggest that if NPs and physicians treated the same patients, then quality of care would be similar. Without adjusting for patient characteristics, adult patients with diabetes attributed to NPs were less likely to receive hemoglobin A1c testing, LDL cholesterol screening, and medical attention for nephropathy. The fact that weighting to balance these characteristics between NP- and physician-attributed patients eliminated most quality differences suggests that quality differences in the unadjusted data were driven by differences in patient population rather than differences in provider behavior. However, for children with asthma, weighting for observable patient characteristics did not eliminate NP-physician differences in quality, suggesting a need for further research to better understand outcomes of NP-led care for children with asthma and other pediatric populations.

A limitation of many previous studies comparing quality and cost for NP- and physician-attributed patients is potential confounding due to unobserved differences in patient characteristics that may influence quality and cost outcomes. In our main analysis, in which we used weights based on observable patient characteristics, some NP-physician differences in quality remained (i.e., lower performance on use of appropriate medications and a higher rate of ED visits for children with asthma attributed to NPs). In IV analyses, we found no evidence of a causal relationship between NP attribution and quality of care, or between presence of NPs at the practice level and quality of care. We caution that, as is typical in IV analyses, the IV estimates were less precise than other estimates in our analysis, and so our results do not rule out clinically meaningful quality differences. However, the findings do not provide any evidence that such quality differences exist.

We also note that the focus of our study (the effects of receiving primary care from an NP, which we measure via patient attribution) is a patient-level variable. Potential concerns about the misuse of patient-level IVs to estimate the effects of practice- or facility-level characteristics therefore should not apply in this context.[51]

Few studies comparing costs for NP- and physician-attributed patients have accounted for lower reimbursement of NPs. In one study, Medicare beneficiaries attributed to NPs had 18% lower costs than those attributed to physicians even after accounting for case mix and differences in reimbursement.[14] Another study found that lower costs for NP-attributed Medicare beneficiaries were driven by lower service use by NPs, and NP-physician cost differences were greatest for low acuity patients.[52] We found that Medicaid FFS costs were similar for NP- and physician-attributed adults with diabetes, but children with asthma who received care from NPs versus physicians had significantly lower FFS costs across all spending categories. Though we did not have detailed clinical data to examine NP-physician cost differences by patient acuity, children with asthma had fewer chronic conditions, on average, than adults with diabetes (1.0 vs 4.5). Further research is needed to understand the potential drivers of lower FFS cost for children with asthma attributed to NPs versus physicians, including potential differences in patient acuity and differences in the volume or type of services provided.

We interpret these results in the context of several limitations. First, our comparisons of costs are limited to Medicaid FFS enrollees and are imprecise, due in part to small sample sizes. Our findings related to cost may not be generalizable to managed care enrollees, as we excluded managed care enrollees from cost analyses due to concerns about inaccurate encounter payments.[42,43] In addition, the completeness of provider NPI data in Medicaid claims varies widely across states,[53] limiting the number of patients we could attribute to providers. Newer Medicaid data in the T-MSIS Analytic File (TAF) may have more complete information on NPI, so this problem may be mitigated in future work using more recent data. Our patient sample was further restricted by limiting to patients attributed to providers in primary care specialties, as designated in SK&A. Further, it is unclear to what extent Medicaid claims data accurately distinguish services provided by NPs versus physicians. Current coding practices do not identify care delivered by NPs under indirect billing when an NP performs services but bills under a physician's name.[54,55] Studies that rely on billing provider NPIs may inaccurately attribute care delivered by NPs to physicians, in which case comparisons of NP- and physician-led care may be biased toward the null. Finally, recognizing that the best Medicaid data available for this study were several years old, and predated state Medicaid expansions, future research should explore if findings have changed as the Medicaid-insured population has grown.

## Conclusion

In the context of shifts in the composition of the primary care workforce and growing demand for care, NPs play an important role in delivery of high-quality primary care to Medicaid-enrolled patients, particularly in rural areas. Our findings suggest that in states with Medicaid pay parity, NP-led care is comparable to physician-led care for adults with diabetes, while associations between NP-led care and quality were mixed for children with asthma. The associations estimated here also suggest that increased use of NP-led primary care could be cost-neutral or cost-saving. However, further work is needed to obtain more precise estimates of the causal effect of NP-led care on cost and quality, both in Medicaid and in other settings beyond Medicare.

## Appendix A

**Table A1.** State Sample Selection.

| States with Medicaid pay parity for nurse practitioners in 2012 | Nurse practitioner scope of practice in 2012 | Included in study sample? | Percent of primary care practices sampled from SK&A (%) |
|---|---|---|---|
| California | Non-FPA | Yes | 33 |
| Delaware | Non-FPA | Yes | 100 |
| District of Columbia | FPA | | |
| Illinois | Non-FPA | | |
| Iowa | FPA | Yes | 100 |
| Louisiana | Non-FPA | | |
| Maine | FPA | Yes | 100 |
| Maryland | Non-FPA | | |
| Michigan | Non-FPA | Yes | 67 |
| Missouri | Non-FPA | Yes | 67 |
| Nebraska | Non-FPA | | |
| New Hampshire | FPA | | |
| New Jersey | Non-FPA | Yes | 67 |
| New York | Non-FPA | Yes | 33 |
| North Carolina | Non-FPA | | |
| Ohio | Non-FPA | Yes | 67 |
| Oklahoma | Non-FPA | | |
| Oregon | FPA | Yes | 100 |
| Pennsylvania | Non-FPA | | |
| Rhode Island | FPA | | |
| Tennessee | Non-FPA | Yes | 67 |
| Utah | Non-FPA | Yes | 100 |
| Virginia | Non-FPA | Yes | 67 |
| Washington | FPA | Yes | 100 |
| West Virginia | Non-FPA | | |
| Wisconsin | Non-FPA | | |
| Wyoming | FPA | Yes | 100 |

*Note*. FPA = full practice authority.

**Table A2.** Patient Characteristics: Adults With Diabetes.

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP-attributed | | MD-attributed | | Standardized difference+ | Standardized difference+ |
| | N or mean | % or SD | N or mean | % or SD | N or mean | % or SD | | |
| Number of patients | 49907 | 100.00 | 2272 | 4.55 | 47635 | 95.45 | | |
| Demographics | | | | | | | | |
| Age (mean, SD) | 48.19 | 0.05 | 46.14 | 0.23 | 48.29 | 0.05 | −0.20*** | 0.00 |
| Female, n (%) | 31618 | 63.35 | 1621 | 71.35 | 29997 | 62.97 | 0.18*** | 0.00 |
| Race/ethnicity, n (%) | | | | | | | | |
| Non-Hispanic White | 22258 | 44.60 | 1486 | 65.40 | 20772 | 43.61 | 0.45*** | 0.00 |
| Non-Hispanic Black | 12082 | 24.21 | 392 | 17.25 | 11690 | 24.54 | −0.18*** | 0.00 |
| Hispanic | 8429 | 16.89 | 209 | 9.20 | 8220 | 17.26 | −0.24*** | 0.00 |
| Other race/ethnicity | 7188 | 14.40 | 185 | 8.14 | 7003 | 14.70 | −0.21*** | 0.00 |
| Medicaid variables | | | | | | | | |
| Eligibility category, n (%) | | | | | | | | |
| Blind/disabled | 28772 | 57.65 | 1429 | 62.90 | 27343 | 57.40 | 0.11*** | 0.00 |
| Section 1931 | 8472 | 16.98 | 486 | 21.39 | 7986 | 16.76 | 0.12*** | 0.00 |

(continued)

**Table A2.** *(continued)*

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP-attributed | | MD-attributed | | Standardized difference+ | Standardized difference+ |
| | N or mean | % or SD | N or mean | % or SD | N or mean | % or SD | | |
| Other poverty | 2091 | 4.19 | 87 | 3.83 | 2004 | 4.21 | −0.02 | 0.00 |
| Section 1115 | 7605 | 15.24 | 116 | 5.11 | 7489 | 15.72 | −0.35*** | 0.00 |
| Medically needy | 1203 | 2.41 | ++ | ++ | ++ | ++ | −0.13*** | 0.00 |
| Foster care | 10 | 0.02 | ++ | ++ | ++ | ++ | 0.01 | 0.00 |
| Other | 1754 | 3.51 | 134 | 5.90 | 1620 | 3.40 | 0.12*** | 0.00 |
| MMC 2012, n (%) | | | | | | | | |
| CMC | 42951 | 86.06 | 2018 | 88.82 | 40933 | 85.93 | 0.09*** | 0.00 |
| FFS | 3317 | 6.65 | 181 | 7.97 | 3136 | 6.58 | 0.05* | 0.00 |
| Other | 3639 | 7.29 | 73 | 3.21 | 3566 | 7.49 | −0.19*** | 0.00 |
| Health status | | | | | | | | |
| Number of comorbidities (mean, SD) | 4.53 | 0.01 | 4.30 | 0.06 | 4.54 | 0.01 | −0.08*** | 0.00 |
| Geographic variables | | | | | | | | |
| Urban/rural setting, n (%) | | | | | | | | |
| Metro | 42703 | 85.63 | 1339 | 58.96 | 41364 | 86.90 | −0.66*** | 0.00 |
| Non-metro, adjacent | 5553 | 11.13 | 709 | 31.22 | 4844 | 10.18 | 0.54*** | 0.00 |
| Non-metro, not adjacent | 1615 | 3.24 | 223 | 9.82 | 1392 | 2.92 | 0.29*** | 0.00 |
| State | | | | | | | | |
| CA | 7011 | 14.05 | 29 | 1.28 | 6982 | 14.66 | −0.51*** | 0.00 |
| DE | 628 | 1.26 | 20 | 0.88 | 608 | 1.28 | −0.04 | 0.00 |
| IA | 852 | 1.71 | 66 | 2.90 | 786 | 1.65 | 0.08*** | 0.00 |
| ME | 521 | 1.04 | 73 | 3.21 | 448 | 0.94 | 0.16*** | 0.00 |
| MI | 3989 | 7.99 | 44 | 1.94 | 3945 | 8.28 | −0.29*** | 0.00 |
| NJ | 3597 | 7.21 | 78 | 3.43 | 3519 | 7.39 | −0.18*** | 0.00 |
| NY | 15673 | 31.40 | 357 | 15.71 | 15316 | 32.15 | −0.39*** | 0.00 |
| OH | 7387 | 14.80 | 263 | 11.58 | 7124 | 14.96 | −0.10*** | 0.00 |
| OR | 1348 | 2.70 | 157 | 6.91 | 1191 | 2.50 | 0.21*** | 0.00 |
| TN | 4991 | 10.00 | 1015 | 44.67 | 3976 | 8.35 | 0.90*** | 0.00 |
| UT | 269 | 0.54 | 11 | 0.48 | 258 | 0.54 | −0.01 | 0.00 |
| VA | 3082 | 6.18 | 78 | 3.43 | 3004 | 6.31 | −0.13*** | 0.00 |
| WA | 454 | 0.91 | 69 | 3.04 | 385 | 0.81 | 0.16*** | 0.00 |
| WY | 105 | 0.21 | 12 | 0.53 | 93 | 0.20 | 0.06** | 0.00 |

+Standardized difference was calculated as the average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients. Medicaid eligibility categories are defined based on uniform eligibility codes: Blind/disabled = 14, 32, 42; Section 1931 = 14, 15, 16, 17; Other poverty = 31, 34, 35; Section 1115 = 51, 52, 54, 55; Medically needy = 21, 22, 24, 25; Foster care = 48; Other = all else.
++Data have been censored to mask cells with fewer than 10 observations.
*$P < .05$. **$P < .01$. ***$P < .001$.

**Table A3.** Patient Characteristics: Children With Asthma.

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP-attributed | | MD-attributed | | Standardized difference+ | Standardized difference+ |
| | N or mean | % or SD | N or mean | % or SD | N or mean | % or SD | | |
| Number of patients | 39765 | 100.00 | 1396 | 3.51 | 38369 | 96.49 | | |
| Demographics | | | | | | | | |
| Age, mean (SD) | 8.91 | 0.02 | 9.37 | 0.09 | 8.90 | 0.02 | 0.14*** | 0.00 |
| Female, n (%) | 16536 | 41.58 | 605 | 43.34 | 15931 | 41.52 | 0.04 | 0.00 |

*(continued)*

**Table A3. (continued)**

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP-attributed | | MD-attributed | | Standardized difference+ | Standardized difference+ |
| | N or mean | % or SD | N or mean | % or SD | N or mean | % or SD | | |
| Race/ethnicity, n (%) | | | | | | | | |
| Non-Hispanic White | 14834 | 37.30 | 765 | 54.80 | 14069 | 36.67 | 0.37*** | 0.00 |
| Non-Hispanic Black | 11470 | 28.84 | 322 | 23.07 | 11148 | 29.05 | –0.14*** | 0.00 |
| Hispanic | 10079 | 25.35 | 184 | 13.18 | 9895 | 25.79 | –0.32*** | 0.00 |
| Other race/ethnicity | 3568 | 8.97 | 129 | 9.24 | 3439 | 8.96 | 0.01 | 0.00 |
| Medicaid variables | | | | | | | | |
| Eligibility category, n (%) | | | | | | | | |
| Blind/disabled | 3836 | 9.65 | 103 | 7.38 | 3733 | 9.73 | –0.08*** | 0.00 |
| Section 1931 | 16197 | 40.73 | 579 | 41.48 | 15618 | 40.70 | 0.02 | 0.00 |
| Other poverty | 16138 | 40.58 | 580 | 41.55 | 15558 | 40.55 | 0.02 | 0.00 |
| Section 1115 | 141 | 0.35 | ++ | ++ | 126 | 0.33 | 0.09*** | 0.00 |
| Medically needy | 903 | 2.27 | ++ | ++ | 897 | 2.34 | –0.16*** | 0.00 |
| Foster care | 970 | 2.44 | 31 | 2.22 | 939 | 2.45 | –0.02 | 0.00 |
| Other | 1580 | 3.97 | 82 | 5.87 | 1498 | 3.90 | 0.09*** | 0.00 |
| MMC 2012, n (%) | | | | | | | | |
| CMC | 35080 | 88.22 | 1218 | 87.25 | 33862 | 88.25 | –0.03 | 0.00 |
| FFS | 1818 | 4.57 | 96 | 6.88 | 1722 | 4.49 | 0.10*** | 0.00 |
| Other | 2867 | 7.21 | 82 | 5.87 | 2785 | 7.26 | –0.06* | 0.00 |
| Health status | | | | | | | | |
| Number of comorbidities (mean, SD) | 1.02, 0.01 | | 0.94, 0.03 | | 1.03, 0.01 | | –0.07** | 0.00 |
| Geographic variables | | | | | | | | |
| Urban/rural setting, n (%) | | | | | | | | |
| Metro | 35350 | 88.90 | 950 | 68.05 | 34400 | 89.66 | –0.55*** | 0.00 |
| Non-metro, adjacent | 3495 | 8.79 | 321 | 22.99 | 3174 | 8.27 | 0.41*** | 0.00 |
| Non-metro, not adjacent | 918 | 2.31 | 125 | 8.95 | 793 | 2.07 | 0.31*** | 0.00 |
| State, n (%) | | | | | | | | |
| CA | 3793 | 9.54 | 37 | 2.65 | 3756 | 9.79 | –0.30*** | 0.00 |
| DE | 697 | 1.75 | 21 | 1.50 | 676 | 1.76 | –0.02 | 0.00 |
| IA | 855 | 2.15 | 68 | 4.87 | 787 | 2.05 | 0.15*** | 0.00 |
| ME | 263 | 0.66 | 23 | 1.65 | 240 | 0.63 | 0.10*** | 0.00 |
| MI | 2742 | 6.90 | ++ | ++ | 2737 | 7.13 | –0.36*** | 0.00 |
| NJ | 7140 | 17.96 | 77 | 5.52 | 7063 | 18.41 | –0.41*** | 0.00 |
| NY | 9952 | 25.03 | 182 | 13.04 | 9770 | 25.46 | –0.32*** | 0.00 |
| OH | 4273 | 10.75 | 195 | 13.97 | 4078 | 10.63 | 0.10*** | 0.00 |
| OR | 862 | 2.17 | 69 | 4.94 | 793 | 2.07 | 0.16*** | 0.00 |
| TN | 4050 | 10.18 | 488 | 34.96 | 3562 | 9.28 | 0.65*** | 0.00 |
| UT | 271 | 0.68 | 15 | 1.07 | 256 | 0.67 | 0.04 | 0.00 |
| VA | 3782 | 9.51 | 79 | 5.66 | 3703 | 9.65 | –0.15*** | 0.00 |
| WA | 984 | 2.47 | 132 | 9.46 | 852 | 2.22 | 0.31*** | 0.00 |
| WY | 101 | 0.25 | ++ | ++ | 96 | 0.25 | 0.02 | 0.00 |

*Note*. SD = standard deviation.
+Standardized difference was calculated as the average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients. Medicaid eligibility categories are defined based on uniform eligibility codes: Blind/disabled = 14, 32, 42; Section 1931 = 14, 15, 16, 17; Other poverty = 31, 34, 35; Section 1115 = 51, 52, 54, 55; Medically needy = 21, 22, 24, 25; Foster care = 48; Other = all else.
++Data have been censored to mask cells with fewer than 10 observations.
*$P < .05$. **$P < .01$. ***$P < .001$.

**Table A4.** Quality Outcomes: Adults With Diabetes.

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP–attributed | | MD–attributed | | | |
| | N | % | N | % | N | % | Standardized difference+ | Standardized difference+ |
| Number of observations | 49 907 | 100 | 2272 | 4.552 | 47 635 | 95.45 | | |
| Outcomes | | | | | | | | |
| Hemoglobin A1c (HbA1c) testing performed | | | | | | | | |
| Overall | 37 890 | 75.92 | 1685 | 74.16 | 36 205 | 76.01 | −0.04* | 0.02 |
| Non-FPA states | 35 071 | 75.22 | 1368 | 72.19 | 33 703 | 75.34 | −0.07** | 0.02 |
| FPA states | 2819 | 85.95 | 317 | 84.08 | 2502 | 86.19 | −0.06 | 0.01 |
| LDL-C screening | | | | | | | | |
| Overall | 35 398 | 70.93 | 1499 | 65.98 | 33 899 | 71.16 | −0.11*** | 0.02 |
| Non-FPA states | 33 040 | 70.86 | 1241 | 65.49 | 31 799 | 71.09 | −0.12*** | 0.03 |
| FPA states | 2358 | 71.89 | 258 | 68.44 | 2100 | 72.34 | −0.09 | −0.01 |
| Medical attention for nephropathy | | | | | | | | |
| Overall | 43 542 | 87.25 | 1944 | 85.56 | 41 598 | 87.33 | −0.05* | 0.00 |
| Non-FPA states | 40 729 | 87.35 | 1624 | 85.70 | 39 105 | 87.42 | −0.05* | −0.01 |
| FPA states | 2813 | 85.76 | 320 | 84.88 | 2493 | 85.88 | −0.03 | 0.00 |
| All 3 performed | | | | | | | | |
| Overall | 30 666 | 61.45 | 1266 | 55.72 | 29 400 | 61.72 | −0.12*** | 0.00 |
| Non-FPA states | 28 582 | 61.30 | 1047 | 55.25 | 27 535 | 61.56 | −0.13*** | 0.02 |
| FPA states | 2084 | 63.54 | 219 | 58.09 | 1865 | 64.24 | −0.13* | −0.06 |
| None performed | | | | | | | | |
| Overall | 2754 | 5.52 | 123 | 5.41 | 2631 | 5.52 | 0.00 | −0.03 |
| Non-FPA states | 2612 | 5.60 | 109 | 5.75 | 2503 | 5.60 | 0.01 | −0.02 |
| FPA states | 142 | 4.33 | 14 | 3.71 | 128 | 4.41 | −0.04 | −0.10 |
| Has one or more claims for diabetes-related admissions in 2013 | | | | | | | | |
| Overall | 1122 | 2.25 | 48 | 2.11 | 1074 | 2.25 | −0.01 | 0.01 |
| Non-FPA states | 1060 | 2.27 | 43 | 2.27 | 1017 | 2.27 | 0.00 | 0.02 |
| FPA states | 62 | 1.89 | ++ | ++ | 57 | 1.96 | −0.05 | −0.06 |

+Standardized difference was calculated as the average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients.
++Data have been censored to mask cells with fewer than 10 observations.
*$P < .05$. **$P < .01$. ***$P < .001$.

**Table A5.** Quality Outcomes: Children With Asthma.

| | Unweighted | | | | | | | Weighted |
|---|---|---|---|---|---|---|---|---|
| | Total | | NP-attributed | | MD-attributed | | | |
| | N or mean | % or SD | N or mean | % or SD | N or mean | % or SD | Standardized difference+ | Standardized difference+ |
| Number of observations | 39765 | 100.00 | 1396 | 3.51 | 38369 | 96.49 | | |
| Outcomes | | | | | | | | |
| Use of appropriate medications for children with asthma, n (%) | | | | | | | | |
| Overall | 26042 | 65.49 | 824 | 59.03 | 25218 | 65.72 | –0.14*** | –0.10** |
| Non-FPA states | 23987 | 65.36 | 628 | 57.14 | 23359 | 65.61 | –0.17*** | –0.11** |
| FPA states | 2055 | 67.05 | 196 | 65.99 | 1859 | 67.16 | –0.02 | –0.03 |
| Has one or more claims for asthma-related emergency department visits in 2013, n (%) | | | | | | | | |
| Overall | 4091 | 10.29 | 150 | 10.74 | 3941 | 10.27 | 0.02 | 0.06* |
| Non-FPA states | 3826 | 10.43 | 120 | 10.92 | 3706 | 10.41 | 0.02 | 0.06 |
| FPA states | 265 | 8.65 | 30 | 10.10 | 235 | 8.49 | 0.06 | 0.06 |
| Has one or more claims for asthma-related admissions in 2013, n (%) | | | | | | | | |
| Overall | 632 | 1.59 | 16 | 1.15 | 616 | 1.61 | –0.04 | 0.00 |
| Non-FPA states | 580 | 1.58 | 11 | 1.00 | 569 | 1.60 | –0.05 | 0.00 |
| FPA states | 52 | 1.70 | ++ | ++ | 47 | 1.70 | 0.00 | 0.01 |

+Standardized difference was calculated as the average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients.
++Data have been censored to mask cells with fewer than 10 observations.
*$P < .05$. **$P < .01$. ***$P < .001$.

**Table A6.** Reduced-Form Estimates of Association Between Differential Distance and Quality for Adults With Diabetes.

| Outcomes | Hemoglobin A1c testing performed | LDL-C screening | Medical attention for nephropathy | All 3 procedures performed | None performed | Has one or more claims for diabetes-related admissions in 2013 |
|---|---|---|---|---|---|---|
| Explanatory variable: Differential distance to NP practice | | | | | | |
| OLS estimate (standard error (SE)) | 0.00258 (0.00162) | 0.00276 (0.00172) | 0.00220 (0.00126) | 0.00297 (0.00185) | −0.00137 (0.000852) | 0.000770 (0.000580) |
| Mean of outcome | 0.759 | 0.709 | 0.873 | 0.615 | 0.055 | 0.023 |
| N | 49855 | 49855 | 49855 | 49855 | 49855 | 49855 |

*Note.* Differential distance = ln(dist_NP)—ln(dist), where dist_NP is the distance to the nearest primary care practice with one or more NPs, and dist is the distance to the nearest primary care practice. Table reports coefficients (standard errors) on differential distance in reduced-form models corresponding to 2SLS estimates reported in Table 2 of manuscript. Regressions control for all covariates used in regression models. All reduced-form estimates were statistically insignificant at the 5% level.

**Table A7.** Reduced-Form Estimates of Association Between Differential Distance and Quality for Children With Asthma.

| Outcomes | Use of appropriate medications for children with asthma | Has one or more claims for asthma-related emergency department visits in 2013 | Has one or more claims for asthma-related admissions in 2013 |
|---|---|---|---|
| Explanatory variable: Differential distance to NP practice | | | |
| OLS estimate (SE) | −0.00005 (0.00201) | −0.00108 (0.00129) | −0.00001 (0.00053) |
| Mean of outcome | 0.655 | 0.103 | 0.016 |
| N | 39744 | 39744 | 39744 |

*Note*. Differential distance = ln(dist_NP)—ln(dist), where dist_NP is the distance to the nearest primary care practice with 1 or more NPs, and dist is the distance to the nearest primary care practice. Table reports coefficients (standard errors) on differential distance in reduced-form models corresponding to 2SLS estimates reported in Table 3 of manuscript. Regressions control for all covariates used in regression models. All reduced-form estimates were statistically insignificant at the 5% level.

**Table A8.** Linear Regression and Instrumental Variables Analysis of Quality for Adults With Diabetes, Stratified by FPA and Non-FPA States.

| Outcomes | Hemoglobin A1c testing performed | LDL-C screening | Medical attention for nephropathy | All 3 procedures performed | None performed | Has one or more claims for diabetes-related admissions in 2013 |
|---|---|---|---|---|---|---|
| Explanatory variable: Provider-level attribution to NP | | | | | | |
| Non-FPA states | | | | | | |
| OLS estimate (SE) | 0.0158 (0.0109) | 0.0145 (0.0116) | −0.00350 (0.00850) | 0.0124 (0.0120) | −0.00324 (0.00571) | 0.0158 (0.0109) |
| 2SLS (IV) estimate (SE) | −0.460 (0.294) | −0.531 (0.309) | −0.392 (0.225) | −0.572 (0.333) | 0.242 (0.155) | −0.460 (0.294) |
| Mean of outcome | 0.7521 | 0.7086 | 0.8736 | 0.6131 | 0.0560 | 0.7521 |
| N | 46 579 | 46 579 | 46 579 | 46 579 | 46 579 | 46 579 |
| FPA states | | | | | | |
| OLS estimate (SE) | −0.00290 (0.0211) | −0.00312 (0.0258) | −0.00219 (0.0202) | −0.0331 (0.0276) | −0.0183 (0.0112) | −0.00290 (0.0211) |
| 2SLS (IV) estimate (SE) | −0.186 (0.304) | −0.0637 (0.401) | 0.00914 (0.296) | −0.00572 (0.425) | 0.0723 (0.166) | −0.186 (0.304) |
| Mean of outcome | 0.8599 | 0.7192 | 0.8574 | 0.6355 | 0.0433 | 0.8599 |
| N | 3276 | 3276 | 3276 | 3276 | 3276 | 3276 |
| Explanatory variable: Practice-level attribution to practice with NP(s) on staff | | | | | | |
| Non-FPA states | | | | | | |
| OLS estimate (SE) | 0.0254** (0.00506) | −0.00174 (0.00544) | 0.00808* (0.00388) | 0.00566 (0.00571) | −0.00786** (0.00267) | 0.0254** (0.00506) |
| 2SLS (IV) estimate (SE) | −0.0859 (0.0546) | −0.0992 (0.0571) | −0.0732 (0.0416) | −0.107 (0.0616) | 0.0452 (0.0287) | −0.0859 (0.0546) |
| Mean of outcome | 0.7521 | 0.7086 | 0.8736 | 0.6131 | 0.0560 | 0.7521 |
| N | 46 579 | 46 579 | 46 579 | 46 579 | 46 579 | 46 579 |
| FPA states | | | | | | |
| OLS estimate (SE) | 0.0264** (0.0125) | −0.000973 (0.0160) | 0.00485 (0.0125) | −0.000245 (0.0172) | −0.0171** (0.00737) | 0.0264** (0.0125) |
| 2SLS (IV) estimate (SE) | −0.0493 (0.0802) | −0.0169 (0.107) | 0.00243 (0.0786) | −0.00152 (0.113) | 0.0192 (0.0439) | −0.0493 (0.0802) |
| Mean of outcome | 0.8599 | 0.7192 | 0.8574 | 0.6355 | 0.0433 | 0.8599 |
| N | 3276 | 3276 | 3276 | 3276 | 3276 | 3276 |

*Note.* Differential distance = ln(dist_NP)—ln(dist), where dist_NP is the distance to the nearest primary care practice with 1 or more NPs, and dist is the distance to the nearest primary care practice. Table reports coefficients (standard errors) on differential distance in first-stage models corresponding to 2SLS estimates reported in Table 2 of manuscript (First stage is identical for all outcomes). Regressions control for all covariates used in regression models.
$^*P < .05$. $^{**}P < .01$.

**Table A9.** Linear Regression and Instrumental Variables Analysis of Quality for Children With Asthma, Stratified by FPA and Non-FPA States.

| Outcomes | Use of appropriate medications for children with asthma | Has one or more claims for asthma-related emergency department visits in 2013 | Has one or more claims for asthma-related admissions in 2013 |
|---|---|---|---|
| Explanatory variable: Provider-level attribution to NP | | | |
| Non-FPA states | | | |
| OLS estimate (SE) | –0.0532*** (0.0151) | 0.0169 (0.00964) | –0.000683 (0.00313) |
| 2SLS (IV) estimate (SE) | 0.0912 (0.528) | 0.324 (0.342) | –0.0663 (0.141) |
| Mean of outcome | 0.6535 | 0.1042 | 0.0158 |
| N | 36682 | 36682 | 36682 |
| FPA states | | | |
| OLS estimate (SE) | –0.0168 (0.0286) | 0.0184 (0.0183) | 0.000410 (0.00794) |
| 2SLS (IV) estimate (SE) | –0.329 (0.710) | –0.223 (0.462) | 0.285 (0.199) |
| Mean of outcome | 0.6708 | 0.08654 | 0.0170 |
| N | 3062 | 3062 | 3062 |
| Explanatory variable: Practice-level attribution to practice with NP(s) on staff | | | |
| Non-FPA states | | | |
| OLS estimate (SE) | –0.0116 (0.00617) | 0.00109 (0.00404) | –0.00317* (0.00154) |
| 2SLS (IV) estimate (SE) | 0.0137 (0.0793) | 0.0488 (0.0512) | –0.00996 (0.0212) |
| Mean of outcome | 0.6535 | 0.1042 | 0.0158 |
| N | 36682 | 36682 | 36682 |
| FPA states | | | |
| OLS estimate (SE) | –0.0107 (0.0167) | 0.00223 (0.0103) | 0.00118 (0.00451) |
| 2SLS (IV) estimate (SE) | –0.0745 (0.159) | –0.0504 (0.103) | 0.0644 (0.0380) |
| Mean of outcome | 0.6708 | 0.0865 | 0.0170 |
| N | 3062 | 3062 | 3062 |

*Note.* Differential distance = ln(dist_NP)—ln(dist), where dist_NP is the distance to the nearest primary care practice with one or more NPs, and dist is the distance to the nearest primary care practice. Table reports coefficients (standard errors) on differential distance in first-stage models corresponding to 2SLS estimates reported in Table 3 of manuscript (First stage is identical for all outcomes). Regressions control for all covariates used in regression models.
*$P < .05$. ***$P < .001$.

**Table A10.** Fee-for-Service Cost Outcomes: Adults With Diabetes.

| Total annualized costs | Total (N = 3317) | | | NP-attributed patients (N = 181) | | | Physician-attributed patients (N = 3136) | | | Standardized difference in mean cost+ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N non-zero | Mean | SD | N non-zero | Mean | SD | N non-zero | Mean | SD | Unweighted | Weighted |
| Outpatient | | | | | | | | | | | |
| Overall | 2059 | $1902 | $4795 | 123 | $1483 | $3311 | 1936 | $1927 | $4868 | −0.11 | −0.03 |
| Non-FPA | 1475 | $2112 | $5304 | 44 | $1753 | $4057 | 1431 | $2123 | $5338 | −0.078 | −0.065 |
| FPA | 584 | $1269 | $2635 | 79 | $1304 | $2718 | 505 | $1264 | $2624 | 0.015 | 0.002 |
| Inpatient | | | | | | | | | | | |
| Overall | 501 | $3862 | $11986 | 23 | $2253 | $7386 | 478 | $3957 | $12198 | −0.17 | −0.02 |
| Non-FPA | 419 | $4567 | $13171 | 11 | $3523 | $10172 | 408 | $4599 | $13253 | −0.091 | −0.038 |
| FPA | 82 | $1733 | $6911 | 12 | $1411 | $4600 | 70 | $1783 | $7207 | −0.062 | −0.018 |
| Prescription | | | | | | | | | | | |
| Overall | 1330 | $1653 | $2798 | 71 | $1704 | $2796 | 1259 | $1650 | $2799 | 0.02 | 0.06 |
| Non-FPA | 989 | $1730 | $2896 | 29 | $2104 | $2879 | 960 | $1718 | $2897 | 0.134 | 0.109 |
| FPA | 341 | $1423 | $2468 | 42 | $1439 | $2724 | 299 | $1420 | $2428 | 0.007 | −0.016 |
| Total | | | | | | | | | | | |
| Overall | 2145 | $7978 | $16350 | 127 | $5525 | $10174 | 2018 | $8123 | $16634 | −0.19 | −0.03 |
| Non-FPA | 1548 | $9143 | $18055 | 47 | $7579 | $13570 | 1501 | $9191 | $18175 | −0.101 | −0.061 |
| FPA | 597 | $4462 | $8609 | 80 | $4163 | $6848 | 517 | $4508 | $8857 | −0.044 | −0.021 |

*Note.* Total costs are based on the sum of inpatient, outpatient, and prescription costs.
SD = standard deviation.
+Standardized difference calculated as average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients.

**Table A11.** Fee-for-Service Cost Outcomes: Children With Asthma.

| Total annualized costs | Total (N = 1818) | | | NP-attributed patients (N = 96) | | | Physician-attributed patients (N = 1722) | | | Standardized difference in mean cost⁺ | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | N non-zero | Mean | SD | N non-zero | Mean | SD | N non-zero | Mean | SD | Unweighted | Weighted |
| Outpatient | | | | | | | | | | | |
| Overall | 901 | $402 | $1241 | 36 | $147 | $322 | 865 | $417 | $1273 | −0.29 | −0.27*** |
| Non-FPA | 619 | $448 | $1409 | 15 | $130 | $370 | 604 | $464 | $1439 | −0.318 | −0.33*** |
| FPA | 282 | $266 | $458 | 21 | $177 | $217 | 261 | $273 | $472 | −0.263 | −0.22 |
| Inpatient | | | | | | | | | | | |
| Overall | 58 | $319 | $1755 | 1 | $45 | $404 | 57 | $335 | $1801 | −0.22 | −0.19** |
| Non-FPA | 44 | $341 | $1838 | 1 | $71 | $506 | 43 | $354 | $1879 | −0.206 | −0.19* |
| FPA | 14 | $256 | $1481 | 0 | $0 | $0 | 14 | $278 | $1541 | −0.255 | −0.21*** |
| Prescription | | | | | | | | | | | |
| Overall | 921 | $600 | $962 | 39 | $345 | $583 | 882 | $615 | $978 | −0.34* | −0.37*** |
| Non-FPA | 626 | $635 | $1053 | 16 | $293 | $627 | 610 | $652 | $1067 | −0.410 | −0.52*** |
| FPA | 295 | $497 | $610 | 23 | $436 | $493 | 272 | $503 | $619 | −0.119 | −0.07 |
| Total | | | | | | | | | | | |
| Overall | 1161 | $1531 | $3724 | 48 | $588 | $990 | 1113 | $1586 | $3816 | −0.36* | −0.35*** |
| Non-FPA | 812 | $1692 | $4100 | 23 | $573 | $1177 | 789 | $1747 | $4184 | −0.382* | −0.43*** |
| FPA | 349 | $1059 | $2223 | 25 | $613 | $541 | 324 | $1097 | $2306 | −0.289 | −0.24* |

*Note.* Total costs are based on the sum of inpatient, outpatient, and prescription costs.
⁺Standardized difference calculated as average rate of outcome for NP-attributed patients minus average rate of outcome for physician-attributed patients.
$^{*}P < .05$. $^{**}P < .01$. $^{***}P < .001$.

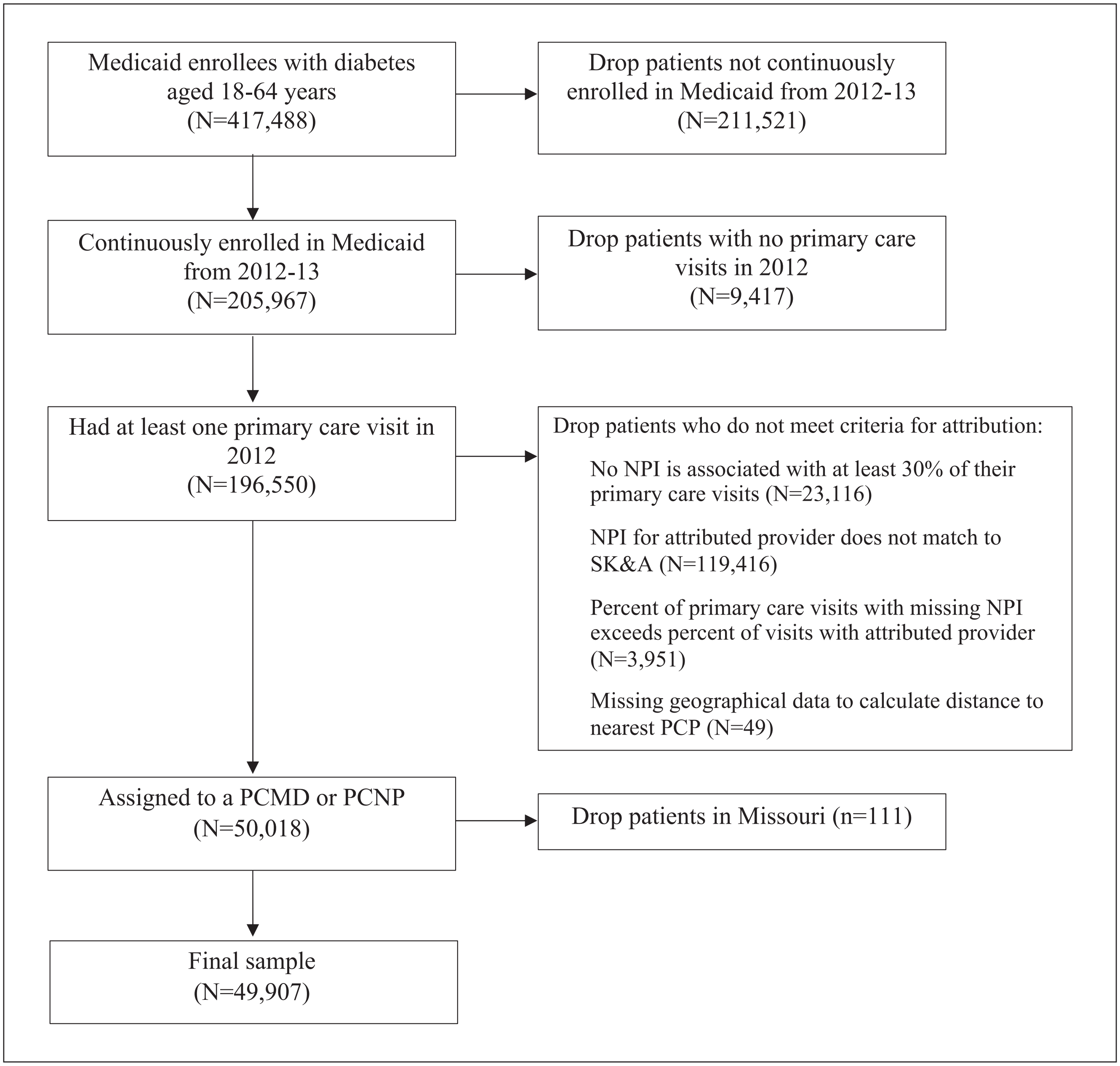


**Figure A1.** Patient flow diagram: Adults with diabetes.
*Note.* PCMD = primary care physician; PCNP = primary care nurse practitioner.

## Appendix B: Methods

### *Appendix B-1: Calculation of Differential Distance*

We used Google Maps Application Programming Interfaces to calculate the driving distance between patient ZIP code centroids and practice coordinates (latitude and longitude) obtained from SK&A. Because distance to practices is skewed and nonnegative, we took the natural log of the distance to each practice before calculating differential distance. For instance, if a patient's distance to the nearest practice was 3 km and distance to the nearest practice with a nurse practitioner (NP) was 5 km, then the differential distance measure would be ln(5)-ln(3). This functional form for differential distance captures the percentage increase in travel distance to a practice with an NP relative to the nearest practice, allowing us to analyze patients with very different distances to practices (eg, metropolitan and non-metropolitan patients) in the same model. For example, a patient with a distance of 30 km to the nearest practice and 50 km to the nearest NP practice would have the same differential

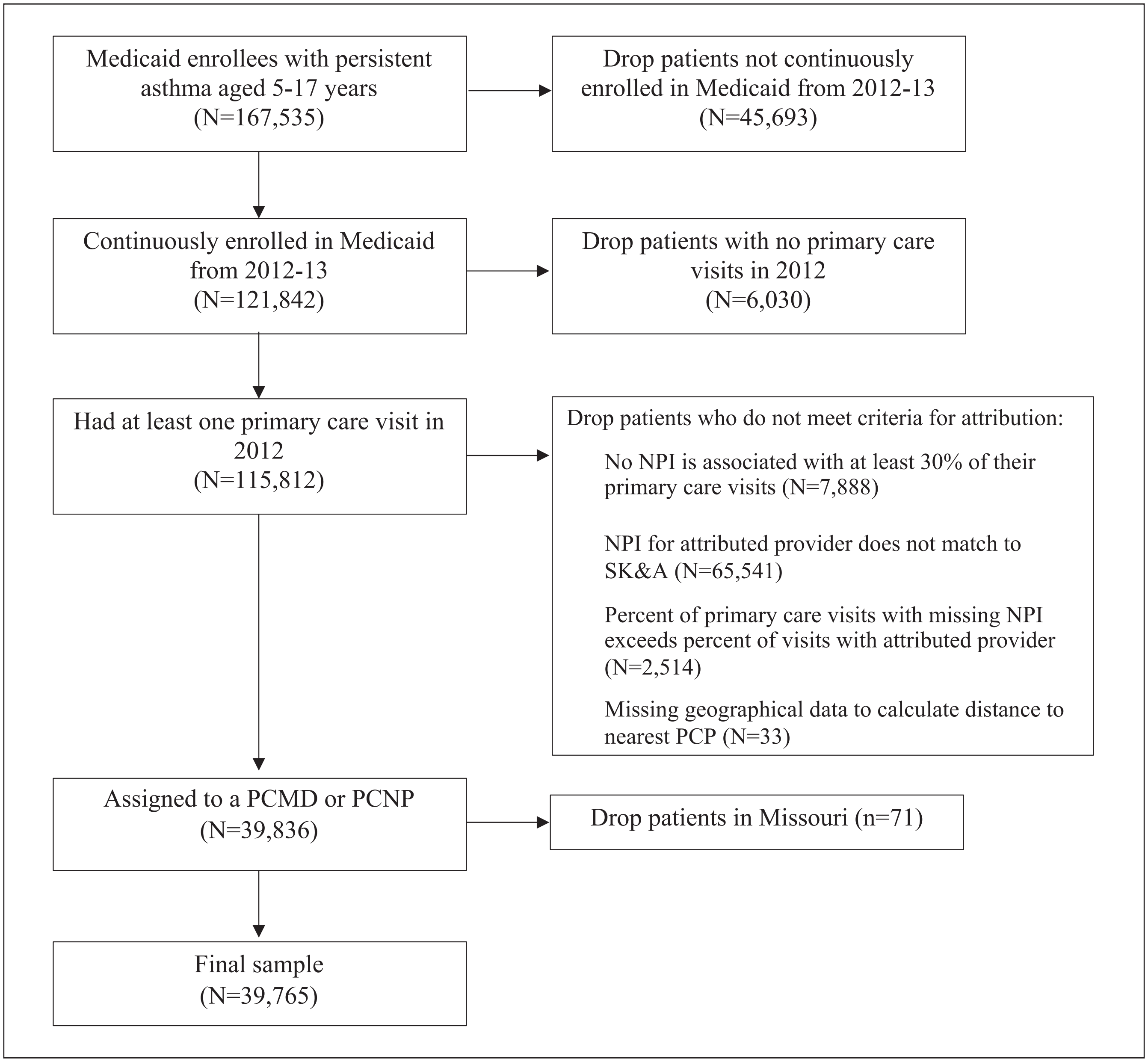


**Figure A2.** Patient flow diagram: Children with persistent asthma.
*Note.* PCMD = primary care physician; PCNP = primary care nurse practitioner.

distance measure as a patient with a distance of 3 km to the nearest practice and 5 km to the nearest NP practice. Without the log transformation, the differential distance measure would contain some large outliers that could be excessively influential on our estimates.

## *Appendix B-2: Additional Discussion of Instrumental Variables Methods and Instrument Validity*

The IV analysis in this study uses a differential distance strategy similar to that used in other papers.[46] This approach requires three key assumptions for the IV estimates to identify the causal effect of NP attribution on outcomes: relevance, exclusion, and monotonicity.[56] First-stage F-statistics on the excluded instruments, which can be used to test relevance, were discussed in the manuscript. Here, we provide further discussion of the validity of the relevance, exclusion, and monotonicity IV assumptions.

The relevance assumption is testable, and we confirmed that differential distance to an NP practice is a strong predictor of NP attribution. The first-stage F-statistics on the differential distance instruments are 116 for adults with diabetes and 50 for children with asthma and, both well above the threshold of 10 customarily viewed as a warning sign of weak instruments (see Appendix for first-stage regression tables and discussion).[iv] First-stage F-statistics for practice-level attribution were even higher, equaling 289 for children with asthma and 540 for adults with diabetes. We note that many more patients were attributed to a practice with NPs on staff than are attributed to an NP at the individual level. For children with asthma, 24.7% of patients are attributed to a practice with an NP on staff, versus 3.5% of patients attributed to an NP at the individual level. For adults with diabetes, 23.5% of patients are attributed to a practice with an NP on staff, versus 4.55% of patients attributed to an NP at the individual level.

For children with asthma, a 10% increase in the differential distance to an NP practice is associated with an 0.04 percentage point reduction in the probability of NP attribution, a 1.2% reduction relative to the sample average NP attribution rate of 3.51%. For adults, a 10% increase in the differential distance to an NP practice is associated with an 0.07 percentage point reduction in the probability of NP attribution, a 1.5% reduction relative to the sample average NP attribution rate of 4.55%.

The exclusion restriction necessary for IV to identify causal effects is that differential distance does not directly affect cost or quality outcomes, so that any causal effect of differential distance on outcomes operates only through its effect on the treatment variable (i.e., patient attribution to an NP practice). This assumption cannot be tested, but we think it is unlikely that the differential distance from a patient residence to an NP practice would be associated with unobserved factors that directly affect quality or cost outcomes independently of the included covariates (which include controls for health status, residence in a metropolitan area, and Medicaid eligibility category).

The monotonicity assumption necessary for IV to identify causal effects is that the effect of differential distance on NP attribution has the same sign for all patients. A violation of this assumption would require there to be patients for whom higher differential distance from an NP practice increases the patient's probability of NP attribution. The monotonicity assumption is also untestable, but we do not think it is likely that this assumption would be violated in our setting.

## Author's Note

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## ORCID iDs

Jordan M. Harrison https://orcid.org/0000-0002-4932-8504
Ashley M. Kranz https://orcid.org/0000-0003-0507-7800
Grant R. Martsolf https://orcid.org/0000-0003-1942-8683

## Notes

i. Missouri was later excluded from the analytic sample.
ii. Medicaid eligibility categories are defined based on uniform eligibility codes: Blind/disabled = 14, 32, 42; Section 1931 = 14, 15, 16, 17; Other poverty = 31, 34, 35; Section 1115 = 51, 52, 54, 55; Medically needy = 21, 22, 24, 25; Foster care = 48; Other = all else.
iii. FFS cost analyses were limited to a subset of states with available data: ME, NY, OH, OR, VA, WA, and WY for adults with diabetes; ME, NY, OH, OR, VA, and WY for children with asthma.
iv. Recent work by Lee et al.[57] points out that inference based on t-statistics can overreject the null even when the first-stage F-statistic is greater than 10. For effects of provider-level NP attribution among children with asthma, findings from Lee et al. indicate that a critical value of 2.16 should be used for hypothesis testing at the 5% significance level given that our first-stage F-statistic is 50. Because our 2SLS estimates are all statistically insignificant, tF inference as suggested by Lee et al.[57] would not change any of our conclusions. Comparison of Anderson-Rubin confidence intervals calculated using the *weakiv* Stata package of Finlay et al.[58] to those based on a Normal distribution also shows that accounting for weak instruments concerns in our inference does not lead to any substantive differences in our findings. We thank an anonymous referee for raising these issues.

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