ORIGINAL RESEARCH

Physician-Level Continuity of Care and Patient Outcomes in All-Payer Claims Database

Mingliang Dai, PhD, Zachary J. Morgan, MS, Kyle Russel, MS, Beth A. Bortz, MPP, Lars E. Peterson, MD, PhD, and Andrew W. Bazemore, MD, MPH

Introduction: **Being one of the few existing measures of primary care functions, physician-level continuity of care (Phy-CoC) is measured by the weighted average of patient continuity scores. Compared with the well-researched patient-level continuity, Phy-CoC is a new instrument with limited evidence from Medicare beneficiaries. This study aimed to expand the patient sample to include patients of all ages and all types of insurance and reassess the associations between full panel-based Phy-CoC scores and patient outcomes.**

Methods: **Cross-sectional analysis at patient-level using Virginia All-Payer Claims Database (VA-APCD). Phy-CoC scores were calculated by averaging patient's Bice-Boxerman Index scores and weighted by the total number of visits. Patient outcomes included total cost and preventable hospitalization.**

Results: **In a sample of 1.6 million Virginians, patients who lived in rural areas or had Medicare as primary insurance were more likely to be attributed to physicians with the highest Phy-CoC scores. Across all adult patient populations, we found that being attributed to physicians with higher Phy-CoC was associated with 7%-11.8% higher total costs, but was not associated with the odds of preventable hospitalization. Results from models with interactions revealed nuanced associations between Phy-CoC and total cost with patient's age and comorbidity, insurance payer, and the specialty of their physician.**

Conclusions: **In this comprehensive examination of Phy-CoC using all populations from the VA-APCD, we found an overall positive association of higher full panel-based Phy-CoC with total cost, but a non-significant association with the risk of preventable hospitalization. Achieving higher full panel-based Phy-CoC may have unintended cost implications. (J Am Board Fam Med 2023;36:976–985.)**

Keywords: **Continuity of Care, Cost, Cross-Sectional Studies, Medicare, Physicians, Primary Health Care, Virginia**

Introduction

Primary Care Physician Continuity of Care is one of the few existing measures of primary care functions newly endorsed by the National Quality Forum in 2022.[1–3] It is a claims-based process measure that evaluates the proportion of patients on a physician's panel who achieved high continuity determined by patient Bice-Boxerman Index (BBI) scores.[4] This measure is also being considered by the Centers for Medicare and Medicaid Services for acceptance into its Merit-based Incentive Payment System.

However, unlike the large evidence base of patient-level continuity built over the past 2 decades that showed a consistent relationship between higher patient continuity and a host of beneficial outcomes,[5–9] physician-level continuity of care

This article was externally peer reviewed.

Submitted 24 March 2023; revised 5 July 2023; accepted 18 July 2023.

From the American Board of Family Medicine (MD, ZJM, LEP, AWB); Virginia Health Information (KR); Virginia Center for Health Innovation (BAB); Department of Family and Community Medicine at the University of Kentucky (LEP); Center for Professionalism and Value in Health Care (AWB).

Funding: This study was funded by the American Board of Family Medicine Foundation.

Conflict of interest: Drs. Dai, Morgan, Peterson, and Bazemore declared no conflict of interest.

Dr. Russel's declaration: VHI received funding from the ABFM, under contract to the Virginia Center for Health Innovation (VCHI), to provide access to Virginia All Payer Claims Database (APCD) data and related technical support for the submitted study topic.

Dr. Bortz's declaration: VCHI received funding from the ABFM Foundation to oversee this specific physician-continuity research project, and a portion of the funding was to support staff time dedicated to research findings dissemination.

Corresponding author: Mingliang Dai, PhD, 1648 McGrathiana Parkway, Suite 550, Lexington KY, 40511 (E-mail: mdai@theabfm.org).

(Phy-CoC) is a relatively new research instrument, with just 2 studies that investigated its associations with patient outcomes.[10,11] Although both studies found significant associations between patients attributed to physicians with higher Phy-CoC scores and lower total costs and lower odds of hospitalization, the evidence has been limited to older Medicare beneficiaries.

Phy-CoC scores are calculated by weighting individual patient BBI scores by total number of primary care visits. Compared with BBI-based patient continuity scores that are intended to capture the dispersion of visits across a group of physicians for individual patients, Phy-CoC scores summarize the continuity scores of patients as the continuity score of a physician, which by design is influenced by the selection of patients. As a result, a physician's continuity score determined by older patients only (eg, Medicare beneficiaries) is likely different from the one that accounts for their full patient panel. Moreover, it is unknown whether the associations between Phy-CoC and patient outcomes established in samples of older patients would hold in a sample of patients of all ages.

To expand the evidence base of Phy-CoC to all patients and address the data limitation of previous research, this study used Virginia All-Payer Claims Database (VA-APCD) which includes billing claims of Virginians of all ages and all types of insurance coverage to reassess Phy-CoC scores by accounting for all patients on a physician's panel. The study was designed to determine how much the inclusion of pediatric patients and younger adults under the aged of 65 together with older patients would change Phy-CoC scores for the same physicians, and whether patients whose primary care physician had higher Phy-CoC scores (full panel-based) would be associated with lower total cost and lower odds of preventable hospitalization.

Methods

Data Source

The VA-APCD includes administrative claims data on state residents insured through fee-for-service Medicare, Medicaid, and private commercial insurers. APCDs have increasingly become a valuable tool to inform policy decisions around health services delivery.[12–14] The VA-APCD has been used to evaluate critical issues of health care including unnecessary health care spending and opioid medication prescribing.[15–17] Compared with the national Medicare claims, the VA-APCD includes health insurance billing claims of 4-4.5 million Virginia residents regardless of their insurance coverage being Medicare, Medicaid, or commercial.[18] Whereas the national Medicare claims are grouped into 7 claim types, the VA-APCD uses a proprietary methodology called the Health Cost Guideline grouper to assign claims to 5 service cost categories, including professional, inpatient, outpatient, prescription, and ancillary. In addition, the VA-APCD has a unique data addition (ie, Evidence-based Measures, EBM) which flags a service claim if it met the definition of an existing quality measure. For example, a hospital inpatient claim will be flagged as preventable hospitalization if the EBM algorithm determines that the claim met the definition of the Agency for Health care Research and Quality's Preventive Quality Indicator #90.[19]

Sample Selection

To investigate the associations between Phy-CoC and patient outcomes at patient level, we sampled patients of all ages and all insurance types who made 1 or more primary care visits in Virginia in 2019. We excluded patients with no primary care visits in 2019. In addition, to produce more generalizable estimates of Phy-CoC, we excluded patients attributed to general practitioners or geriatricians due to limited number of physicians in each specialty, as well as patients whose primary care physicians had fewer than 30 patients in 2019.[20] We defined a primary care visit as an office-based encounter with a primary care physician. We used the claim category dedicated to 'Professional office visits' in the Health Cost Guideline grouper to identify office visits, which we verified to capture nearly all the primary care E&M visit codes.[21] We defined clinicians as primary care physicians if their specialty was Family Medicine, Internal Medicine, or Pediatric Medicine.

Independent Variable: Physician-Level Continuity of Care (Phy-CoC) Score

To calculate Phy-CoC scores, we followed the 2-step method applied in previous studies.[10,11] First, we calculated the BBI score for each patient using Formula 1 where n_i is the number of visits the patient had with physician i, N is the total number of visits, and k is the number of physicians seen by the patient. Depending on the number of visits to unique physicians, the BBI ranges from 0 to 1 with patients whose visits are with the same primary care physician having a BBI of 1.

$$BBI = \frac{\sum_{i=1}^{k} n_i^2 - N}{N \times (N-1)} \quad (1)$$

Then, for each physician, we computed an average of patient BBI_j weighted by the total number of visits, N_j, for all p attributed patients to obtain the Phy-CoC score, ranging from 0 to 1 (Formula 2). To compare with prior studies, we categorized scores into quintiles from 1 (bottom quintile, lowest scores) to 5 (top quintile, highest scores). As this study expanded the patient population to include younger patients, we expected our Phy-CoC scores to differ from those based solely on older patients.

$$Phy - CoC = \frac{\sum_{j=1}^{p} (BBI_j^2 \times N_j)}{\sum_{j=1}^{p} N_j} \quad (2)$$

Outcome Variables

To determine whether the established associations between Phy-CoC and patient outcomes can be generalized to patients of all ages, we examined 2 cost and utilization outcomes that have been shown to benefit from higher Phy-CoC in older Medicare populations: total cost and preventable hospitalization.

Total cost was calculated by summing total allowed costs for all claim types of a patient including professional, inpatient, outpatient, prescription, and ancillary claims. If a patient had multiple insurance coverage, for example both Medicare and Medicaid, claims of both payers will be included in total cost. We calculated average patient cost in descriptive analysis but used log-transformed cost in regression analysis to account for the right-skewness of the cost distribution.

A preventable hospitalization was identified if the condition for the hospital admission matched 1 of the conditions listed in the specification of PQI-90 composite measure by Agency for Health care Research and Quality.[19] In VA-APCD, the determination of preventable hospitalization was readily available by linking to the Evidence-Based Measures data addition. We created a dichotomous variable to indicate patients with any preventable hospitalization.

Other Covariates

To account for potential confounders of the outcomes, we obtained information on patient age, gender, primary insurance payer, rurality using Rural Urban Commuting Areas,[22,23] social determinants of health using the Social Deprivation Index (SDI),[24] comorbidity using Charlson Comorbidity Index (CCI),[25] and risk adjustment for higher future medical expenditure using Milliman Advanced Risk Adjusters (MARA) risk adjustment coefficients.[26] In addition, we attributed patients to a single physician with whom they had the most primary care visits in 2019 and included the specialty of the patient's attributed physician as a covariate.[27]

Analysis

We first examined the distributions of Phy-CoC score quintiles by patient characteristics, physician specialty, and primary payer. We also calculated sample averages of total cost and rate of preventable hospitalization by Phy-CoC quintiles. To simplify the statistical comparison to lower Phy-CoC scores in adjusted analysis, we kept quintiles 3 to 5 as higher levels of Phy-CoC and combined quintiles 1 and 2 as the reference category. For total cost, we performed linear mixed regression estimating percentage change in total cost associated with Phy-CoC. We chose this model after running into convergence and fit issues with the standard log-linked generalized linear model. For preventable hospitalization, we performed mixed logistic regression modeling of the odds of any preventable hospitalization. To determine whether the adjusted associations would be affected by the inclusion of healthier individuals, that is, patients with 1 primary care visit during the year, we conducted a sensitivity analysis in a restricted sample of patients with 2 or more visits. All models were at patient level and included a random intercept to adjust for clustering at physician level and accounted for patient, physician, and payer covariates. To allow for heterogeneity of effects with Phy-CoC, additional models with interactions between Phy-CoC and select covariates were estimated if Phy-CoC was significant associated with the modeled outcome. This study was approved by the American Academy of Family Physicians Institutional Review Board.

Results

The study sample included more than 1.6 million Virginians with 1 or more office-based primary care visits in 2019 who were attributed to a single physician with whom they had the greatest number of visits (Table 1). Patients in quintile 1 were

Table 1. Patient Characteristics by Physician-Level Continuity of Care Quintile, 2019

Patient Sample (n = 1,612,377)	Attributed to physicians with bottom (1) to top (5) quintiles of Physician-Level Continuity of Care				
	Quintile 1 n = 323,115	Quintile 2 n = 319,010	Quintile 3 n = 350,216	Quintile 4 n = 335,228	Quintile 5 n = 284,808
Range of Phy-CoC scores	<0.39	0.39-0.55	0.55-0.64	0.64-0.73	>=0.73
Age, mean (SD)	28 (26)	48 (25)	56 (22)	58 (22)	58 (23)
Gender					
Woman	18.8%	20.0%	22.1%	21.7%	17.3%
Man	21.6%	19.5%	21.2%	19.6%	18.1%
Geography of residence					
Isolated small rural town	8.6%	15.6%	14.9%	24.6%	36.4%
Small rural town	9.7%	12.4%	19.0%	22.2%	36.7%
Large rural city/town	15.7%	12.7%	16.3%	24.6%	30.6%
Urban	21.3%	20.8%	22.4%	20.4%	15.1%
SDI score	29 (29)	26 (26)	30 (29)	33 (30)	36 (30)
CCI score	0.7 (1.8)	1.2 (2.3)	1.4 (2.4)	1.6 (2.5)	1.7 (2.6)
MARA score	0.6 (1.4)	0.9 (1.7)	1.1 (1.8)	1.2 (1.9)	1.2 (2.0)
Utilization outcomes in 2019					
Total cost, mean (SD)	$5,496 (22,426)	$8,428 (23,980)	$9,551 (25,197)	$10,441 (25,183)	$10,777 (25,672)
Any preventable hospitalization	0.3%	0.6%	0.8%	0.9%	1.1%
Primary insurance payer					
Medicare	8.3%	16.7%	24.1%	26.7%	24.2%
Medicaid	34.7%	19.9%	14.7%	15.4%	15.2%
Commercial	26.9%	22.4%	21.2%	16.9%	12.6%
Specialty of attributed physician					
Family medicine	14.7%	21.2%	26.3%	21.2%	16.5%
Internal medicine	7.2%	18.3%	22.1%	27.2%	25.1%
Pediatric medicine	61.9%	17.7%	5.7%	7.2%	7.4%

Abbreviations: SDI, Social deprivation Index; CCI, Charlson's comorbidity Index; MARA, Milliman Advanced Risk Adjusters; SD, standard deviation.

attributed to physicians with the lowest Phy-CoC scores and patients in quintile 5 the highest. The average age of patients attributed to physicians in the bottom quintile of continuity was 28 years old, much younger that those of physicians with higher Phy-CoC. Rural residents were more likely than urban residents to have an attributed physician with higher Phy-CoC, that is, quintiles 4 or 5. In 2019, Virginia patients attributed to physicians in the top quintile of Phy-CoC were more likely to live in more disadvantaged areas, to have a greater number and/or more severe forms of comorbidities, and increased risks for higher future medical expenditure. The same group of patients also had higher average cost and were more likely to be hospitalized for preventable causes. Only 8.3% of Medicare beneficiaries were attributed to physicians in the bottom quintile of Phy-CoC compared with 26.9% of commercially insured patients and 34.7% of Medicaid enrollees. Compared with patients of family physicians or internists, pediatric patients were much less likely to be attributed pediatricians with higher Phy-CoC.

Table 2 summarized adjusted associations between Phy-CoC and 2 patient outcomes: total cost and odds of preventable hospitalization. Accounting for patient, physician, and payer covariates, patients attributed to physicians with higher Phy-CoC scores (quintile 3 to 5) were associated with 7%-11.8% higher total cost (ie, $368-$574 increase in cost) than patients attributed to physicians with lower Phy-CoC scores (quintiles 1&2). Female patients, patients with higher comorbidities as determined by log-transformed CCI scores, and patients with higher health risk as determined by log-transformed MARA scores were associated with the largest increases in total cost. In contrast, the total cost of Medicare and Medicaid patients

Table 2. Adjusted Associations Between Physician-Level Continuity of Care Quintile, Total Cost, and Preventable Hospitalization

Variable	Total Cost % Change (95% CI)	Any Preventable Hospitalization Odds Ratio (95% CI)
Physician-Level Continuity of Care Quintile		
Quintile 5 (highest scores)	10.8% (8.1%, 13.7%)*	1.08 (1.01, 1.15)
Quintile 4	11.8% (9.1%, 14.6%)*	0.97 (0.91, 1.03)
Quintile 3	7.0% (4.4%, 9.6%)*	0.98 (0.92, 1.04)
Quintiles 1&2 (lowest scores)	–	–
Age†	−0.4% (−0.5%, −0.3%)*	1.16 (1.14, 1.18)*
Gender		
Female	10.5% (10.2%, 10.8%)*	1.22 (1.17, 1.27)*
Male	–	–
Geography of residence		
Isolated small rural town	1.6% (0.5%, 2.7%)*	1.01 (0.90, 1.14)
Small rural town	0.8% (−0.3%, 1.9%)	1.25 (1.14, 1.37)*
Large rural city/town	1.9% (0.9%, 2.8%)*	1.20 (1.09, 1.31)*
Urban	–	–
Primary insurance payer		
Medicare	−34.9% (−35.2%, −34.6%)*	1.56 (1.44, 1.70)*
Medicaid	−25.0% (−25.5%, −24.6%)*	1.62 (1.43, 1.84)*
Commercial	–	–
SDI		
75+	0.3% (−0.2%, 0.8%)	1.08 (1.03, 1.14)
1 to 74	–	–
CCI (log)†	8.7% (8.6%, 8.7%)*	1.23 (1.22, 1.24)*
MARA (log)†	28.8% (28.8%, 28.9%)*	1.49 (1.48, 1.50)*
Physician specialty		
Internal medicine	0.7% (−1.3%, 2.7%)	0.96 (0.92, 1.00)
Pediatric medicine	−10.4% (−12.4%, −8.3%)*	–**
Family medicine	–	–

Abbreviations: SDI, Social deprivation Index; CCI, Charlson's comorbidity Index; MARA, Milliman Advanced Risk Adjusters; CI, confidence interval.
Notes: *$P < .05$.
**The specification of preventable hospitalization targets patients aged 18 and older. As a result, patients of pediatricians were excluded from this regression.
†Age centered at 53, estimate of 10-year increase. CCI centered at 0, estimate of 1 point increase. MARA centered at 1, estimate of 1 point increase.

was 34.9% and 25.0% lower respectively than commercial patients. Patients of pediatricians had 10.4% lower total cost than patients of family physicians. Compared with the significant associations with the cost outcome, patients with physicians of higher Phy-CoC scores were not significantly different in their odds of experiencing a preventable hospitalization. Patients of female gender, older ages, rural residence, higher CCI or MARA scores (both log-transformed), and who were primarily covered by Medicare or Medicaid had significantly higher odds of preventable hospitalization. As the specification of preventable hospitalization targets patients aged 18 and older,[19] patients of pediatricians were excluded from this regression analysis. Restricting to patients with 2 or more primary care visits did not change the main associations between Phy-CoC, total cost and preventable hospitalization despite minor changes in the magnitude of the coefficients. Results of the sensitivity analysis results can be found in Appendix A.

Given the significant associations between Phy-CoC and total cost, we re-estimated the total cost model with 2-way interactions with physician specialty, patient's primary payer, age, log-transformed CCI and MARA scores to investigate whether the effect on total cost was heterogeneous at distinct

Table 3. Adjusted Associations Between Physician-Level Continuity of Care Quintile and Total Cost with Interactions with Patient Characteristics

	Physician-Level Continuity of Care Quintile†		
CoC Interacting with	Quintile 3	Quintile 4	Quintile 5
Physician specialty			
Internal medicine	−4.8% (−9.8%, 0.4%)	2.4% (−2.9%, 8.0%)	1.8% (−3.6%, 7.5%)
Pediatric medicine	−12.6% (−19.6%, −4.9%)*	−17.0% (−23.8%, −9.6%)*	−26.0% (−31.9%, −19.6%)*
Family medicine	–	–	–
Primary payer			
Medicare	1.6% (0.4%, 2.9%)*	−1.0% (−2.3%, 0.2%)	2.8% (1.4%, 4.1%)*
Medicaid	2.1% (0.4%, 3.8%)*	8.7% (6.9%, 10.5%)*	1.1% (−0.5%, 2.8%)
Commercial	–	–	–
Patient age†			
10 years older	−2.7% (−3.0%, −2.4%)*	−2.8% (−3.1%, −2.5%)*	−3.8% (−4.2%, −3.5%)*
CCI (log)†			
1 point higher	−1.7% (−1.9%, −1.5%)*	−2.4% (−2.6%, −2.1%)*	−1.7% (−1.9%, −1.4%)*
MARA (log)†			
1 point higher	1.8% (1.6%, 1.9%)*	1.9% (1.8%, 2.0%)*	1.6% (1.5%, 1.8%)*

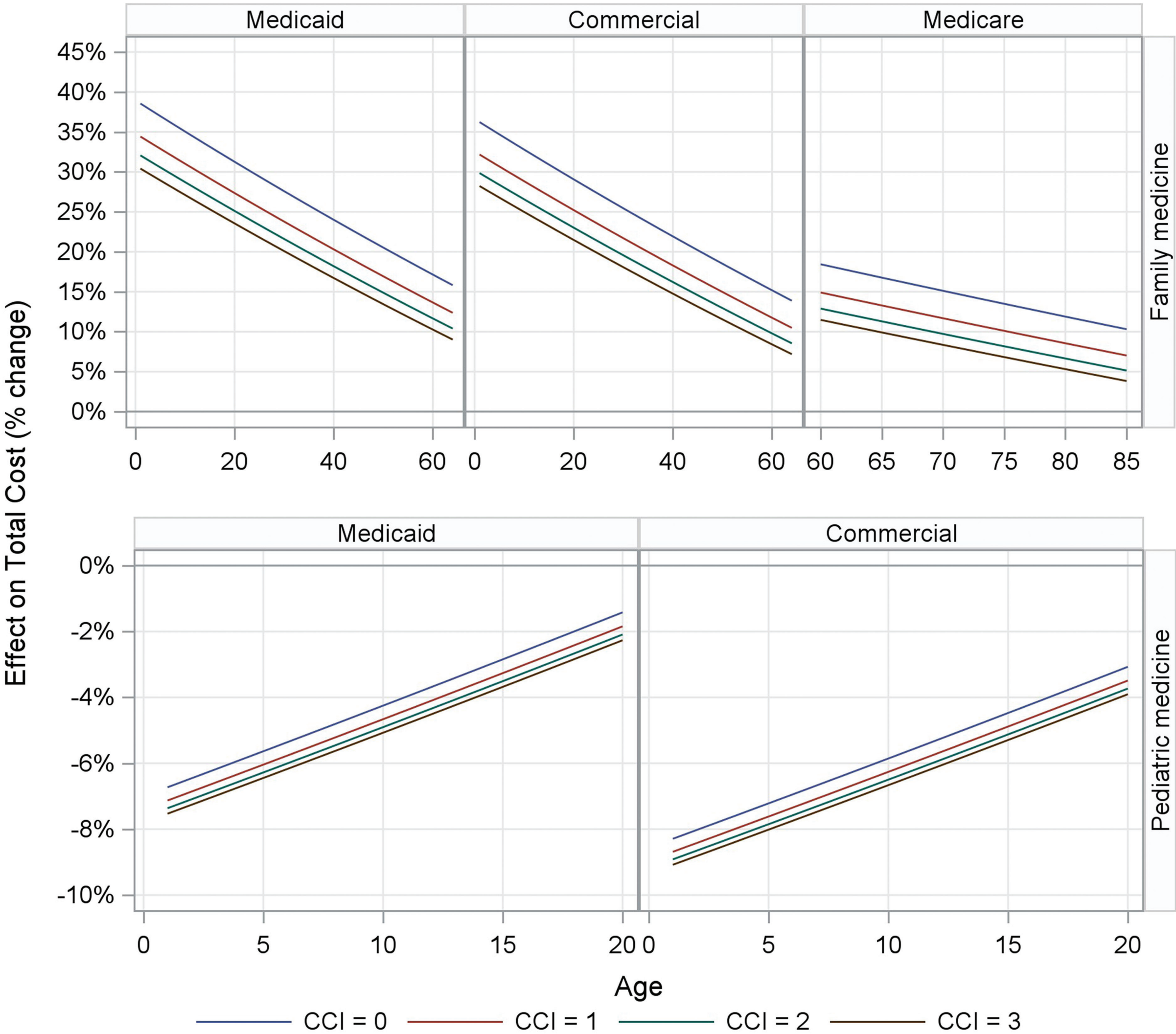
Abbreviations: CoC, continuity of care; CCI, Charlson's comorbidity index; MARA, Milliman advanced risk adjusters.
Notes: Estimates of two-way interactions are shown, with all main effects (as in Table 2) included in the model.
*$P < .05$.
†Quintiles 1&2 are reference category for CoC. Age centered at 53, estimate of 10-year increase. CCI centered at 0, estimate of 1 point increase. MARA centered at 1, estimate of 1 point increase.

levels of these covariates (Table 3). For pediatric patients relative to patients of family physicians within the same quintile, attributed to pediatricians with higher Phy-CoC scores, that is, quintiles 3 to 5, was associated with significantly lower total cost (-12.6% to -26%). These large reductions should be interpreted with caution as they reflected changes in the effect of Phy-CoC resulting from interactions in the model and were relative to patients with family physicians who as a whole had 10% higher total cost than pediatric patients (in Table 2). This pattern largely held true for patients of older ages and with higher CCI scores. On the other hand, for Medicare and Medicaid patients, as well as patients with elevated risks of higher future medical expenditure, being attributed to physicians with higher Phy-CoC scores was overall associated with increases in total cost. Due to the non-significant associations of Phy-CoC with the odds of preventable hospitalization, we did not re-estimate the model with interactions.

To further contextualize the associations between Phy-CoC and total cost, we stratified the sample by patient's primary insurance payer and specialty of the attributed physician and plotted the estimated effect on total cost (Figure 1). Data used to generate this figure were extracted from the total cost regression model that included 3-way interactions of Phy-CoC, patient age, and patient CCI scores (see Appendix B for full regression results). We simplified the visualization by presenting patients of family physicians and pediatricians, given that the results for patients of internists were comparable to those of family physicians. The x-axis is patient age, and the y-axis is the percentage difference in total cost between patients with the highest (quintile 5) and lowest (quintiles 1&2) Phy-CoC scores. The trend lines were drawn by payer and each color represented patients with a distinct CCI score, demonstrating the changing effect on total cost conditional on patient's age and comorbidity.

For patients of family physicians, being attributed to physicians with the highest Phy-CoC was associated with significantly higher total cost indicated by the positive percentage values on the y-axis. However, the degree of cost increase was smaller for patients with greater comorbidities and declined dramatically as patients age. In contrast, for pediatric patients, being attributed to pediatricians with the highest Phy-CoC was associated with significantly lower total cost indicated by negative percentage values on the y-axis. The degree of cost reduction was slightly larger for patients with

Figure 1. Contextualizing the associations between physician-level continuity of care and total cost with patient age and comorbidity.



Notes: CCI = Charlson's comorbidity Index, with highest scores indicating greater number and/or severity of comorbidities

greater comorbidities and shrank as patients grew into adulthood.

Discussion

This study is the first to investigate the association between physician-level continuity of care (Phy-CoC) and common patient outcomes in a statewide patient sample, expanding the evidence from older Medicare patients to patients of all ages and all types of insurance coverage. Across all adult patient populations, we found that being attributed to physicians with higher Phy-CoC was associated with higher total cost, a finding that was inconsistent with the evidence that higher Phy-CoC was associated with lower total cost in Medicare patients.[10,11] We did not find a significant association between higher Phy-CoC and the odds of preventable hospitalization. In the discussion below, we focused on this important albeit unexpected main finding on total cost first. We also discuss the nuanced findings on patient age and comorbidity, payer, and physician specialty, with a goal to offer a more comprehensive picture of the relationship between Phy-CoC and patient cost across all patient populations.

First, the inclusion of pediatric patients and younger adults under the aged of 65, a main contribution of this study and a fundamental change in study design compared with previous studies, lowered Phy-CoC scores and most likely led to the difference in patient cost. To illustrate, In the 2018 study of Phy-CoC among Medicare beneficiaries,[10] Phy-CoC scores were <0.6 for quintile 1 (the lowest) and >0.83 for quintile 5 (the highest). In the current study, Phy-CoC scores of quintile 1 and quintile 5 were <0.39 and >=0.73 respectively. The lower scores generated by full patient panels confirmed that Phy-CoC scores which are essentially weighted averages of patient BBI scores are sensitive to the patient base used for calculation. Mathematically speaking, full panel-based Phy-CoC scores are lowered by averaging higher BBI scores from older patients with lower BBI scores from younger patients. Consequently, achieving higher full panel-based Phy-CoC would require younger patients on the panel to have higher patient continuity, which would require greater utilization of primary care and other health services and drive the total cost up. Built on all patient populations, this finding suggests that achieving higher full panel-based Phy-CoC may be associated with unintended cost implications and that careful calibration of the target population is needed to achieve improvement in Phy-CoC while containing cost.

Second, the trend lines revealed nuanced associations between Phy-CoC and total cost with patient's age and comorbidity, insurance payer, and the specialty of their physician, but also unavoidably made the interpretation less straightforward. The downward trend lines of patients of family physicians and internists captured the increasingly potent effect of having a physician with higher Phy-CoC on lowering cost for patients with advanced age and a greater number of comorbidities, while acknowledging the across-the-board cost elevation associated with higher Phy-CoC. The stratification by physician specialty and insurance payer highlighted the necessity to assess physician continuity by specialty even among primary care physicians and implied that macro factors such as eligibility rules instituted by insurance payers might be responsible for the varying magnitude of the associations. Pediatricians were the only group of physicians for whom achieving higher continuity was associated with lower cost for their patients regardless of age and comorbidity. Thus, efforts to improve Phy-CoC among pediatricians may be a promising way to lower total cost for pediatric patients.

In addition, notably, the use of All-Payer Claims Database, in contrast to previous studies using only Medicare claims, permitted the first comparison of Phy-CoC scores by payer. This led to the disturbing discovery that more than a third (34.7%) of Medicaid patients, highest among all payers studied, were attributed to physicians in the bottom quintile of Phy-CoC. This is concerning given the higher likelihood of social and economic disadvantages among Medicaid beneficiaries. This finding may hint at the need for targeted implementation of continuity measurement in Medicaid value-based payment plans, with incentives tied to higher scores to try and mitigate disparities in care outcomes. Finally, patients living in urban areas were less likely than those in rural to be attributed to physicians in top quintiles of Phy-CoC, a finding likely indicating easier access to specialty service and other clinical alternatives in urban areas. These finding may suggest the need to stratify by rural and urban measures of continuity used in value-based purchasing models.

Limitations

This study has several major limitations. First, despite the advantage of having all-payer claims from Virginia, this study was limited in its ability to generalize the findings to other states. Second, the cross-sectional design of the study produced a snapshot of the associations but did not allow longitudinal investigation which might be required to detect the true effect of higher Phy-CoC especially for younger and healthier adults, for whom multiple years may be needed for any cost savings to be observed. Third, although cost and utilization are commonly studied patient outcomes, the distinct care-seeking behaviors of younger versus older adults may render these outcomes less robust. Future studies are urged to identify outcomes that appeal to both younger and older patients and reevaluate the associations with Phy-CoC.

Conclusion

We found an overall positive association of higher full panel-based Phy-CoC with total cost, but a nonsignificant association with the risk of preventable hospitalization. This comprehensive examination of Phy-CoC using all populations from the VA-APCD yielded important insights of factors with remarkable influence over the associations between Phy-CoC and patient's total cost, including patient's age and comorbidity, insurance payer, and the specialty of attributed physician, allowing more contextualized interpretation. Achieving higher full panel-based Phy-CoC may have unintended cost implications.

To see this article online, please go to: http://jabfm.org/content/36/6/976.full.

References

1. National Quality Forum. Primary Care and Chronic Illness Final Report - Spring 2021 Cycle. 2021. Published February 14, 2022; Accessed August 18, 2022. Available at: https://www.qualityforum.org/Publications/2022/03/Primary_Care_and_Chronic_Illness_Final_Report_-_Spring_2021_Cycle.aspx.
2. Dai M, Pavletic D, Shuemaker JC, Solid CA, Phillips RL. Measuring the value functions of primary care: physician-level continuity of care quality measure. Ann Fam Med 2022;20:535–40.
3. National Quality Forum. Quality. ID #483 (NQF 3568): Person-Centered Primary Care Measure Patient Reported Outcome Performance Measure (PCPCM PRO-PM). Published online 2022. Available at: https://qpp.cms.gov/docs/QPP_quality_measure_specifications/CQM-Measures/2023_Measure_483_MIPSCQM.pdf.
4. Bice TW, Boxerman SB. A quantitative measure of continuity of care. Med Care 1977;15:347–9.
5. Romano MJ, Segal JB, Pollack CE. The association between continuity of care and the overuse of medical procedures. JAMA Intern Med 2015;175:1148–54.
6. Axon RN, Gebregziabher M, Everett CJ, Heidenreich P, Hunt KJ. Dual health care system use is associated with higher rates of hospitalization and hospital readmission among veterans with heart failure. Am Heart J 2016;174:157–63.
7. Saultz JW, Lochner J. Interpersonal continuity of care and care outcomes: a critical review. Ann Fam Med 2005;3:159–66.
8. Saultz JW, Albedaiwi W. Interpersonal continuity of care and patient satisfaction: a critical review. Ann Fam Med 2004;2:445–51.
9. Bazemore A, Merenstein Z, Handler L, Saultz JW. The impact of interpersonal continuity of primary care on health care costs and use: a critical review. Ann Fam Med 2023;21:274–9.
10. Bazemore A, Petterson S, Peterson LE, Bruno R, Chung Y, Phillips RL. Higher primary care physician continuity is associated with lower costs and hospitalizations. Ann Fam Med 2018;16:492–7.
11. Yang Z, Ganguli I, Davis C, et al. Physician versus practice-level primary care continuity and association with outcomes in Medicare beneficiaries. Health Serv Res 2022;57:914–29.
12. Rocco P, Kelly AS, Béland D, Kinane M. The new politics of US health care prices: institutional reconfiguration and the emergence of all-payer claims databases. *J Health Polit Policy Law* 2017;42(1):5–52.
13. All-payer claims databases: state initiatives to improve health care transparency. | Commonwealth Fund. Accessed August 16, 2021. Available at: https://www.commonwealthfund.org/publications/issue-briefs/2010/sep/all-payer-claims-databases-state-initiatives-improve-health-care.
14. Miller PB, Love D, Sullivan E, Porter J, Costello A. All-payer claims databases: an overview for policymakers. Durham, NH: APCD Council; May 2010. Available at: http://www.apcdcouncil.org/publication/all-payer-claims-databases-overviewpolicymakers. Accessed February 15, 2018.
15. Mafi JN, Russell K, Bortz BA, Dachary M, Hazel WA, Fendrick AM. Low-cost, high-volume health services contribute the most to unnecessary health spending. Health Affairs 2017;36:1701–4.
16. Orfield NJ, Gaddis A, Russell KB, Hartman DW, Apel PJ, Mierisch C. New long-term opioid prescription-filling behavior arising in the 15 months after orthopaedic surgery. The Journal of Bone and Joint Surgery 2020;102:332–9.
17. LeBaron VT, Camacho F, Balkrishnan R, Yao N (Aaron), Gilson AM. Opioid epidemic or pain crisis? Using the Virginia all payer claims database to describe opioid medication prescribing patterns and potential harms for patients with cancer. JOP 2019;15:e997–e1009.
18. Virginia Health Information. All Payer Claims Database (APCD). Accessed June 14, 2023. Available at: https://www.vhi.org/apcd/.
19. Agency for Healthcare Research and Quality, U.S. Department of Health and Human Services. Prevention Quality Indicator 90 (PQI 90) Prevention Quality Overall Composite. Accessed March 14, 2022. Available at: https://qualityindicators.ahrq.gov/Downloads/Modules/PQI/V2021/TechSpecs/PQI_90_Prevention_Quality_Overall_Composite.pdf.
20. Phillips WR, Dai M, Frey J, Peterson LE. General Practitioners in US medical practice compared with family physicians. Ann Fam Med 2020;18:127–30. 4.
21. Nyweide DJ, Anthony DL, Bynum JPW, et al. Continuity of care and the risk of preventable hospitalization in older adults. JAMA Intern Med 2013;173:1879.
22. U.S. Department of Agriculture. Rural-urban commuting area codes. Accessed March 14, 2022. Available at: https://www.ers.usda.gov/data-products/rural-urban-commuting-area-codes/.
23. WWAMI Rural Health Research Center. Rural urban commuting area codes data. Accessed June 16, 2023. Available at: https://depts.washington.edu/uwruca/ruca-uses.php.
24. Butler DC, Petterson S, Phillips RL, Bazemore AW. Measures of social deprivation that predict

health care access and need within a rational area of primary care service delivery. Health Serv Res 2013;48:539–59.
25. Glasheen WP, Cordier T, Gumpina R, Haugh G, Davis J, Renda A. Charlson Comorbidity Index: ICD-9 update and ICD-10 translation. Am Health Drug Benefits 2019;12:188–97.
26. Milliman. Overview: Milliman advanced risk technologies. Accessed March 14, 2022. Available at: https://us.milliman.com/en/products/mara.
27. Pham HH, Schrag D, O'Malley AS, Wu B, Bach PB. Care patterns in Medicare and their implications for pay for performance. N Engl J Med 2007;356:1130–9.

Appendix.

Appendix A. Adjusted Associations Between Physician CoC, Total Cost and Preventable Hospitalization: A Sensitivity Analysis of Patients with 2 or More visits in 2019

Variable	Total Cost % Change (95% CI)	Any Preventable Hospitalization Odds Ratio (95% CI)
CoC		
Quintile 3	5.9% (3.4%, 8.5%)*	1.00 (0.94, 1.07)
Quintile 4	10.1% (7.5%, 12.8%)*	0.98 (0.92, 1.05)
Quintile 5	8.8% (6.1%, 11.5%)*	1.08 (1.01, 1.15)
Quintiles 1&2	–	–
Age[†]	−1.4% (−1.5%, −1.2%)*	1.16 (1.13, 1.18)*
Gender		
Woman	8.4% (8.0%, 8.7%)*	1.22 (1.17, 1.27)*
Man	–	–
Geography of residence		
Isolated small rural town	1.4% (0.2%, 2.6%)*	1.03 (0.91, 1.16)
Small rural town	1.0% (−0.2%, 2.2%)	1.25 (1.14, 1.37)*
Large rural city/town	1.8% (0.8%, 2.9%)*	1.17 (1.07, 1.28)*
Urban	–	–
Primary insurance payer		
Medicare	−33.7% (−34.1%, −33.4%)*	1.53 (1.40, 1.70)*
Medicaid	−23.5% (−24.0%, −23.0%)*	1.54 (1.34, 1.78)*
Commercial	–	–
SDI		
75+	0.3% (−0.2%, 0.9%)	1.08 (1.02, 1.14)
1 to 74	–	–
CCI (log)[†]	7.2% (7.1%, 7.3%)*	1.24 (1.22, 1.25)*
MARA (log)[†]	29.0% (29.0%, 29.1%)*	1.49 (1.48, 1.51)*
Physician specialty		
Internal medicine	0.7% (−1.3%, 2.7%)	0.96 (0.94, 1.07)
Pediatric medicine	−13.8% (−15.8%, −11.9%)*	0.26 (0.18, 0.39)*
Family medicine	–	–

Notes: Estimates of two-way interactions are shown, with all main effects (as in Table 3) included in the model.
*$P < .05$.
[†]Quintiles 1&2 are reference category for CoC. Age centered at 53, estimate of 10-year increase. CCI centered at 0, estimate of 1 point increase. MARA centered at 1, estimate of 1 point increase.
Abbreviations: SDI, social deprivation index; CCI, Charlson's comorbidity index; MARA, Milliman advanced risk adjusters; CI, confidence interval.

Appendix B. Regression Model of 2019 Total Allowed Patient Costs with 3-way Interactions

Variable	Modeled Coefficients	Implied Percent Change
Intercept	8.5760 (8.5572, 8.5949)	$5303.11 ($5204.00, $5404.11)
Age		
Centered at 53, Unit Increase of 10	0.0039 (0.0018, 0.0061)	0.4% (0.2%, 0.6%)
Gender		
Woman	0.0968 (0.0939, 0.0996)	10.2% (9.8%, 10.5%)
Man	REFERENCE	REFERENCE
SDI		
75+	0.0035 (−0.0015, 0.0085)	0.3% (−0.1%, 0.8%)
1 to 74	REFERENCE	REFERENCE
Rurality (From RUCA)		
Isolated small rural town	0.0155 (0.0047, 0.0264)	1.6% (0.5%, 2.7%)
Large rural city/town	0.0053 (−0.0056, 0.0162)	0.5% (−0.6%, 1.6%)
Small rural town	0.0179 (0.0083, 0.0276)	1.8% (0.8%, 2.8%)
Urban	REFERENCE	REFERENCE
Payer		
Medicare	−0.4286 (−0.4368, −0.4203)	−34.9% (−35.4%, −34.3%)
Medicaid	−0.2960 (−0.3038, −0.2881)	−25.6% (−26.2%, −25.0%)
Commercial	REFERENCE	REFERENCE
CCI (log)		
Centered at 0, Unit Increase of 1	0.0887 (0.0869, 0.0905)	9.3% (9.1%, 9.5%)
MARA (log)		
Centered at 1, Unit Increase of 1	0.2525 (0.2517, 0.2533)	28.7% (28.6%, 28.8%)
PCP Specialty		
Internal medicine	0.0270 (−0.0058, 0.0598)	2.7% (−0.6%, 6.2%)
Pediatric medicine	0.1505 (0.1133, 0.1876)	16.2% (12.0%, 20.6%)

Continued

Appendix B. Continued

Variable		Modeled Coefficients	Implied Percent Change
Family medicine		REFERENCE	REFERENCE
BB-COC-PC of attributed PCP			
Percentile 40 to 60		0.1293 (0.0966, 0.1620)	13.8% (10.1%, 17.6%)
Percentile 60 to 80		0.1642 (0.1296, 0.1989)	17.9% (13.8%, 22.0%)
Percentile 80 to 100		0.1612 (0.1234, 0.1991)	17.5% (13.1%, 22.0%)
Percentile 0 to 40		REFERENCE	REFERENCE
Specialty * Age			
Internal medicine	Age Centered at 53, Unit Increase of 10	−0.0205 (−0.0242, −0.0167)	−2.0% (−2.4%, −1.7%)
Pediatric medicine	Age Centered at 53, Unit Increase of 10	0.0858 (0.0799, 0.0916)	9.0% (8.3%, 9.6%)
Family medicine	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
MARA * Speciality			
Internal medicine	MARA Centered at 1, Unit Increase of 1	0.0098 (0.0082, 0.0115)	1.0% (0.8%, 1.2%)
Pediatric medicine	MARA Centered at 1, Unit Increase of 1	−0.0300 (−0.0313, −0.0287)	−3.0% (−3.1%, −2.8%)
Family medicine	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
CCI * Speciality			
Internal medicine	CCI Centered at 0, Unit Increase of 1	0.0020 (−0.0012, 0.0052)	0.2% (−0.1%, 0.5%)
Pediatric medicine	CCI Centered at 0, Unit Increase of 1	0.0003 (−0.0032, 0.0037)	0.0% (−0.3%, 0.4%)
Family medicine	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
BB-COC-PC * Specialty			
Internal medicine	Percentile 40 to 60	−0.0468 (−0.1020, 0.0085)	−4.6% (−9.7%, 0.9%)
Internal medicine	Percentile 60 to 80	0.0640 (0.0094, 0.1186)	6.6% (0.9%, 12.6%)
Internal medicine	Percentile 80 to 100	0.0174 (−0.0388, 0.0736)	1.8% (−3.8%, 7.6%)
Internal medicine	Percentile 0 to 40	REFERENCE	REFERENCE
Pediatric medicine	Percentile 40 to 60	−0.1665 (−0.2876, −0.0455)	−15.3% (−25.0%, −4.4%)
Pediatric medicine	Percentile 60 to 80	−0.1453 (−0.2626, −0.0281)	−13.5% (−23.1%, −2.8%)

Continued

Appendix B. Continued

Variable		Modeled Coefficients	Implied Percent Change
Pediatric medicine	Percentile 80 to 100	−0.0963 (−0.2272, 0.0346)	−9.2% (−20.3%, 3.5%)
Pediatric medicine	Percentile 0 to 40	REFERENCE	REFERENCE
Family medicine	Percentile 40 to 60	REFERENCE	REFERENCE
Family medicine	Percentile 60 to 80	REFERENCE	REFERENCE
Family medicine	Percentile 80 to 100	REFERENCE	REFERENCE
Family medicine	Percentile 0 to 40	REFERENCE	REFERENCE
BB-COC-PC * Payer			
Medicare	Percentile 40 to 60	0.0126 (0.0001, 0.0250)	1.3% (0.0%, 2.5%)
Medicare	Percentile 60 to 80	−0.0102 (−0.0229, 0.0026)	−1.0% (−2.3%, 0.3%)
Medicare	Percentile 80 to 100	0.0279 (0.0145, 0.0413)	2.8% (1.5%, 4.2%)
Medicare	Percentile 0 to 40	REFERENCE	REFERENCE
Medicaid	Percentile 40 to 60	0.0149 (−0.0013, 0.0312)	1.5% (−0.1%, 3.2%)
Medicaid	Percentile 60 to 80	0.0850 (0.0686, 0.1013)	8.9% (7.1%, 10.7%)
Medicaid	Percentile 80 to 100	0.0169 (0.0003, 0.0335)	1.7% (0.0%, 3.4%)
Medicaid	Percentile 0 to 40	REFERENCE	REFERENCE
Commercial	Percentile 40 to 60	REFERENCE	REFERENCE
Commercial	Percentile 60 to 80	REFERENCE	REFERENCE
Commercial	Percentile 80 to 100	REFERENCE	REFERENCE
Commercial	Percentile 0 to 40	REFERENCE	REFERENCE
BB-COC-PC * Age			
Percentile 40 to 60	Age Centered at 53, Unit Increase of 10	−0.0173 (−0.0207, −0.0139)	−1.7% (−2.1%, −1.4%)
Percentile 60 to 80	Age Centered at 53, Unit Increase of 10	−0.0142 (−0.0178, −0.0105)	−1.4% (−1.8%, −1.0%)
Percentile 80 to 100	Age Centered at 53, Unit Increase of 10	−0.0285 (−0.0324, −0.0245)	−2.8% (−3.2%, −2.4%)

Continued

Appendix B. Continued

Variable			Modeled Coefficients	Implied Percent Change
Percentile 0 to 40	Age Centered at 53, Unit Increase of 10		REFERENCE	REFERENCE
BB-COC-PC * MARA				
Percentile 40 to 60	MARA Centered at 1, Unit Increase of 1		0.0080 (0.0067, 0.0094)	0.8% (0.7%, 0.9%)
Percentile 60 to 80	MARA Centered at 1, Unit Increase of 1		0.0087 (0.0073, 0.0102)	0.9% (0.7%, 1.0%)
Percentile 80 to 100	MARA Centered at 1, Unit Increase of 1		0.0102 (0.0087, 0.0118)	1.0% (0.9%, 1.2%)
Percentile 0 to 40	MARA Centered at 1, Unit Increase of 1		REFERENCE	REFERENCE
BB-COC-PC * CCI				
Percentile 40 to 60	CCI Centered at 0, Unit Increase of 1		−0.0116 (−0.0142, −0.0090)	−1.2% (−1.4%, −0.9%)
Percentile 60 to 80	CCI Centered at 0, Unit Increase of 1		−0.0145 (−0.0173, −0.0117)	−1.4% (−1.7%, −1.2%)
Percentile 80 to 100	CCI Centered at 0, UnitIncrease of 1		−0.0132 (−0.0162, −0.0101)	−1.3% (−1.6%, −1.0%)
Percentile 0 to 40	CCI Centered at 0, Unit Increase of 1		REFERENCE	REFERENCE
BB-COC-PC * Speciality * Age				
Internal medicine	Percentile 40 to 60	Age Centered at 53, Unit Increase of 10	0.0159 (0.0102, 0.0215)	1.6% (1.0%, 2.2%)
Internal medicine	Percentile 60 to 80	Age Centered at 53, Unit Increase of 10	−0.0009 (−0.0066, 0.0048)	−0.1% (−0.7%, 0.5%)
Internal medicine	Percentile 80 to 100	Age Centered at 53, Unit Increase of 10	0.0077 (0.0018, 0.0136)	0.8% (0.2%, 1.4%)
Internal medicine	Percentile 0 to 40	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
Pediatric medicine	Percentile 40 to 60	Age Centered at 53, Unit Increase of 10	−0.0120 (−0.0316, 0.0076)	−1.2% (−3.1%, 0.8%)
Pediatric medicine	Percentile 60 to 80	Age Centered at 53, Unit Increase of 10	0.0028 (−0.0148, 0.0204)	0.3% (−1.5%, 2.1%)
Pediatric medicine	Percentile 80 to 100	Age Centered at 53, Unit Increase of 10	0.0576 (0.0362, 0.0790)	5.9% (3.7%, 8.2%)

Continued

Appendix B. Continued

Variable			Modeled Coefficients	Implied Percent Change
Pediatric medicine	Percentile 0 to 40	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
Family medicine	Percentile 40 to 60	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
Family medicine	Percentile 60 to 80	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
Family medicine	Percentile 80 to 100	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
Family medicine	Percentile 0 to 40	Age Centered at 53, Unit Increase of 10	REFERENCE	REFERENCE
BB-COC-PC * MARA * Speciality				
Internal medicine	Percentile 40 to 60	MARA Centered at 1, Unit Increase of 1	−0.0039 (−0.0064, −0.0014)	−0.4% (−0.6%, −0.1%)
Internal medicine	Percentile 60 to 80	MARA Centered at 1, Unit Increase of 1	−0.0019 (−0.0043, 0.0006)	−0.2% (−0.4%, 0.1%)
Internal medicine	Percentile 80 to 100	MARA Centered at 1, Unit Increase of 1	−0.0075 (−0.0100, −0.0049)	−0.7% (−1.0%, −0.5%)
Internal medicine	Percentile 0 to 40	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
Pediatric medicine	Percentile 40 to 60	MARA Centered at 1, Unit Increase of 1	−0.0002 (−0.0044, 0.0040)	−0.0% (−0.4%, 0.4%)
Pediatric medicine	Percentile 60 to 80	MARA Centered at 1, Unit Increase of 1	−0.0010 (−0.0047, 0.0027)	−0.1% (−0.5%, 0.3%)
Pediatric medicine	Percentile 80 to 100	MARA Centered at 1, Unit Increase of 1	−0.0144 (−0.0182, −0.0106)	−1.4% (−1.8%, −1.1%)
Pediatric medicine	Percentile 0 to 40	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 40 to 60	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 60 to 80	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE

Continued

Appendix B. Continued

Variable			Modeled Coefficients	Implied Percent Change
Family medicine	Percentile 80 to 100	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 0 to 40	MARA Centered at 1, Unit Increase of 1	REFERENCE	REFERENCE
BB-COC-PC * CCI * Speciality				
Internal medicine	Percentile 40 to 60	CCI Centered at 0, Unit Increase of 1	−0.0058 (−0.0105, −0.0011)	−0.6% (−1.0%, −0.1%)
Internal medicine	Percentile 60 to 80	CCI Centered at 0, Unit Increase of 1	−0.0136 (−0.0182, −0.0091)	−1.4% (−1.8%, −0.9%)
Internal medicine	Percentile 80 to 100	CCI Centered at 0, Unit Increase of 1	−0.0032 (−0.0080, 0.0016)	−0.3% (−0.8%, 0.2%)
Internal medicine	Percentile 0 to 40	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
Pediatric medicine	Percentile 40 to 60	CCI Centered at 0, Unit Increase of 1	0.0110 (0.0002, 0.0217)	1.1% (0.0%, 2.2%)
Pediatric medicine	Percentile 60 to 80	CCI Centered at 0, Unit Increase of 1	0.0053 (−0.0048, 0.0154)	0.5% (−0.5%, 1.6%)
Pediatric medicine	Percentile 80 to 100	CCI Centered at 0, Unit Increase of 1	0.0113 (0.0008, 0.0217)	1.1% (0.1%, 2.2%)
Pediatric medicine	Percentile 0 to 40	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 40 to 60	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 60 to 80	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 80 to 100	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE
Family medicine	Percentile 0 to 40	CCI Centered at 0, Unit Increase of 1	REFERENCE	REFERENCE

Abbreviations: SDI, social deprivation index; CCI, Charlson's comorbidity index; MARA, Milliman advanced risk adjusters; CI, confidence interval.