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Association of medical tests use with care continuity in primary care service: evidence from the Department of Veterans Affairs

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Background: Continuity of care (CoC) is an important component of health care delivery that can have cost implications and improve patient outcomes. We analysed data obtained from the Department of Veterans Affairs to examine the relationship between CoC and use of image-oriented diagnostic tests in patients with comorbid chronic conditions.

Methods: A longitudinal, retrospective cohort study involving participants ≥18 years old, with comorbid diabetes and chronic kidney disease. We used a multivariate linear regression model to test whether greater care continuity, measured using a care continuity index (CCI), is associated with less frequent use of diagnostic tests.

Results: Total of 267,442 patients and 8,142,036 tests were included. Of the diagnostic tests we chose to evaluate, the 4 most frequently ordered tests were X-ray (45.6%), electrocardiogram (EKG, 16.8%), computerized tomography (CT, 13.4%), and magnetic resonance imaging (MRI, 3.4%). Overall, greater CCI was associated with fewer use of tests ($P < 0.001$). A 1 standard deviation (SD, 0.27) increase in CCI was associated with 4.2% decrease ($P < 0.001$) in number of tests. But a mixed pattern existed. For X-ray and EKG, greater continuity was associated with less testing, 6.2% ($P < 0.001$) and 3.3% ($P < 0.05$) reductions, respectively. Whereas, for CT and MRI, greater continuity was associated with more testing, 2.3% ($P < 0.001$) and 1.4% increases ($P < 0.01$), respectively.

Conclusion: Overall, greater CoC was associated with fewer use of tests, representing a greater presumed efficiency of care. This has implications for designing health care delivery.

Key words: care continuity, computerized tomography, continuity of care, CT, diagnostic tests, EKG, electrocardiogram, imaging tests, magnetic resonance imaging, medical tests, MRI, X-ray

Introduction

Continuity of care (CoC) may be defined as a process by which a physician–patient relationship is cooperatively developed in ongoing care management towards a shared goal of high quality and cost-effective care.[1] The opposite of CoC would be care fragmentation, in which care delivery often involves multiple providers and organizations with no single common entity effectively coordinating the different aspects of the patient's care.[2]

Over the past several decades, the subject of CoC and its association with positive patient outcomes and reduced health care costs has been well discussed in literature.[3–13] In 1998, work by O'Connor et al. demonstrated that adult Health Maintenance Organization (HMO) members with diabetes who had greater CoC with a health care provider were more likely to receive recommended diabetic care, including greater frequency of haemoglobin A1C surveillance, foot exams, dilated retinal exams, and other preventative health testing.[5] In another study of almost 5,000 Belgian adults, greater provider continuity with a family physician translated to a greater reduction of total health costs. A similar study looking at claims from approximately 1.5 million Medicare beneficiaries in the United States found a strong association between higher provider care continuity and reduction in total health costs, as well as lower rate of hospitalizations.[6] Yet another more recent analysis of fee-for-service Medicare beneficiaries also similarly substantiates an association of greater provider care continuity with reduced outpatient, as well as total, expenditures among older adults with diabetes, hypertension, or dyslipidaemia.[7]

Our study chose to evaluate the impact of care continuity on image-guided diagnostic tests given the rapid expansion of medical imaging within physician services over the past several decades, which has logically contributed to increased

Key messages

- Strong care continuity translates to improved patient outcomes and reduced costs.
- Greater care continuity is associated with less overall use of diagnostic tests.
- Greater care continuity is associated with lesser use of EKG and X-ray tests.
- Greater care continuity is also associated with more use of CT and MRI tests.
- Strong care continuity allows for more efficient use of health care resources.
- Greater efficiency of care delivery has potential implications on health care design.

medical costs. The Medicare Payment Advisory Commission (MedPAC) has often reported increased expenditures on imaging tests among physician services.[14,15] In fact, from 2000 to 2006, it was reported that Medicare expenditures on imaging services were more than doubled.[14] The March 2021 report to congress also cites further increases in spending from imaging tests.[16] Overuse of medical imaging tests creates a concerning imbalance between the clinical benefit of the diagnostic imaging test versus the risk of unnecessary exposure to radiation, particularly in the elderly population in whom data have shown higher rates of imaging tests use.[17–19]

Despite the well discussed nature of care continuity and positive patient outcomes alongside reduced health care expenditures, evidence evaluating the association between care continuity and use of medical tests remain sparse. Based on existing literature regarding CoC, a reasonable assumption is that higher continuity will promote better understanding between provider and patient, thereby proving beneficial and driving value. Logically, this should translate into a reduction in overuse of medical tests. A provider who is well familiar with a patient's case, and has previously ordered certain tests, is less likely to duplicate efforts in ordering the same test since said provider should be aware of previous tests and the results therein. If one were to borrow the term "customer" from a work by Clark et al. and apply to patients, it could be reasoned that CoC creates an opportunity for learning, allowing a provider to get to know a patient better, and vice versa, through repeated encounters.[20] Greater continuity results in a stronger patient–provider relationship, a higher patient satisfaction as trust is gained, enhanced productivity, and improved efficiency.[21] With greater CoC, a provider is more informed on the patient's condition and is able to more quickly determine a patient's health needs.[22,23]

In 1 previous study, it was found that increased CoC was associated with lower overuse of medical procedures among over 1.2 million fee-for-service Medicare patients.[23] But the results of association varied in accordance with specific procedures. Specifically, higher CoC was significantly associated with lower odds of use of 9 procedures, while higher CoC was significantly associated with greater odds of use of 3 procedures.[23]

In this study, we aim to evaluate the relationship of continuity of primary care with the use of image-guided diagnostic tests in a primary care setting, specifically among patients with comorbid diabetes and chronic kidney disease (CKD), a population that presumably requires higher utilization of health care services, including medical procedures. Both diabetes and CKD are chronic conditions that often necessitate frequent contact with health care services for screenings and routine surveillance for potential complications. Additionally, high-quality diabetes care often necessitates a greater CoC between clinical teams, and even more so when there is a presence of kidney disease that places the patient at even greater risk of cardiovascular morbidity and mortality.[5,24,25] Patients with multiple comorbidities often require more frequent visits and greater potential for testing opportunities over time. This population therefore provides a convenient opportunity to explore our outcome of interest.

Methods

This study was conducted as a longitudinal, retrospective cohort study using data obtained from the Veterans Health Administration (VHA), a component of the Department of Veterans Affairs (VA). As the largest integrated health care system in the United Sates, housing an extensive collection of data that offers a diverse assortment of integrated patient-level information maintained in an array of national databases,[26] the VHA provides a reliable and ideal setting for this study. Since the 1990s, the VA has placed focus on primary care to serve as its foundation to coordinate care and provide a long-term, patient–provider relationships for veterans.[8,27] In 2010, the VA launched its current primary care model, the Patient Aligned Care Team (PACT), made up of an interdisciplinary team of a primary care provider (PCP), clinical pharmacist, registered nurse care manager, a licensed practical nurse or medical assistant, and a clerk.[8,27–29] Each veteran is assigned to 1 PCP but may sometimes be seen by another provider. For example, a covering provider when the PCP is out of office, or rural veterans who may visit both community-based outpatient clinic and the larger VA medical centre (VAMC).[28]

Study cohort

Eligible study participants were adults (18 years or older) from across the VHA, diagnosed with both diabetes and CKD during the study time period—1 October 2002 to 30 September 2013. Patients were excluded if they were on dialysis, received a kidney transplant, or had renal failure prior to study entry date. See Supplementary Fig. 1.

Data collection

We aggregated data on a calendar year-quarter basis for all included patients with at least 1 quarter of data. We defined baseline period as the quarter in which a patient entered the study, the index date as the first date of the quarter in which the patient entered the study, and the last quarter as the earliest of the third quarter in 2013 or the quarter in which the patient died. We populated missing lab values using the "last observation carried forward" method.[30] When multiple values are observed for a given measure in a quarter, we averaged them.

Study outcomes

The key outcome variable examined was the use of medical tests. We included data on the following tests in the study observations: X-ray, electrocardiogram (EKG), ultrasound, computerized tomography (CT), magnetic resonance imaging (MRI), electromyogram, electroencephalogram, positron emission tomography, topographical brain mapping, magnetoencephalography, electrophysiology, interventional radiology, and nuclear medicine.

CoC measurement

To measure CoC, we used the quantitative measure termed care continuity index (CCI), first described in Ahuja et al.[4] and has since been published in other literature.[3] The index is based on Herfindahl–Hirschman index, a commonly accepted measure of market concentration that is typically used to determine market competitiveness.[31] For each observation (patient-quarter), we first calculated each PCP's share (equivalently, fraction) of the patient's total outpatient visits in the past year. CCI is then obtained by summing up the squares of those fractions. Higher CCI indicates greater continuity. An illustration for CCI calculation has been included in Supplementary Appendix. To ensure that our results are not biased by how we define CoC, we conduct a robustness check in which we use the CoC measure proposed in Bice and Boxerman,[32] with the assumption that all providers are unreferred, and found that our conclusions hold.

For each patient, we calculated the number of tests during the same time period for which we calculated CCI.

To capture information regarding patient's comorbidities, Charlson Comorbidity Index score was calculated at baseline, based on 1 year prior to study entry.[33–36]

Statistical analysis

To examine the relationship between CCI and the use of the medical tests of interest, we used a multivariable linear regression model while controlling for other factors that may influence the outcome of interest, including total number of primary care visits and all other visits (as 2 separate variables) that might influence our estimates. We found that the distribution plots for the number of tests followed a logarithmic distribution. Therefore, we performed our analysis using a log-linear regression model.

To examine whether the association between CCI and the use of tests differed with each individual test, we also ran separate multivariate log-linear regression models for each test, with a focus on 4 tests that together represented almost 80% of all tests. Specifically, X-ray accounted for 57.5%, while EKG, CT, and MRI, represented 21.2%, 16.9%, and 4.3%, respectively.

Variables adjusted for include demographics (including age, gender, race, marital status, enrollment priority, diabetes duration, homelessness, or residence in a rural area), Charlson Comorbidity Index at baseline, medications used by the patient, lab values (such as creatinine levels, glycated haemoglobin or haemoglobin A1C, lipid parameter, blood pressure, and body mass index), main events (cardiovascular complications, microvascular complications, death from any cause, and hypoglycaemic event), and organizational characteristics (i.e. characteristics of the patient's primary care facility—facility most often visited during the past 4 quarters—such as details on whether affiliated with a teaching hospital, urban location, or a VA-owned site).

All data analysis was performed with SAS statistical software (version 9.4; SAS Institute Inc.) as 2-sided tests with statistically significant findings defined as $P < 0.05$. StataMP version 15 (College Station, TX) statistical software was also used for regression analysis. This study was approved by the Institutional Review Boards of Texas Tech University Health Sciences Center and Veterans Affairs, and the Research and Development committee of the North Texas VA Health Care System.

Results

A total of 267,442 unique patients were included in our cohort of diabetes and CKD comorbid patients (Supplementary Fig. 1). The patient baseline characteristics are summarized in Table 1. On average, patients were 69.9 years of age on study entry, 73% of the cohort were non-Hispanic White, and 98% were male. Sixty-eight percent of the cohort had a

Table 1. Cohort characteristics.

Characteristic	*n* = 267,442
Age, mean (SD), years	69.9 (10.1)
Age <65 years, %	34.5
Male sex, %	97.5
Race, %	
Non-Hispanic White	72.8
Non-Hispanic Black	13.7
Married, %	59.5
Diabetes duration, mean (SD), years	1.9 (2.38)
Homeless, %	0.2
Rural, %	51.2
Body mass index[a], mean (SD)	31.1 (6.3)
Glycated haemoglobin, mean (SD), %	6.99 (1.48)
Creatinine, serum, mean (SD), mg/dL	1.58 (0.65)
LDL cholesterol, mean (SD), mg/dL	90.4 (32.1)
Systolic blood pressure, mean (SD), mm Hg	133.3 (17.1)
Charlson Comorbidity Index score (%)[b]	
5	42.6
6	25.4
7	17.6
8	14.3
Comorbidity, %	
Obstructive coronary disease	39.3
Peripheral arterial disease revascularization/amputation	18.8
Cancer	15.0
Chronic obstructive pulmonary disease/asthma	14.9
Dementia	3.5
HIV	0.4

HIV, human immunodeficiency virus; LDL, low-density lipoprotein.
[a]Body mass index (BMI) = weight (kg)/height (m)^2.
[b]The Charlson Comorbidity Index is a validated tool used to estimate mortality risk in patients with multiple comorbidities in longitudinal studies.[33,34] A higher score implies a higher mortality risk or higher resource use. In this study, the lowest Charlson Comorbidity Index score is 5, considering comorbidity of diabetes and CKD in all patients.

Table 2. Summary statistics on CCI and image-oriented diagnostic tests per patient per year.

	Mean (SD) (per patient per year)	Median (IQR) (per patient per year)
CCI	0.72 (0.27)	0.68 (0.51–1)
All tests (n = 8,142,036)	3.58 (4.35)	2 (1–12)
X-ray (45.6%)	1.63 (2.25)	1 (2–6)
EKG (16.8%)	0.60 (1.25)	0 (0–3)
CT (13.4%)	0.48 (1.03)	0 (0–3)
MRI (3.4%)	0.12 (0.43)	0 (0–1)

Charlson Comorbidity Index score of 5–6 at baseline. Ninety-six percent received primary care service from a VAMC, the larger VA hospital facilities that provide a diverse range of health care services to veterans.

The average number of quarters a patient remained in the study was 25.06. Approximately 2.5% of our cohort died during the study observation period. Patients had an average of 5.13 outpatient visits per year and on average, saw 2 unique PCPs per year with approximately 2.5 visits per provider per year. The mean CCI observed for the study period was 0.72.

A total of 8,142,036 tests were included in our data aggregate for the study period: X-ray, EKG, CT, and MRI constituted 45.6%, 16.8%, 13.4%, and 3.4% of the total number of tests, respectively. During the study period, we observed that a patient underwent an average of 3.58 tests per year. Table 2 provides the summary statistics observed in the study.

Our regression analysis revealed a 4.2% (95% confidence interval [CI], 2.1%–6.3%; $P < 0.001$) decrease in the overall use of tests for each standard deviation (SD, 0.27) increase in CCI. This relationship also held true for X-ray and EKG use with 6.2% (95% CI, 4%–8.3%; $P < 0.001$) and 3.3% (95% CI, 0.7%–5.9%; $P < 0.001$) respective decrease in use, with each SD increase in CCI. However, for CT and MRI, we found that 1 SD increase in CCI led to 2.3% (95% CI, 1%–3.6%; $P < 0.01$) and 1.4% (95% CI, 0.5%–2.2%; $P < 0.05$) increase, respectively, in the use of these tests. Figure 1 further illustrates the relationship between the predicted value of use of each test as a function of CCI.

Discussion

In our analysis, we found a mixed-model pattern in the association between CoC and the use of medical tests. Overall, a higher CCI, our measure for CoC, was associated with lesser use of tests. But in examining use of individual tests as a function of CCI, we found that greater CoC was associated with fewer use of X-ray and EKG but associated with greater use of CT and MRI. This variation highlights a few important points. In the view of the fact that X-ray made up almost half of the total number of tests observed for the study period, it stands to reason that X-ray is often a first-line imaging test ordered by a provider in trying to determine a patient's health needs. But CT and MRI making up only 17% of the total number of tests supports the reason that these 2 tests are not routinely used and are usually reserved when more advanced imaging is clinically indicated. Therefore, if a patient were to receive primary care from multiple different providers, as is in the case of care fragmentation, we would observe a correlated higher frequency of use of X-ray imaging tests. But when there is strong continuity in a patient–provider relationship, it stands to reason that such provider would already have information from any prior X-ray test and other pertinent patient-related information, and can essentially quickly determine when there is a need for a more sophisticated, and expensive, imaging test such as an MRI or a CT. Similarly, a PCP who is seeing a patient for the first time might order an EKG for common complaints such as chest pain or shortness of breath, particularly when considering a patient with comorbid diabetes and CKD who is at increased cardiovascular risk. But a provider who is more familiar with a patient's history is less likely to repeat such tests if one already exists. This logic therefore holds consistent with our finding of an inverse relationship between CoC and X-ray and EKGs, but a positive relationship between CoC and the use of MRI and CT imaging tests.

Our findings are comparable to findings from 2 separate studies. The first study reported a positive association of care continuity with lower overall overuse of medical tests and procedures, with an OR 0.93 (95% CI, 0.93–0.94) for each 0.1 unit increase in CCI.[23] The authors also reported a positive association between CoC and overuse of CT, specifically CT of the thorax, consistent with our finding. While this study focused on 19 potentially overused medical procedures, our study focused on tests frequently ordered to answer a specific medical question such as to establish a diagnosis, screen for disease, provide prognostic information, or to confirm disease free condition.[37] Another study specifically looked at whether care fragmentation was associated with a greater use of radiology and other diagnostic tests.[38] Our findings are comparable to findings from this study in that the authors reported that patients with the most fragmented care had twice as many of radiology and other diagnostics as patients with the least fragmented care.[38] This study was however limited by its cross-sectional design. While CCI is a relatively new measure of CoC, we conducted extensive sensitivity analysis and robustness checks, including using Bice–Boxerman Index to calculate CoC,[17] as was done in these 2 studies, to validate our findings.

We propose that the positive association between CCI and use of MRI and CT tests is a positive finding, considering that these 2 tests are more sophisticated and advanced tests and cost a lot more than X-rays or EKG. For example, according to Kaiser Permanente, a similarly large integrated health care system in the United Sates, the cost of an MRI ranges from $692 to $1,560, the cost of CT scan ranges from $359 to $1,674, while EKG costs $31, and X-rays cost ranges from $38 to $118 under a deductible plan type.[38,39] Blue Cross Blue Shield of Massachusetts lists similar prices.[40]

One process by which CCI may have been positively associated with the use of MRI and CT tests is through providers who have formed a long-term relationship with their patients, who may already have explored less expensive diagnostic tests, having access to results therein before determining the need for more advanced tests. Another hypothesis we propose to explain this positive relationship is that a long-term provider is more likely to be able to quickly recognize when a patient's condition requires referral to a specialist, who may then be the one to order these expensive tests in establishing a diagnosis or require these tests as part of pre-referral work-up process. Granted, we do not have the full disclosure of the physician decision-making process.

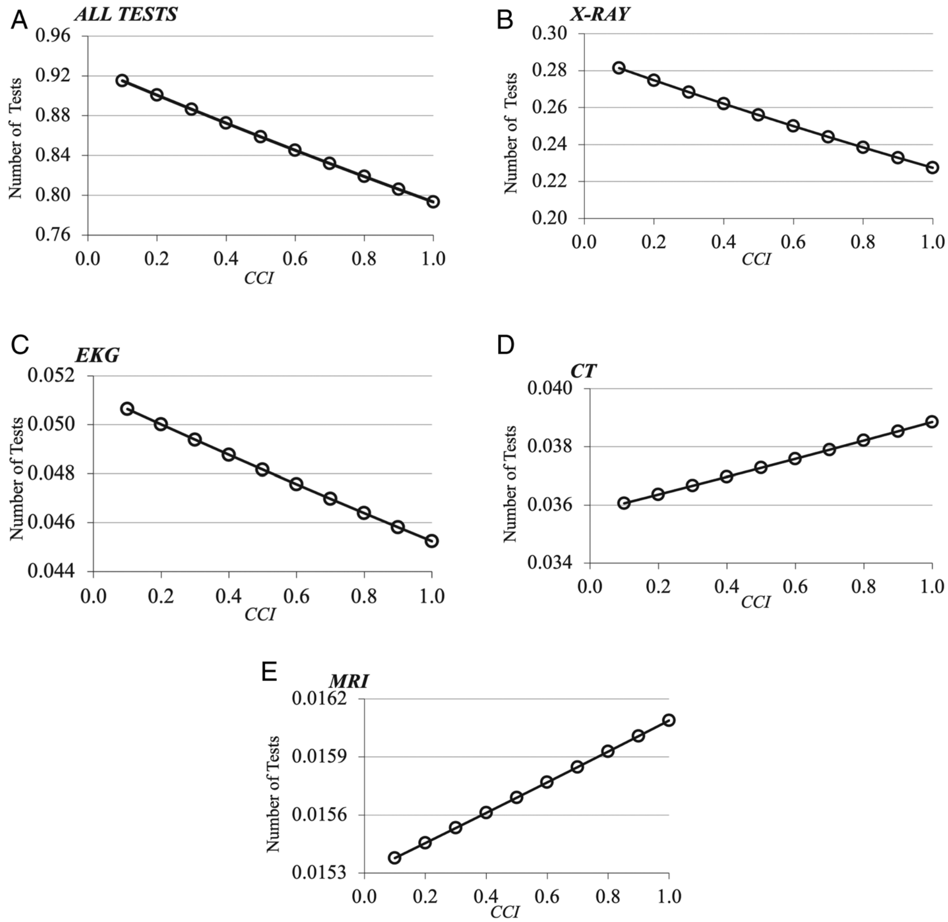

Fig. 1. Adjusted multivariate regression analysis of the use of image-oriented diagnostic tests as a function of CCI. (A) Use of all image-oriented diagnostic tests as a function of CCI (4.2% decrease for each SD increase in CCI, $P < 0.001$); (B) use of X-ray as a function of CCI (6.2% decrease for each SD increase in CCI, $P < 0.001$); (C) use of EKG as a function of CCI (3.3% decrease for each SD increase in CCI, $P < 0.001$); (D) use of CT as a function of CCI (2.3% increase for each SD increase in CCI, $P < 0.01$); and (E) use of MRI as a function of CCI (1.4% increase for each SD increase in CCI, $P < 0.05$). CCI, care continuity index; SD, standard deviation.

The presumed efficiency, reflected in the reduction in the use of tests, has potential financial implications too. For example, 1 SD increase in CCI results in 250,892 fewer X-rays and 49,765, fewer EKG tests ordered for our cohort, on average. This translates to an average cost savings of $11.1 million (95% CI, 6.5–15.5 million) over the course of 11 years or $1 million annually (95% CI, 0.6–1.4 million), using the lower end of costs from Kaiser Permanente. The cost of an imaging test can vary based on location, the medical provider performing the test, and body part on which the test will be performed, and the insurance type, among a multitude of possible factors that may influence pricing. There was a negative linear relationship between overall use of tests examined in this cohort as a function of CCI, however our estimated cost savings only highlights X-rays and EKG and does not include potentially other more costly tests included in our analysis. Our projected cost savings also does not highlight other potential gains that could be associated with reducing the overuse of tests in patient care, such as patient satisfaction and improved quality of life.

Limitations

Our data are primarily limited to the VA and do not include data on patients who may have received care from outside the VA. However, when we restrict the data to patients who are "Medicare ineligible," our findings remained true. Secondly, we were unable to obtain data related to cost of tests included in our analysis within the VA, but we do recognize that the cost of obtaining care in the VA is considered lower than outside the VA and as such our estimate cost savings may potentially be lesser for the VA. We also recognize that because the cost of obtaining care in the VA is considered lower, it is very likely that our cohort included patients who primarily obtained their care from within the VA. Therefore, any excluded data on non-VA care should have minimal impact on our findings. Thirdly, our data were primarily limited to the VA population, a population known to be primarily made up of non-Hispanic, White males.[41] As such, this limits the generalizability of our study to settings where females may make up a considerable proportion of the population.

While the cohort is older, we believe it still has value today. Our study objective was to evaluate how CoC may impact patient care, specifically in terms of use of image-oriented diagnostic tests. In this patient population, we believe this relationship will retain its significance throughout time, even as practice has changed. Moreover, we evaluated each patient-quarter to account for time when practice patterns may have changed.

Our calculation of CCI based on HHI may appear to be less than logical to measure continuity between individuals given its original intent for the finance industry. We checked our calculation of CCI for robustness using CoC measure proposed by Bice and Boxerman that other studies have used previously. While we note that our calculation excludes patients who have fewer than 3 visits, we found that our results still held true if we do not limit to 3 visits. Limiting to 3 visits was important as CCI becomes a patient who visits only once will have a CCI of one, by default, and may potentially bias our estimates. Lastly, while we found strong associations that held true after controlling for many covariates, we could not determine the causal mechanism.

Conclusion

CoC is an important concept in any health care system, especially considering its significant impact on varied aspects of health care delivery. Our findings demonstrate important implications for health care providers, managers, and policymakers. More specifically, our study shows that in a primary care setting, health care delivery system that involves fragmented care risks inefficient use of resources, potentially from providers duplicating efforts in diagnostic procedures. But a high CoC is significantly associated with less frequent use of medical tests, which translates to greater efficiency of care delivery.

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Supplementary material

Supplementary material is available at *Family Practice* online.

Author contributions

Dr. Ahuja had full access to the data and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Nothing to disclose.

Ethical approval

This study was approved by the Institutional Review Board of the North Texas Veterans Affairs Medical Center as an amendment under the parent submission titled "The Safety and Effectiveness of Metformin Patients with Type 2 Diabetes Mellitus and Chronic Kidney Disease."

Conflict of interest

None declared.

Data availability

The data underlying this article cannot be shared publicly due to this being a federally restricted data, and are only available to individuals that are employed with the Veterans Affairs (VA) and have been granted access through the IRB review process. Sharing these data in any form is prohibited by federal law. We have provided details on the variables used in the paper but would be glad to provide a complete data dictionary and any additional summary statistics.

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