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Antidiabetic medication use in patients with type 2 diabetes and chronic kidney disease

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ABSTRACT

Aims: To quantify patterns of conventional and newer antidiabetic medication use in patients with type 2 diabetes mellitus (T2DM) and chronic kidney disease (CKD).
Methods: We used data from a large claims and integrated dataset that includes employed and commercially insured patients in the US to select patients who had T2DM and CKD with information on laboratory values and prescriptions for antidiabetic medications from January 1, 2014 to January 1, 2015. We stratified the analyses by sociodemographic variables.
Results: In a cohort of 38,577 patients with T2DM and CKD, we found wide variation in the treatment of T2DM by CKD stage as well as by several sociodemographic factors. Although metformin was the most commonly prescribed medication, only about half of patients in the cohort and fewer than two-thirds of patients with early stage CKD were prescribed metformin. Approximately 10.6% of patients with CKD stage 4 and 2.1% of the patients with CKD stage 5 were prescribed metformin. Sulfonylureas with active metabolites that accumulate with impaired kidney function were prescribed in more than one-third of patients with CKD stages 3b, 4, and 5. Only 3.4% and 12.3% of patients were prescribed GLP-1 and DPP-4 respectively.
Conclusions: Prescriptions for metformin were lower than expected among patients with mild to moderate CKD. Prescriptions for newer antidiabetic medications with known safety and efficacy across the spectrum of CKD remained low. Prescriptions for agents contraindicated in advanced CKD continued to be written in a sizeable fraction of patients.

1. Introduction

Maintaining glycemic control in type 2 diabetes mellitus (T2DM) can help prevent micro- and macrovascular complications and improve disease outcomes.[1,2] Optimal management of T2DM is particularly important in patients with chronic kidney disease (CKD) because of exceptionally high rates of complications, including further deterioration of kidney function that can ultimately lead to kidney failure, and accelerated atherosclerotic and calcific arteriosclerotic vascular disease that plague patients with both conditions.[3–8] Diabetes care and relevant clinical practice guidelines are continuously evolving, yet little is known about how to optimize T2DM care in patients with CKD. Relatively few patients with moderate to advanced CKD are included in most clinical trials and there is a paucity of outcomes data in patients with T2DM and CKD.[9,10] The clearance of several antidiabetic medications is reduced in patients with impaired kidney function and raises the risk of adverse drug outcomes, including hypoglycemia, particularly with insulin and sulfonylureas, and lactic acidosis associated with the use of metformin in patients with advanced CKD. More recently, newer antidiabetic medications such as glucagon-like peptide-1 receptor agonists (GLP-1) and dipeptidyl peptidase-4 inhibitors (DPP-4) have been introduced to the market and approved for use, but data are lacking on how these newer drugs, and "mature" conventional drugs, such as metformin, sulfonylureas (SU), thiazolidinediones (TZD), and insulin are being prescribed in patients with T2DM and CKD. We therefore sought to describe treatment approaches for glycemic control in patients with T2DM and CKD by examining patterns of newer (GLP-1

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and DPP-4) and conventional (metformin, SU, TZD, and insulin) antidiabetic medication use in this patient population. We hypothesized that the provision of newer agents were positively associated with younger patient age, male sex, white race, non-Hispanic ethnicity, higher household income, and coastal geography, and that prescribing patterns varied by CKD stage and prescribing provider specialty.

2. Subjects

This study was approved by the Institutional Review Board of Stanford University and conducted in accordance with the Declaration of Helsinki guidelines. We used data from a large claims and integrated database that includes employed and commercially insured patients in the United States (US). The Clinformatics Data Mart, OptumInsight Life Sciences dataset (OptumInsight, Eden, Prairie, MN) is a single payer, closed data system that includes patient-level administrative and demographic information including type of insurance plan, age, sex, eligibility, income, and medical and prescription claims, laboratory values including glycosylated hemoglobin (HbA1c) and serum creatinine, and unique identifiers for linking patients. Using the Socioeconomic Status (SES) data file version 7.0, we selected adults age ≥ 18 years in 2015 who had continuous enrollment between January 1, 2014 and January 1, 2015 (Fig. 1). Of these patients, we excluded 6,488,560 patients who had missing laboratory data on serum creatinine from 2014 to 2015 and those with missing data on demographic variables including sex, race, and geographic region. We then selected patients who had T2DM from January 1, 2014 to January 1, 2015 whom we defined as those with a clinical diagnosis of T2DM based on the International Classification of Diseases, Ninth Revision, codes (ICD-9 codes), those with HbA1c ≥7% (≥53 mmol/mol), or those with ≥2 prescription claims for antidiabetic medications (N = 275,160). We further restricted the cohort to patients who had CKD from January 1, 2014 to January 1, 2015 by classifying them into CKD stages 1 through 5 using the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF KDOQI) classification guidelines (Appendix A Table A.1).[11] We used sex-specific data on urinary albumin-to-creatinine ratio (UACR) to assess albuminuria (>17 mg/g for men or >25 mg/g for women) and CKD stage was only determined if eGFR and UACR data were both not missing unless eGFR alone clearly indicated CKD stage 3 or higher. We further excluded patients who did not have prescriptions for antidiabetic medications after January 1, 2015. The final cohort consisted of 37,577 patients.

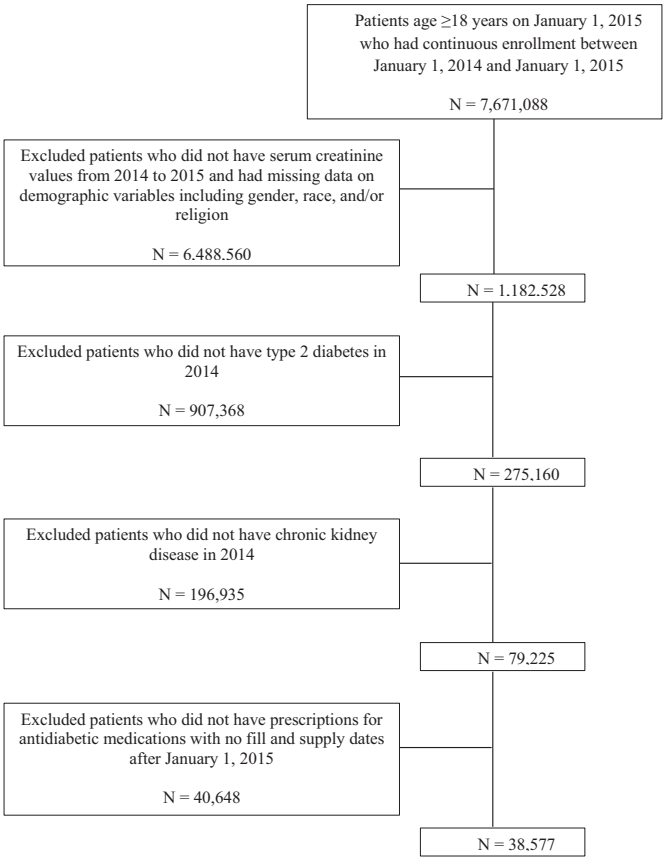

Fig. 1. Cohort assembly of patients age ≥ 18 years with T2DM and CKD in The Clinformatics Data Mart, OptumInsight Life sciences database (OptumInsight, Eden, Prairie, MN) in 2015.

3. Materials and methods

3.1. Medication use

We defined medication use according to pharmacy fill information for two newer classes (GLP-1 and DPP-4) and four "mature" conventional classes of antidiabetic medications (metformin, SU, TZD, and insulin). We gathered medication data for patients who filled prescriptions for any of the study drugs on or prior to January 1, 2015 but after January 1, 2014. Combination therapy was considered present if prescriptions were filled for >1 of the antidiabetic classes during the specified time window.

3.2. Covariates

We obtained patient age, sex, and geographic region from the "Optum SES Member" file (SES data file version 7.0) and information on race and Hispanic ethnicity and income from the "Optum SES Socioeconomic" file. We defined CKD stages as previously described, and comorbidities using ICD-9 codes and procedure codes from at least one inpatient or two or more outpatient encounters separated by at least one day.[12,13]

3.3. Statistical analysis

We used descriptive statistics – frequencies and percentages for categorical variables and means and standard deviations for continuous variables – to summarize the characteristics of patients with T2DM and CKD in 2015 and obtained frequency and percentage data to ascertain the proportion of eligible patients who filled a prescription for the antidiabetic medication of interest. We stratified our analyses by age, sex, race, ethnicity, income, geographic region, CKD stage, and prescribing provider specialty.

4. Results

A total of 38,577 patients with T2DM and CKD were included in the present study (Table 1). The cohort had similar prevalence of female and male patients and was diverse in terms of race and ethnicity, income, and geographic region, with an average age of 72 years and mean HbA1c of 7.5% (58 mmol/mol). The majority of the patients had CKD stage 3, with 44.4% of the patients having stage 3a and 22.3% having stage 3b. The mean serum creatinine and urinary albumin-to-creatinine ratio (UACR) were 1.3 mg/dL and 318 mg/g, respectively.

4.1. Overall and by CKD stage

In 2015, metformin was the most common medication prescribed to patients in this cohort (49.2%), followed by SU (38.8%) and insulin (24.8%) (Table 2). Only four patients in the entire cohort were prescribed a first generation SU such as chlorpropamide or tolazamide, with a majority of patients being prescribed second generation SU including glipizide (60%), glimepiride (36.6%), and to a lesser extent

Table 1
Characteristics of patients with diabetes and chronic kidney disease in 2015[a].

	Overall N = 38,577
Age, mean ± SD, years	72.0 ± 10.6
Sex	
Female	19,649 (50.9%)
Male	18,928 (49.1%)
Race and ethnicity	
Asian	1793 (4.7%)
Black	4700 (12.2%)
Hispanic	8385 (21.7%)
White	23,699 (61.4%)
Income	
<$40 K	13,638 (35.4%)
$40–$49 K	3797 (9.8%)
$50–$59 K	3207 (8.3%)
$60–$74 K	3820 (9.9%)
$75–$99 K	4390 (11.4%)
$100 K+	6515 (16.9%)
Unknown	3210 (8.3%)
Geographic region	
East North Central	1328 (3.4%)
East South Central	1263 (3.3%)
Middle Atlantic	2995 (7.8%)
Mountain	7114 (18.4%)
New England	183 (0.5%)
Pacific	5480 (14.2%)
South Atlantic	10,616 (27.5%)
West North Central	985 (2.6%)
West South Central	8408 (21.8%)
Unknown	205 (0.5%)
CKD	
Stage 1	3374 (8.8%)
Stage 2	6453 (16.7%)
Stage 3a	17,139 (44.4%)
Stage 3b	8613 (22.3%)
Stage 4	2542 (6.6%)
Stage 5	456 (1.2%)
Comorbidities	
Alcohol use	198 (0.5%)
Cancer	3389 (8.8%)
Cardiovascular disease	3238 (8.4%)
Chronic liver disease	1104 (2.9%)
Congestive heart failure	4629 (12.0%)
Coronary artery disease	9113 (23.6%)
Dementia	1002 (2.6%)
GI bleeding	1342 (3.5%)
Hyperlipidemia	26,453 (68.6%)
Peripheral vascular disease	3999 (10.4%)
Tobacco use	1497 (3.9%)
Laboratory data	
HbA1c, mean ± SD, %	7.5 ± 1.5
HbA1c, mean ± SD, mmol/mol	58 ± 16
Missing, N (%)	5359 (13.9)
Serum creatinine, mean ± SD, mg/DL	1.3 ± 0.6
Urinary albumin-to-creatinine ratio, mean ± SD mg/g	318 ± 967
Missing, N (%)	18,253 (47.3)

[a] Unless otherwise noted, values are number (percentage) of patients.

glyburide (3.2%). The proportion of patients who were prescribed glimepiride in CKD stages 3a, 3b, 4, and 5 were 37.4%, 36.3%, 34.6%, and 25.8% respectively. The corresponding proportions of patients prescribed glyburide were 2.9%, 2.3%, 1.8%, and 4.0%. Among the newer medications, 3.4% of patients were prescribed GLP-1 and 12.3% of patients were treated with DPP-4. Among patients with CKD stage 1-3a, metformin was the most commonly prescribed medication with over half of the patients with T2DM and CKD stage 3a being prescribed this agent. In more advanced CKD (stages 3b-5), the proportion of patients who were prescribed metformin was lower, with only 2% of the patients with CKD stage 5 being prescribed metformin. The proportion of patients who were prescribed insulin was higher in advanced CKD with nearly 60% of the patients with CKD stage 5 being prescribed insulin. The proportion of patients treated with SU was the highest in CKD stages 3b and 4 (45.3% and 46.2% respectively). The proportion of patients who were prescribed TZD was relatively low and there was minimal variation by CKD stage The proportion of patients who were prescribed GLP-1 was highest in patients with CKD stage 1 (6.1%); the frequency of GLP-1 use was lower among patients with more advanced CKD compared with those with early stage CKD, with the prevalence being 2.6% in patients with CKD stage 5. The proportion of patients treated with DPP-4 was higher in more advanced CKD, with the prevalence being the highest in patients with CKD stage 4 (17.3%). Combination therapy remained relatively low but was the highest in patients with CKD stage 1 (11.4%).

4.2. Variation in prescribing patterns by age, sex, race/ethnicity, income, and geography

When considering prescription patterns by patient age, there was little variation in the proportion of patients prescribed metformin and TZD across different age groups although the proportion was lower in patients >80y (Appendix A Table A.2). A higher proportion of patients in older age groups were prescribed SU while a lower proportion was prescribed insulin. Prescriptions for GLP-1 varied widely across age groups with older patients being treated less frequently (0.8% among >80y and 1.5% among 76–80y *vs.* 8.8% among 18–55y and 7.0% among 56–65y). The proportion of patients prescribed DPP-4 was the highest among those who were 56–65y (14.8%), followed by those who were >80y (12.4%). No material differences were observed in other age groups.

The proportion of patients prescribed metformin, insulin, GLP-1, and DPP-4 varied little by sex. However, a higher proportion of men were treated with SU and TZD than were women (Appendix A Table A.3). White patients were prescribed more medications in every drug class than patients of other racial and ethnic groups (Appendix A Table A.4). Asian patients were the least likely to be treated with antidiabetic medications across all classes, followed by Black and Hispanic patients, despite similar HbA1c values.

A larger proportion of patients in higher income groups were prescribed TZD whereas in lower income groups, a larger proportion of patients were prescribed SU (Appendix A Table A.5). Patients in higher income groups were more commonly treated with newer antidiabetic medications, with the largest proportion of patients prescribed GLP-1 and DPP-4 being in the highest income groups of ≥100 K (6.5% and 14.9% respectively). Prescriptions for metformin were highest in the Mountain (56.0%), West North Central (54.6%), Pacific (52.0%), and New England (50.3%) regions (Appendix A Table A.6, Appendix A Table A.7). Overall, there was not a wide variation in the proportion of patients treated with SU across different geographic regions, but it was the highest in the Pacific region. The proportion of patients prescribed TZD was the lowest in the West North Central region (3.5%) and higher in the West South Central (6.0%), Mountain (6.9%), and Pacific (8.1%) regions while the proportion of patients treated with insulin were the highest in the Midwest and the South. The proportion of patients treated with GLP-1 was higher in the Midwest whereas a higher proportion of patients were prescribed DPP-4 in the coastal regions as well as in the East North and East South Central regions.

4.3. Variation by prescribing provider specialty

Patients who were treated with metformin were most frequently prescribed to by primary care providers (PCPs, 81.7%), followed by endocrinologists (6.1%), and nephrologists (0.7%) (Table 3). Generally, patients who received prescriptions for antidiabetic medications from nephrologists remained low in this cohort (0.4–1.9%). Patients who were treated with SU, TZD, insulin, GLP-1 and DPP-4 had their prescriptions written most frequently by PCPs, and endocrinologists favored GLP-1.

Table 2
Number and percentage of patients with diabetes and chronic kidney disease who are prescribed antidiabetic medications by CKD stage[a].

Medications	All N = 38,577	CKD stage					
		1 N = 3374	2 N = 6453	3a N = 17,139	3b N = 8613	4 N = 2542	5 N = 456
Metformin	18,971 (49.2%)	2192 (65.0%)	4224 (65.5%)	9474 (55.3%)	2801 (32.5%)	270 (10.6%)	10 (2.1%)
SU	14,983 (38.8%)	1036 (30.7%)	2212 (34.3%)	6505 (38.0%)	3905 (45.3%)	1174 (46.2%)	151 (33.1%)
TZD	2377 (6.2%)	193 (5.7%)	338 (5.2%)	1010 (5.9%)	617 (7.2%)	201 (7.9%)	18 (4.0%)
Insulin	9567 (24.8%)	798 (23.7%)	1436 (22.3%)	3516 (20.5%)	2471 (28.7%)	1075 (42.3%)	271 (59.4%)
GLP-1	1325 (3.4%)	207 (6.1%)	268 (4.2%)	527 (3.1%)	251 (2.9%)	60 (2.4%)	12 (2.6%)
DPP-4	4749 (12.3%)	361 (10.7%)	601 (9.3%)	1937 (11.3%)	1349 (15.7%)	439 (17.3%)	62 (13.6%)
Combination therapy	2262 (5.9%)	383 (11.4%)	534 (8.3%)	1025 (6.0%)	279 (3.2%)	40 (1.6%)	1 (0.2%)

Abbreviations: DPP-4, dipeptidyl peptidase-4-inhibiotrs; GLP-1, glucagon-like peptide-1 receptor agonists; SU, sulfonylureas; TZD, thiazolidinediones.
[a] Rows and columns may not add up to total N because patients may be on more than one medication at a time.

5. Discussion

As hypothesized, we found wide variation in the treatment of T2DM in patients with CKD, especially by CKD stage, and also by several sociodemographic factors. Metformin was the most commonly prescribed medication, followed by SU and insulin, but the proportion of patients treated with metformin was <50% with the proportion being <66% even for patients with early stage CKD. This finding was surprising given that published clinical practice guidelines recommend metformin as the first line of treatment in patients with T2DM and normal or near normal kidney function or in patients with mild to moderate CKD, unless contraindicated or not tolerated.[14] Metformin is associated with low hypoglycemia risk, cardiovascular safety, weight neutrality, and a survival benefit in patients with mild to moderate CKD.[15] While metformin is the recommended first-line therapy, even in patients with mild to moderately impaired kidney function,[16–18] its use is advised against in patients with kidney function that is more severely impaired due to a small risk of lactic acidosis and associated risk with all-cause mortality in patients with CKD stage 5.[19] The issue of metformin use in patients with CKD stage 3 remains controversial despite evidence from large cohort studies showing that metformin does not pose excess risk of adverse outcomes for patients with T2DM and CKD stages 1–3.[20,21] More recent guidelines, however, recommend that providers use metformin therapy with caution in patients with advanced CKD.[22] In the real world, metformin continues to be prescribed to patients with more advanced CKD. We found that 10.6% of patients with CKD stage 4 and 2.1% of the patients with CKD stage 5 were treated with metformin.

First generation SU such as chlorpropamide, tolazamide, and tolbutamide are eliminated exclusively by the kidneys and therefore not recommended in patients with CKD due to hypoglycemia risk. We identified one patient in CKD stage 1 and three patients in CKD stage 3a who were prescribed first generation SU. Glipizide is the recommended SU of choice in patients with CKD because it is metabolized by the liver into inactive metabolites, and its clearance is unaffected by reduction in GFR.[23] Glyburide is metabolized by the liver but eliminated in the bile and urine. The risk of hypoglycemia associated with glyburide use increases steadily in patients with impaired kidney function; therefore, the drug is contraindicated in patients with eGFR <60 mL/min. While glimepiride has similar properties, it is associated with lower hypoglycemia risk compared with glyburide and can be used conservatively in patients with stage 3 CKD.[23,24] In accordance with clinical practice guidelines, a majority of patients with CKD who were prescribed SU were prescribed glipizide. However, more than one-third of patients who were prescribed SU were prescribed glimepiride, and glimepiride was widely used in CKD stages 4 and 5, where this agent is contraindicated. While used less frequently, glyburide continues to be prescribed to patients with CKD stages 4 and 5.

Among the newer agents, DPP-4 were prescribed more frequently than GLP-1. The proportion of patients treated with GLP-1 was higher in the earlier stages of CKD whereas DPP-4 prescriptions were more common in CKD stages 3, 4, and 5. DPP-4 are associated with a low risk of hypoglycemia and are weight neutral.[25] All DPP-4 except linagliptin are excreted by the kidneys. Nevertheless, they can be used safely in the setting of impaired kidney function with appropriate

Table 3
Number and percentage of patients with diabetes and chronic kidney disease who are prescribed antidiabetic medications by specialty of providers providing the medications[a].

Provider specialty	Antidiabetic medications						
	Metformin N = 18,971	SU N = 14,983	TZD N = 2377	Insulin N = 9567	GLP-1 N = 1325	DPP-4 N = 4749	Combination therapy N = 2262
Endocrinologists	1153 (6.1%)	954 (6.4%)	225 (9.5%)	1710 (17.9%)	420 (31.7%)	470 (9.9%)	226 (10.0%)
Nephrologists	134 (0.7%)	211 (1.4%)	25 (1.1%)	75 (0.8%)	5 (0.4%)	88 (1.9%)	16 (0.7%)
PCPs	15,498 (81.7%)	12,129 (81.0%)	1858 (78.2%)	6605 (69.0%)	752 (56.8%)	3602 (75.8%)	1773 (78.4%)
Other/unknown	2266 (11.9%)	1774 (11.8%)	279 (11.7%)	1386 (14.5%)	154 (11.6%)	617 (13.0%)	255 (11.3%)

Abbreviations: DPP-4, dipeptidyl peptidase-4 inhibitors; GLP-1, glucagon-like peptide-1 receptor agonists; PCP, primary care physicians; SU, sulfonylureas; TZD, thiazolidinediones.
[a] Rows and columns may not add up to total N because patients may be on more than one medication at a time.

dose adjustment based on the patient's eGFR.[25] Likewise, GLP-1 are associated with low risk of hypoglycemia and weight reduction, but they are costly and delivered by injection. Within the GLP-1 class, liraglutide, dulaglutide, or albiglutide can be used without dose adjustments in patients with CKD,[26] but exenatide is to be avoided in patients with eGFR <30 mL/min as impaired kidney function decreases its clearance.[27] We found that only about 2.5% of patients with CKD stages 4 and 5 were treated with GLP-1, but we were not able to determine the proportion of patients treated with different medications within the GLP-1 class.

The new 2018 Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD) on the management of hyperglycemia in T2DM recommends the use of GLP-1 or sodium-glucose cotransporter 2 (SGLT-2) inhibitors in patients with established cardiovascular disease (CVD) or CKD based on emerging evidence on the benefit of these newer antidiabetic medications on improving cardiovascular outcomes, heart failure, and CKD progression.[14] If HbA1c is still above target, guidelines recommend avoiding TZD in patients with heart failure and adding another class of drug with proven cardiovascular safety such as DPP-4 (not saxagliptin). In our study, the proportion of patients treated with GLP-1 was only 3.0% while 12.3% of the patients were treated with DPP-4. Future studies with more recent data in Optum should examine whether these proportions have changed with evolving clinical guidelines.

We found variations in prescription patterns by age, race and ethnicity, income, geographic region, and provider specialty. Treatment with insulin was less prevalent in older age groups, which is expected given that various factors such as comorbidities, poor physical function, and cognitive impairment in older adults with CKD can make insulin administration and glucose monitoring difficult.[15] Younger patients may be more open to trying new medications and breaking away from previously established or more conventional treatment regimens. In our study, we found that the proportion of patients treat with GLP-1 was higher in younger age groups whereas treatment with DPP-4 was the highest among patients 56–65y. Although there are data in the literature that show a lack of racial and ethnic disparities in diabetes treatment patterns,[28] we found that white patients, compared with Asian, Black, or Hispanic patients, were treated at a higher frequency with all classes of antidiabetic medications examined in the study. In general, prescriptions for metformin and newer medications were more common among patients in higher income groups, probably due to their high cost.

With increasing availability of newer drugs, it is becoming more challenging for providers to make prescription choices for T2DM management while taking into consideration factors such as efficacy, safety, and cost, particularly for patients with CKD. We found that antidiabetic medication prescriptions were more frequently written by PCPs and providers of other or unknown specialty than endocrinologists and nephrologists. The percentage of prescriptions written by nephrologists was generally low in this study. Among the three specialties of interest, GLP-1 were mostly favored by endocrinologists and the least by PCPs. There may be knowledge and competency gaps among providers who do not specialize in T2DM care, preventing nephrologists and PCPs from prescribing newer drugs more widely compared to endocrinologists.[29] When prescribing antidiabetic medications, providers often need to consider a wide range of factors, including potential long-term side effects, medication cost and cost-effectiveness, and therapeutic indications and contraindications,[30] especially regarding the use of metformin in patients with CKD stage 3, which remains controversial. This is particularly true for prescriptions of newer agents such as GLP-1 for which long-term data are still lacking and with which providers, especially PCPs, may have little to no clinical experience.

The strengths of the present study include a large population-based sample of patients with T2DM and CKD who are often excluded from clinical trials, clinically relevant and important prescription pattern data that provide insight into how T2DM has been treated in patients with CKD, and examination of these patterns by various sociodemographic factors that puts into perspective the prescribing practice contexts in a more generalizable real-world setting. The study also has some limitations. We were not able to examine all the antidiabetic medication classes, particularly SGLT-2 inhibitors, another newer class of clinical importance in patients with CKD due to the limitations of the data set at the time when this analysis was performed. Similarly, we did not have data on dosages of the medications prescribed and could not examine dosing of contraindicated agents by CKD stage. Furthermore, we did not examine all agents within each class of antidiabetic medication. We were unable to examine pattern trends over time due to the lack of homogenous composition of patients in the Optum database over time, which prevented us from making direct comparisons between different years. For similar reasons, the data presented herein reflect the Optum database and may not be generalizable to the general US population, particularly the uninsured. We were not able to determine if patients adhered to their treatment regimen or if the medication dose was reduced according to recommendations made by their providers and clinical guidelines. Due to approximately half of the patients in the study missing data on UACR, we could not use the newer 2012 Kidney Disease Improving Global Outcomes criteria to classify CKD stage. While albuminuria is associated with CVD risk and therefore, drugs with proven cardiovascular benefit such as GLP-1 s might be preferred in patients with albuminuria, eGFR may be more clinically relevant with respect to the choice of agent, safety, and dosing. Lastly, due to the cross-sectional nature of the study, we could not assess associations between antidiabetic medication prescriptions and favorable or adverse outcomes.

6. Conclusion

The present study sheds light on how newer and conventional antidiabetic medications are have been prescribed in patients with T2DM and CKD. There were wide variations by sociodemographic factors and while metformin was the most commonly prescribed medication, only about half of the patients were treated with metformin and fewer than two-thirds of patients with early stage CKD were prescribed metformin, despite its being favored by clinical practice guidelines. Prescriptions for newer antidiabetic medications with known safety and efficacy remained low. Prescriptions for agents that are contraindicated in advanced CKD continued to be written. GLP-1 were favored primarily by endocrinologists, with nephrologists prescribing a very low number of antidiabetic medications.

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Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jdiacomp.2019.107423.

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