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SGLT2 inhibitor prescribing among adults with type 2 diabetes and cardiorenal disease in a retrospective cross-sectional electronic health record study

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Research Article

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Abstract

Background

Sodium-glucose cotransporter-2 (SGLT2) inhibitors provide cardiorenal benefits, but their use in routine diabetes care varies. We quantified documented prescribing among adults with type 2 diabetes, recorded cardiorenal disease, and examined associated factors.

Methods

We conducted a single-center retrospective cross-sectional electronic health record study of 7266 adults attending general internal medicine in Türkiye in 2025. A prespecified potential eligibility phenotype comprised recorded kidney disease, heart failure and/or atherosclerotic cardiovascular disease with estimated glomerular filtration rate (eGFR) ≥ 20 mL/min/1.73 m². We summarized prescribing proportions with Wilson 95% confidence intervals (CIs); we used chi-square tests for group comparisons, and we examined associated factors using logistic regression.

Results

Phenotype status was indeterminate in 1419 participants, and 81 assessable participants had eGFR < 20 mL/min/1.73 m². Among 5766 participants in the primary analysis, 2436 (42%) met the phenotype; 296 had documented SGLT2 inhibitor prescribing (12%; 95% CI 11–14). Prescribing was more frequent among participants meeting the phenotype than among those not meeting it (12% vs 8.6%; odds ratio 1.47, 95% CI 1.24–1.75; P < 0.001), although the association was weak (phi = 0.058). Prescribing did not differ significantly across seven cardiorenal subgroups (P = 0.627). Documented metformin and insulin use were associated with prescribing in the complete-case multivariable model (n = 2113).

Conclusions

Documented SGLT2 inhibitor prescribing was recorded in 12% of adults meeting the prespecified phenotype. Electronic case-finding may support targeted medication review, but incomplete prescription capture and unmeasured contraindications limit assessment of individual treatment appropriateness.

Background

Type 2 diabetes is associated with substantial cardiovascular and kidney morbidity and mortality [1, 2]. Contemporary management therefore extends beyond glycemic control and incorporates cardiovascular and kidney risk, heart failure, hypoglycemia, body weight, treatment burden, and patient preferences [3, 4]. Sodium-glucose cotransporter-2 (SGLT2) inhibitors reduce the risk of chronic kidney disease progression and heart failure events across broad patient populations [5–8], while effects on

atherosclerotic cardiovascular outcomes vary according to agent and trial population [9–11]. Current guidelines recommend SGLT2 inhibitors for appropriate people with type 2 diabetes and chronic kidney disease or heart failure, and include SGLT2 inhibitors with demonstrated cardiovascular benefit among recommended treatment options for those with established atherosclerotic cardiovascular disease [4, 12, 13]. These recommendations are based on cardiorenal risk and are not dependent solely on glycated hemoglobin levels.

Despite these recommendations, SGLT2 inhibitor uptake remains heterogeneous in routine clinical practice. Studies from the United States have reported relatively low use among people with type 2 diabetes and established cardiovascular disease, with substantial variation across healthcare facilities [14, 15]. National data from South Korea similarly demonstrate persistent gaps despite increasing uptake over time [16], whereas selected chronic kidney disease cohorts have reported higher but still variable prescribing rates across healthcare settings [17]. Quality-improvement initiatives suggest that clinician education, audit and feedback, and targeted patient identification may address at least part of this implementation gap [18]. However, prescribing estimates depend heavily on population characteristics, healthcare organization, reimbursement policies, and the data sources used to ascertain treatment.

Real-world evidence on SGLT2 inhibitor prescribing among people with type 2 diabetes and cardiorenal disease in Turkey remains limited; available evidence includes a retrospective Turkish type 2 diabetes cohort and a nationwide treatment-pattern study [19, 20]. Electronic health records may pragmatically identify patients with recorded cardiorenal conditions who could benefit from further medication review, while recognizing that electronic case-finding cannot establish individual treatment appropriateness. We therefore aimed to quantify documented SGLT2 inhibitor prescribing among adults with type 2 diabetes who met a prespecified potential eligibility phenotype based on recorded chronic kidney disease, heart failure and/or atherosclerotic cardiovascular disease, and estimated glomerular filtration rate. Secondary aims were to compare prescribing across recorded cardiorenal disease subgroups and to explore demographic, clinical, laboratory, and glucose-lowering treatment characteristics associated with documented prescribing.

Methods

Study design and participants

We conducted a single-center, retrospective cross-sectional electronic health record study in the Internal Medicine Outpatient Clinic of a tertiary hospital in Türkiye. We identified all unique adults with type 2 diabetes who attended the clinic between 1 January and 31 December 2025. We excluded type 1 diabetes and pregnancy when constructing the cohort. The resulting analytic cohort comprised 7266 adults with type 2 diabetes. Separate counts for these initial exclusions were not retained.

The study included all eligible patients attending during the prespecified study period; no sampling was undertaken, and no a priori sample-size calculation was performed. We quantified the precision of the

primary prescribing estimate using a 95% confidence interval.

For phenotype-based analyses, participants required an available serum creatinine/eGFR measurement within the prespecified assessment window. Of the 7266 participants, 1419 had indeterminate phenotype status because no eligible creatinine/eGFR measurement was available and were excluded from phenotype-based analyses. Among the remaining 5847 participants with assessable phenotype status, 81 had eGFR < 20 mL/min/1.73 m² and were excluded from the primary phenotype analysis. The final primary analysis cohort therefore comprised 5766 participants, of whom 2436 met the prespecified potential eligibility phenotype, and 3330 did not.

Data sources and definitions

We obtained data from the hospital information management system, including outpatient, emergency department, inpatient, and discharge records, laboratory results, and electronic prescription and medication modules. We identified concomitant metformin, insulin, and glucagon-like peptide-1 receptor agonist use from available hospital electronic prescription and medication records. The dataset did not capture prescriptions issued outside the study center, dispensing data, or medication records from other healthcare institutions.

We defined the index date as the last internal medicine outpatient visit in 2025. We identified type 2 diabetes primarily using International Classification of Diseases, Tenth Revision (ICD-10) codes E11 and E11.0-E11.9; we used glucose-lowering medication records as supplementary information and did not consider them sufficient as a stand-alone criterion for diabetes classification. Hypertension was identified using codes I10-I13; chronic kidney disease (CKD) using N18, N18.1-N18.5, N18.9 and N19; heart failure using I50, I50.0-I50.4 and I50.9; and atherosclerotic cardiovascular disease (ASCVD) using I20-I25, I63-I64, G45, I70, I73.9, Z95.1 and Z95.5. We identified CKD, heart failure, and ASCVD from diagnostic records documented in the 5 years before the index date. ASCVD codes represented ischemic heart disease, cerebrovascular disease or transient ischemic attack, peripheral arterial disease, and coronary revascularization or stent status. We defined prior-year hospitalization as at least one inpatient admission during the 365 days preceding the index date.

We determined CKD status from diagnostic codes and did not clinically adjudicate it independently. Because ICD-10 code N19 does not establish chronicity, we interpret the CKD variable as recorded code-based kidney disease rather than clinically confirmed CKD. Similarly, the ASCVD code set included I64 (stroke not specified as hemorrhage or infarction) and G45 (transient cerebral ischemic attacks and related syndromes), so it did not establish an atherosclerotic cause for every coded cerebrovascular event. Estimated glomerular filtration rate (eGFR) was calculated using the 2021 Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) creatinine equation without a race coefficient [21]. For both eGFR and glycated hemoglobin (HbA1c), we used the laboratory value closest to the index date within the preceding 90 days. Blank or non-numeric HbA1c entries were treated as missing.

We defined the prespecified potential eligibility phenotype as recorded CKD, heart failure, and/or ASCVD together with eGFR ≥ 20 mL/min/1.73 m². This phenotype was intended for electronic case-finding and did not confirm individual clinical eligibility for SGLT2 inhibitor treatment.

SGLT2 inhibitor prescribing and study outcomes

Documented SGLT2 inhibitor prescribing was defined as dapagliflozin or empagliflozin recorded on the active medication list at the index date or prescribed within the preceding 90 days. The dataset identified no other SGLT2 inhibitors. This outcome reflects prescribing documented within the study center and does not establish medication dispensing, adherence, persistence, or treatment exposure. Likewise, absence of a same-center prescription record does not exclude prescribing by another healthcare provider or institution.

The primary outcome was the proportion of participants meeting the prespecified potential eligibility phenotype who had documented current or recent SGLT2 inhibitor prescribing at the study center. Secondary outcomes included documented prescribing by phenotype status; prescribing proportions across mutually exclusive recorded CKD, heart failure, and ASCVD subgroups; and demographic, clinical, laboratory, and glucose-lowering treatment characteristics associated with documented SGLT2 inhibitor prescribing.

Statistical analysis

We performed statistical analyses using IBM SPSS Statistics for Windows, version 31.0. Categorical variables are presented as n (%). Continuous-variable distributions were assessed using histograms and Q-Q plots. Age was approximately normally distributed and is presented as mean ± standard deviation; between-group comparisons were performed using the independent-samples t-test. HbA1c, serum creatinine, and eGFR were non-normally distributed and are presented as median [interquartile range]; we compared groups using the Mann-Whitney U test.

Associations between categorical variables were assessed using Pearson's chi-square test or Fisher's exact test when expected cell counts were small. Effect sizes are reported as phi for the two-group phenotype comparison and Cramer's V for comparisons across mutually exclusive cardiorenal disease subgroups. We present prescribing proportions, including the primary outcome and disease-subgroup estimates, with 95% confidence intervals calculated using the Wilson score method.

We examined factors associated with documented SGLT2 inhibitor prescribing among participants meeting the potential eligibility phenotype using univariable and multivariable binary logistic regression. The multivariable model included age, sex, HbA1c, documented metformin use, and documented insulin use. Covariates were selected on the basis of clinical relevance and data availability rather than univariable statistical significance. Documented GLP-1 receptor agonist use was evaluated in univariable analysis but was not included in the multivariable model because only seven participants meeting the

phenotype had documented use, resulting in sparse data for a reliable adjusted estimate. In univariable analyses, serum creatinine was modeled per 88.4 μmol/L, equivalent to 1.0 mg/dL in the source dataset; eGFR was modeled per 1 mL/min/1.73 m²; and HbA1c per 10.9 mmol/mol (1.0%). We report results as odds ratios (ORs) with 95% confidence intervals.

We excluded participants with indeterminate phenotype status from analyses requiring phenotype classification. Missing data were not imputed. The primary multivariable model used complete cases and included 2113 of 2436 participants meeting the phenotype (87%), including 263 with documented SGLT2 inhibitor prescribing. We excluded 323 participants from this model because HbA1c was missing or non-numeric; all other model variables were complete.

To explore potential selection associated with missing data, we compared selected baseline characteristics and documented SGLT2 inhibitor prescribing by eGFR availability and, within the cohort meeting the phenotype, by HbA1c availability. As a sensitivity analysis, we repeated the adjusted model without HbA1c in the full cohort meeting the phenotype (n = 2436) and compared estimates with those from the primary complete-case model.

Secondary subgroup and association analyses were considered exploratory, and no adjustment was made for multiple comparisons. All statistical tests were two-sided, with $P < 0.05$ considered statistically significant.

Ethics approval

The study followed the Declaration of Helsinki and was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee on 18 March 2026 (decision no. 2026/4/13). The ethics committee waived the requirement for individual informed consent because of the retrospective, minimal-risk study design. All study data were coded and anonymized before analysis.

Use of AI in manuscript preparation

During manuscript preparation, the authors used ChatGPT (OpenAI) for English-language editing, clarity and concision, manuscript organization, terminology consistency, journal-specific presentation, and reference and citation checking. AI was not used to analyze individual-level study data or fit statistical models. The authors reviewed the edited content and take responsibility for the final manuscript.

Results

Study population

The analytic cohort comprised 7266 adults with type 2 diabetes. Phenotype status was indeterminate in 1419 participants (20%) because no eligible serum creatinine/eGFR measurement was available within the prespecified assessment window. Among the 5847 participants with assessable phenotype status,

81 had eGFR < 20 mL/min/1.73 m² and were excluded from the primary phenotype analysis. The final primary analysis cohort therefore comprised 5766 participants, of whom 2436 (42%) met the prespecified potential eligibility phenotype, and 3330 (58%) did not (Fig. 1).

Participants without an available eGFR had lower recorded prevalence of CKD, heart failure, and ASCVD; fewer prior-year hospitalizations; and less frequent documented SGLT2 inhibitor prescribing than those with an available eGFR (6.6% vs 10.0%; P < 0.001).

In the primary analysis cohort, mean age was 64 ± 11 years, and 3353 participants (58%) were women. Hypertension was recorded in 5508 (96%), CKD in 309 (5.4%), heart failure in 707 (12%), and ASCVD in 2055 (36%). Overall, documented SGLT2 inhibitor prescribing was present in 582 participants (10%). Among the 5132 participants with analyzable HbA1c, median HbA1c was 60 [50–77] mmol/mol (7.6 [6.7–9.2]%) (Table 1).

Table 1
Characteristics of participants in the primary phenotype analysis

Variable	n (%) or summary statistic
Age, years	64 ± 11
Women	3353 (58)
Hypertension	5508 (96)
Chronic kidney disease	309 (5.4)
Heart failure	707 (12)
ASCVD	2055 (36)
Hospitalization in previous year	1350 (23)
HbA1c, mmol/mol (%)	60 [50–77] (7.6 [6.7–9.2])
Serum creatinine, μmol/L	80 [65–100]
eGFR, mL/min/1.73 m²	87 [64–101]
Documented metformin use	566 (9.8)
Documented insulin use	421 (7.3)
Documented GLP-1 receptor agonist use	30 (0.5)
Documented SGLT2 inhibitor prescribing	582 (10)
Potential eligibility phenotype	2436 (42)

Note: Categorical variables are presented as n (%). Age is presented as mean ± SD; HbA1c, serum creatinine and eGFR as median [interquartile range]. HbA1c was available for 5132 of 5766 participants; six non-numeric laboratory-status entries were treated as missing. We identified documented glucose-lowering medication use from hospital electronic prescription and medication records. ASCVD, atherosclerotic cardiovascular disease; eGFR, estimated glomerular filtration rate; GLP-1, glucagon-like peptide-1; HbA1c, glycated hemoglobin; SGLT2, sodium-glucose cotransporter-2; SD, standard deviation.

Primary outcome

Among the 2436 participants meeting the prespecified potential eligibility phenotype, 296 had documented SGLT2 inhibitor prescribing, corresponding to a prescribing proportion of 12% (95% CI 11–14). The remaining 2140 participants (88%) had no current or recent same-center prescribing record.

Among the 3330 participants not meeting the phenotype, 286 had documented SGLT2 inhibitor prescribing (8.6% [95% CI 7.7–9.6]). Documented prescribing was therefore more frequent among participants meeting the phenotype than among those who did not (OR 1.47 [95% CI 1.24–1.75]; P < 0.001). However, the magnitude of this association was small (phi = 0.058) (Table 2).

Table 2
Documented SGLT2 inhibitor prescribing by potential eligibility phenotype status

Potential eligibility phenotype	Documented prescribing, n/N (%)	Prescribing, % (95% CI)	Crude OR (95% CI)
Does not meet phenotype	286/3330 (8.6)	8.6 (7.7–9.6)	1.00 (reference)
Meets phenotype	296/2436 (12)	12 (11–14)	1.47 (1.24–1.75)

Note: Pearson chi-square(1) = 19.675; P < 0.001; phi = 0.058. Confidence intervals for prescribing proportions were calculated using the Wilson score method. The potential eligibility phenotype was defined as recorded CKD, heart failure, and/or ASCVD with eGFR ≥ 20 mL/min/1.73 m². Documented prescribing was defined as dapagliflozin or empagliflozin recorded on the active medication list at the index date or prescribed within the preceding 90 days. ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; OR, odds ratio; SGLT2, sodium-glucose cotransporter-2.

Cardiorenal disease subgroups

Among participants meeting the potential eligibility phenotype, ASCVD alone was the most common mutually exclusive disease subgroup (1525/2436; 63%), followed by heart failure plus ASCVD (390; 16%), heart failure alone (212; 8.7%) and CKD alone (141; 5.8%).

Documented SGLT2 inhibitor prescribing ranged from 9.2% (95% CI 5.5–15) in participants with CKD alone to 16% (95% CI 8.9–27) in those with CKD plus ASCVD. There was no statistically significant overall difference in prescribing across the seven mutually exclusive cardiorenal disease subgroups (P = 0.627; Cramer's V = 0.042) (Table 3).

Table 3
Documented SGLT2 inhibitor prescribing across mutually exclusive cardiorenal disease subgroups

Recorded cardiorenal disease subgroup	Total, n	Documented prescribing, n (%)	Prescribing, % (95% CI)
ASCVD alone	1525	179 (12)	12 (10–13)
CKD alone	141	13 (9.2)	9.2 (5.5–15)
Heart failure alone	212	32 (15)	15 (11–21)
CKD + ASCVD	63	10 (16)	16 (8.9–27)
CKD + heart failure	28	4 (14)	14 (5.7–31)
Heart failure + ASCVD	390	47 (12)	12 (9.2–16)
CKD + heart failure + ASCVD	77	11 (14)	14 (8.2–24)

Note: Pearson chi-square(6) = 4.369; P = 0.627; Cramer's V = 0.042. Confidence intervals for prescribing proportions were calculated using the Wilson score method. Subgroups were mutually exclusive and included participants meeting the prespecified potential eligibility phenotype, defined as recorded CKD, heart failure and/or ASCVD with eGFR ≥ 20 mL/min/1.73 m². Documented prescribing was defined as dapagliflozin or empagliflozin recorded on the active medication list at the index date or prescribed within the preceding 90 days. ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; SGLT2, sodium-glucose cotransporter-2.

Factors associated with documented prescribing

Among participants meeting the potential eligibility phenotype, age, sex, recorded CKD, heart failure, ASCVD, and prior-year hospitalization did not differ significantly according to documented SGLT2 inhibitor prescribing status. Median HbA1c was higher among participants with documented prescribing than among those without (67 [56–83] vs 63 [51–79] mmol/mol; 8.3 [7.3–9.7]% vs 7.9 [6.8–9.4]%; P = 0.001), whereas serum creatinine and eGFR were similar between groups. Documented metformin, insulin, and GLP-1 receptor agonist use was more frequent among participants with documented SGLT2 inhibitor prescribing (Additional file 1: Table S1).

The complete-case multivariable model included 2113 participants, including 263 with documented SGLT2 inhibitor prescribing. After adjustment for age, sex, HbA1c, documented metformin use, and documented insulin use, metformin use (adjusted OR 13.11 [95% CI 9.29–18.52]; P < 0.001) and insulin use (adjusted OR 5.65 [95% CI 3.83–8.33]; P < 0.001) remained associated with documented SGLT2 inhibitor prescribing. Age, sex, and HbA1c were not independently associated with prescribing in the adjusted model (Table 4).

Table 4
Associations with documented SGLT2 inhibitor prescribing among participants meeting the phenotype

Variable	Crude OR (95% CI)	P	Adjusted OR (95% CI)	P
Age, per year	0.988 (0.977–1.000)	0.054	1.000 (0.985–1.015)	0.996
Sex, men vs women	1.15 (0.90–1.48)	0.252	1.16 (0.86–1.58)	0.335
HbA1c, per 10.9 mmol/mol (1.0%)	1.08 (1.02–1.15)	0.011	0.99 (0.92–1.06)	0.744
Documented metformin use	17.47 (12.87–23.72)	< 0.001	13.11 (9.29–18.52)	< 0.001
Documented insulin use	8.74 (6.43–11.90)	< 0.001	5.65 (3.83–8.33)	< 0.001

Note: The dependent variable was current or recent documented SGLT2 inhibitor prescribing (0 = no, 1 = yes). The multivariable model included age, sex, HbA1c, documented metformin use, and documented insulin use and was restricted to complete cases (n = 2113; documented prescribing n = 263). Covariates were selected on the basis of clinical relevance and data availability rather than univariable statistical significance. HbA1c was modeled per 10.9 mmol/mol (1.0%). Odds ratios are presented with 95% confidence intervals; P values were obtained using Wald tests. CI, confidence interval; HbA1c, glycated hemoglobin; OR, odds ratio; SGLT2, sodium-glucose cotransporter-2.

Documented GLP-1 receptor agonist use was associated with prescribing in univariable analysis, but only seven participants meeting the phenotype had documented GLP-1 receptor agonist use; therefore, it was not included in the multivariable model, and the univariable estimate should be interpreted cautiously (Additional file 1: Table S2).

Missing data and sensitivity analysis

HbA1c was unavailable or non-numeric in 323 of 2436 participants meeting the phenotype (13%). Participants without analyzable HbA1c were slightly older and less likely to have recorded CKD than those with available HbA1c, whereas documented SGLT2 inhibitor prescribing was similar between groups (10% vs 12%; P = 0.253).

In the sensitivity model excluding HbA1c and including all 2436 participants meeting the phenotype, the adjusted associations for documented metformin use (OR 13.44 [95% CI 9.72–18.59]) and documented insulin use (OR 5.70 [95% CI 3.98–8.17]) were similar to those observed in the primary complete-case model.

The metformin and insulin estimates were similar when the model was fitted without HbA1c in the full phenotype-positive cohort. Because both the analyzed population and the covariate set changed, this sensitivity analysis does not establish that missing HbA1c was unbiased.

Discussion

In this large real-world cohort of adults with type 2 diabetes attending general internal medicine, documented SGLT2 inhibitor prescribing was recorded in 12% of participants meeting the prespecified potential eligibility phenotype based on cardiorenal disease and kidney function. Although prescribing was more frequent among participants meeting the phenotype than among those who did not, the association was small. We found no statistically significant overall variation in prescribing across mutually exclusive CKD, heart failure, and ASCVD subgroups. Documented metformin and insulin use were strongly associated with SGLT2 inhibitor prescribing in adjusted analyses, whereas age, sex, and HbA1c were not. These findings describe prescribing patterns captured within a single-center electronic health record and should not be interpreted as evidence of individual treatment eligibility, treatment exposure, or inappropriate non-prescribing.

The 12% documented prescribing proportion observed among participants meeting the phenotype is broadly consistent with the lower range reported in previous high-risk populations. In the United States Veterans Affairs system, SGLT2 inhibitor use was reported in approximately 11% of adults with type 2 diabetes and ASCVD and in 15% of those with concomitant heart failure and ASCVD [14, 15]. National data from South Korea similarly demonstrated increasing uptake over time but persistent gaps among people with type 2 diabetes and established ASCVD [16]. By contrast, studies in selected CKD populations have reported higher prescribing proportions, although with substantial variation between healthcare settings [17]. A separate two-center study also reported low prescribing of SGLT2 inhibitors or GLP-1 receptor agonists despite compelling indications [22]. These differences likely reflect variation in study populations, calendar period, prescribing authority, reimbursement policies, eligibility definitions, and the methods used to ascertain medication use. Direct numerical comparisons should therefore be interpreted cautiously.

Real-world evidence from Turkey remains limited. Previous Turkish studies have described glucose-lowering treatment patterns and the extent to which contemporary recommendations are reflected in routine care [19, 20], but data specifically examining documented SGLT2 inhibitor prescribing across recorded cardiorenal disease phenotypes are scarce. Our study extends this literature by applying an explicitly defined electronic health record-based phenotype to a large general internal medicine cohort and by reporting prescribing proportions with confidence intervals and effect-size estimates.

We found no statistically significant overall variation in documented SGLT2 inhibitor prescribing across the seven mutually exclusive cardiorenal disease subgroups. However, this finding should not be interpreted as evidence of equivalent prescribing across disease categories. Several subgroups were small, resulting in wide confidence intervals and limited precision for subgroup-specific estimates. In addition, CKD, heart failure, and ASCVD were identified from routine diagnostic coding rather than independent clinical adjudication. These factors limit the ability to determine whether specific cardiorenal phenotypes influenced prescribing decisions in routine practice.

HbA1c was higher among participants with documented SGLT2 inhibitor prescribing in unadjusted analyses, but this association was no longer evident after multivariable adjustment. By contrast,

documented metformin and insulin use remained strongly associated with SGLT2 inhibitor prescribing. These findings should not be interpreted as evidence that metformin or insulin use increased the likelihood of SGLT2 inhibitor initiation. Because treatment timing and sequencing were unavailable and the study was cross-sectional, the observed associations may instead reflect greater treatment intensity, more frequent healthcare contact, or correlated capture of glucose-lowering medications within the same electronic record system.

The magnitude of the associations with metformin and insulin also warrants caution. Strong odds ratios in this context may partly reflect shared prescribing and documentation processes rather than independent pharmacological or clinical determinants of SGLT2 inhibitor prescribing. Documented GLP-1 receptor agonist use was uncommon, and the small number of exposed participants precluded reliable multivariable estimation.

From a clinical and health-system perspective, these findings support the potential value of electronic health record-based case-finding as a quality-improvement tool. Clinicians could flag patients with recorded cardiorenal disease and eGFR above the prespecified threshold for targeted medication review, clinician decision support, or audit-and-feedback interventions. Previous studies have identified barriers to SGLT2 inhibitor initiation, including cost, knowledge gaps, concerns about adverse effects, and healthcare-setting variation [23, 24], while a multicomponent Veterans Affairs intervention incorporating education, academic detailing, audit and feedback, and patient outreach increased prescribing of SGLT2 inhibitors and/or GLP-1 receptor agonists in high-risk patients with diabetes [18].

Importantly, electronic case-finding should prompt individualized clinical review rather than serve as an automated treatment recommendation. Decisions regarding SGLT2 inhibitor therapy should remain conditional on comorbidities, kidney function, contraindications, previous intolerance, competing clinical priorities, and patient preferences. Accordingly, the phenotype used in this study primarily identifies patients who may warrant further review, not to classify non-prescribing as inappropriate care.

Strengths and limitations

Strengths of this study include a large general internal medicine cohort, a prespecified, electronic health record-based potential eligibility phenotype, a reproducible definition of documented SGLT2 inhibitor prescribing, and reporting confidence intervals and effect sizes alongside hypothesis tests.

Several limitations should be considered. First, the single-center retrospective cross-sectional design limits generalizability and precludes causal or temporal inference. Second, phenotype status was indeterminate in 1419 participants (20%) because no eligible serum creatinine/eGFR measurement was available. These participants had lower recorded prevalences of CKD, heart failure, and ASCVD; fewer prior-year hospitalizations; and less frequent documented SGLT2 inhibitor prescribing than those with available eGFR, suggesting missingness was unlikely to be completely random. Selection related to eGFR availability may therefore have influenced phenotype-based estimates.

Third, we identified CKD, heart failure, and ASCVD from routine diagnostic coding rather than independent clinical adjudication, and albuminuria data were unavailable. In particular, because ICD-10 code N19 does not establish chronicity, we interpret the CKD variable as recorded code-based kidney disease rather than clinically confirmed CKD. Fourth, the dataset did not capture contraindications, previous intolerance, recurrent genitourinary infection, volume status, frailty, patient preference, cost, or reimbursement factors that may influence SGLT2 inhibitor prescribing. The broad cerebrovascular code set, including I64 and G45, could also misclassify non-atherosclerotic events as ASCVD. The eGFR threshold used for case-finding is not an absolute contraindication to continued treatment: SGLT2 inhibitors may be continued below 20 mL/min/1.73 m² in appropriate patients [12].

Fifth, medication ascertainment was limited to records available within the study center. Prescriptions issued elsewhere, dispensing, adherence, and persistence were unavailable; therefore, the absence of a same-center prescription record does not imply absent treatment or inappropriate care. Concomitant glucose-lowering medication records may also have been incomplete.

Finally, HbA1c was unavailable or non-numeric in 323 of 2436 participants meeting the phenotype (13%), restricting the primary multivariable analysis to complete cases. Participants without analyzable HbA1c were slightly older and less likely to have recorded CKD, although documented SGLT2 inhibitor prescribing was similar according to HbA1c availability. The sensitivity model, including the full cohort meeting the phenotype, produced similar metformin and insulin estimates, but the analyzed population and covariate set changed, and residual selection bias cannot be excluded.

Conclusions

In this large real-world cohort of adults with type 2 diabetes, documented SGLT2 inhibitor prescribing was recorded in 12% of participants meeting a prespecified cardiorenal potential eligibility phenotype. Electronic health record-based case-finding may help identify patients for targeted medication review and quality-improvement initiatives, but it cannot determine individual treatment appropriateness or confirm treatment exposure. Future multicenter prospective studies should investigate patient-, clinician-, and health-system-level factors influencing SGLT2 inhibitor prescribing and should incorporate more complete medication, contraindication, and cardiorenal phenotype data.

Abbreviations

ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CKD, chronic kidney disease; CKD-EPI, Chronic Kidney Disease Epidemiology Collaboration; eGFR, estimated glomerular filtration rate; GLP-1, glucagon-like peptide-1; HbA1c, glycated hemoglobin; ICD-10, International Classification of Diseases, Tenth Revision; OR, odds ratio; SD, standard deviation; SGLT2, sodium-glucose cotransporter-2.

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Samsun University Non-Interventional Clinical Research Ethics Committee on 18 March 2026 (decision no. 2026/4/13). The ethics committee waived the requirement for individual informed consent because of the retrospective, minimal-risk study design. All study data were coded and anonymized before analysis.

Consent for publication

Not applicable. The manuscript contains no identifiable individual participant information.

Availability of data and materials

The individual-level data underlying this study are not publicly available because they contain confidential health information and are subject to privacy and ethical restrictions. Aggregate results are reported in this article and Additional file 1.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

AÖ conceptualized the study, developed the methodology, conducted the investigation, curated and analyzed the data, prepared the visualization, and drafted the manuscript. AVŞ contributed to methodology and formal analysis and reviewed and edited the manuscript. AKD supervised the study, managed the project, and reviewed and edited the manuscript. All authors read and approved the final manuscript.

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Figures

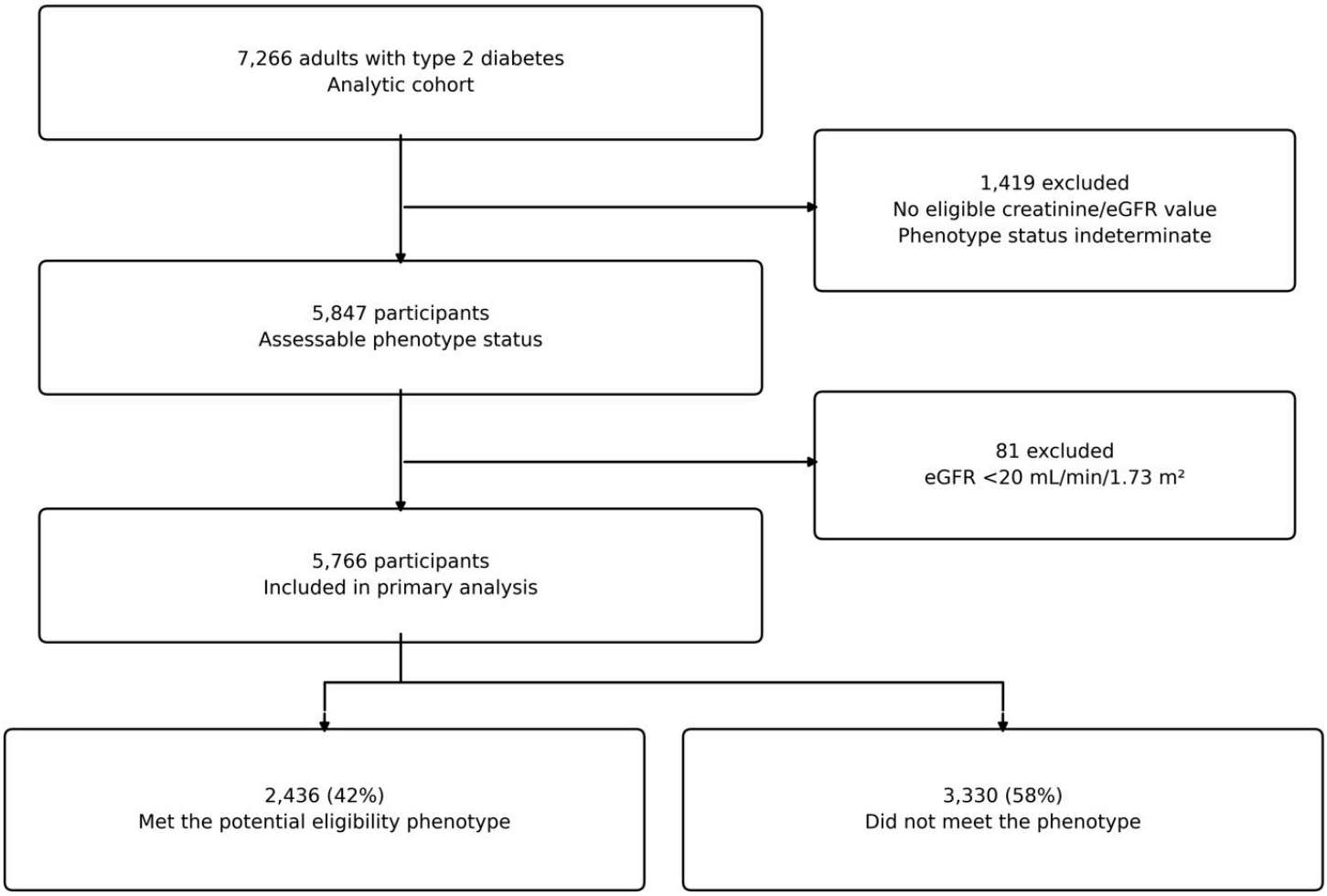

Figure 1

Study population and formation of the primary analysis cohort. The analytic cohort comprised 7266 adults with type 2 diabetes. Phenotype status was indeterminate in 1419 participants because no eligible serum creatinine/eGFR measurement was available within the prespecified assessment window. Among 5847 participants with assessable phenotype status, 81 had eGFR <20 mL/min/1.73 m² and were excluded from the primary phenotype analysis. The final primary analysis cohort comprised 5766 participants, of whom 2436 met the prespecified potential eligibility phenotype, and 3330 did not. We excluded type 1 diabetes and pregnancy during cohort construction before forming the analytic cohort; we did not retain separate counts for these initial exclusions. eGFR, estimated glomerular filtration rate.

Supplementary Files

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