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Knowledge, Prescribing Practices, and Perceived Barriers Regarding Novel Glucose-Lowering Medications Among Community Physicians: A Cross-Sectional Survey Across 36 Primary Healthcare Institutions in Pudong, Shanghai

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Abstract

Background

Novel glucose-lowering medications have shifted type 2 diabetes care toward integrated glycemic, cardiovascular, kidney, and weight management. Community physicians are central to implementing these recommendations, but their medication-specific knowledge, prescribing practices, and implementation barriers remain insufficiently characterized in China.

Methods

We conducted an anonymous web-based cross-sectional survey among community physicians from 36 primary healthcare institutions in Pudong New Area, Shanghai, between 10 August and 5 September 2025. Eligible participants routinely participated in diabetes care and prescribed medications. The questionnaire assessed professional characteristics, 20 knowledge items, seven belief-related items, prescribing during the preceding 3 months, and perceived barriers. Knowledge answers were reviewed by endocrinologists and clinical pharmacists. Descriptive analyses included 444 eligible questionnaires.

Results

The mean knowledge score was 11.40 (SD 3.41) of 20, corresponding to a mean item accuracy of 57.0%; internal consistency was acceptable (KR-20 = 0.741). Accuracy remained high for the mechanisms of glucagon-like peptide-1 receptor agonists (90.5%) and sodium-glucose cotransporter 2 inhibitors (88.7%) and for management of persistent vomiting after glucagon-like peptide-1 receptor agonist use (94.1%). Marked gaps involved once-weekly insulin icodec in special populations (3.6%), dipeptidyl peptidase-4 inhibitors requiring no dose adjustment in kidney impairment (14.9%), glucagon-like peptide-1 receptor agonist selection in severe kidney impairment (13.7%), and adverse effects of glucagon-like peptide-1 receptor agonists (21.2%). During the preceding 3 months, 68.9% reported prescribing a sodium-glucose cotransporter 2 inhibitor and 38.7% a glucagon-like peptide-1 receptor agonist. In institution-clustered generalized estimating equation models, sodium-glucose cotransporter 2 inhibitor prescribing was positively associated with knowledge score (aOR 1.09 per point, 95% CI 1.02–1.17) and general-practice department (aOR 4.37, 95% CI 2.85–6.70). Participation in at least three training activities was associated with glucagon-like peptide-1 receptor agonist prescribing (aOR 2.21, 95% CI 1.19–4.10).

Conclusions

Community physicians understood basic mechanisms and benefits but had important gaps in special-population prescribing and complex decisions. Continuing professional development should be combined with formulary communication, patient support, and specialist-primary care collaboration.

Background

Type 2 diabetes mellitus is a major and growing public health challenge. Its clinical burden extends beyond hyperglycemia to atherosclerotic cardiovascular disease, heart failure, chronic kidney disease, obesity, and premature mortality. Contemporary treatment recommendations therefore increasingly prioritize therapies according to cardiovascular and kidney risk, weight-management needs, hypoglycemia risk, and patient preferences rather than glycated hemoglobin alone [1–4].

SGLT2 inhibitors and GLP-1 receptor agonists have become central to this risk-based treatment paradigm. Large cardiovascular and kidney outcome trials have demonstrated clinically important benefits of these drug classes in selected populations [5–10]. Dipeptidyl peptidase-4 (DPP-4) inhibitors also remain widely used because of their oral administration, low intrinsic hypoglycemia risk, and general tolerability, although dose adjustment and drug selection require attention in patients with organ dysfunction [1, 3]. The rapid expansion of indications, evidence, and available products increases the cognitive demands placed on nonspecialist physicians.

Primary healthcare institutions manage a large proportion of people with diabetes in China. Community physicians provide longitudinal follow-up, renew or modify prescriptions, screen for complications, and coordinate referrals. Chinese primary-care guidelines emphasize standardized assessment and individualized treatment, while recent international recommendations place even greater weight on cardiovascular and kidney protection [1–4, 11]. However, formulary availability and guideline publication do not automatically translate into confident and appropriate prescribing. Knowledge gaps, limited specialist access, medication cost, patient acceptance, supply constraints, and uncertainty regarding local formularies may all impede implementation.

Previous knowledge-attitude-practice surveys have often combined heterogeneous questionnaire items into a single total score, making it difficult to identify clinically actionable gaps. Prescribing practices are also multidimensional and may be better represented by specific behavioral outcomes than by an unvalidated practice score. Evidence focused specifically on community physicians who directly diagnose and treat diabetes and prescribe medications remains limited, particularly across multiple primary healthcare institutions within an urban Chinese district.

We therefore conducted a cross-sectional survey of community physicians from 36 primary healthcare institutions in Pudong New Area, Shanghai. The study aimed to assess overall knowledge and identify item-specific gaps regarding novel glucose-lowering medications; describe recent prescribing practices; and characterize beliefs and perceived implementation barriers. By distinguishing basic pharmacological knowledge from patient-specific prescribing decisions, the study sought to generate actionable evidence for continuing professional development and implementation support in primary care.

Methods

Study design and setting

This multicenter, anonymous, web-based cross-sectional survey was conducted between 10 August and 5 September 2025 in 36 community healthcare institutions in Pudong New Area, Shanghai, China. All participating institutions used the same questionnaire and data-collection process. The report was prepared with reference to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [12].

Participants

Eligible participants were physicians who: (1) worked at a participating community healthcare institution; (2) directly participated in routine diabetes diagnosis or treatment; (3) prescribed medications in daily clinical practice; (4) voluntarily provided electronic informed consent; and (5) submitted the online questionnaire. Pharmacists, nurses, other nonphysician personnel, persons not involved in diabetes care, and personnel without routine prescribing duties were outside the target population.

Questionnaires were excluded using prespecified response-time data-quality criteria. Of 458 submitted questionnaires, four completed in less than 3 minutes and ten completed in more than 1 hour were excluded. The remaining 444 questionnaires were included in the primary analysis.

Recruitment and survey administration

The questionnaire link was distributed through work-related WeChat groups at the participating institutions. Participation was voluntary; no participation quota was assigned to an institution, and no financial or nonfinancial compensation was provided. The online platform was configured to prevent more than one submission by the same user. Because the number of physicians who received or viewed the link was not recorded, a conventional response rate and institution-specific response rates could not be calculated. We therefore report the questionnaire inclusion proportion rather than a response rate.

The uneven numbers of participants across institutions reflected voluntary participation rather than differential mandatory recruitment. Institution was retained as a clustering variable in adjusted analyses; institution-specific performance rankings were not conducted.

Questionnaire development and pilot testing

The questionnaire was developed with reference to diabetes guidelines, medication labeling, and relevant literature. Knowledge items and reference answers were reviewed by endocrinology specialists and clinical pharmacists for clinical relevance, clarity, and consistency with the evidence base available at the time of the survey. A pilot survey involving 11 participants was used to assess comprehensibility, completion time, feasibility, and preliminary internal consistency. The questionnaire was subsequently shortened and revised to produce the 20-item knowledge section used in the formal survey.

Because the pilot and final questionnaires were not identical, pilot reliability estimates were interpreted as evidence of preliminary feasibility rather than full psychometric validation of the final instrument. The final questionnaire comprised four domains: participant and professional characteristics; medication knowledge; beliefs, confidence, and prescribing intention; and prescribing practices and implementation barriers.

The expert panel for the first-round Delphi consultation comprised 11 specialists from 9 institutions across four provinces (Shanghai, Shanxi, Shandong, Henan, and Guangdong), including 6 endocrinologists and 5 clinical pharmacists. Their professional titles included attending physicians $n = 4$, associate chief physicians $n = 1$, chief pharmacists $n = 2$, and associate chief pharmacists $n = 4$. The mean age of the panel was 41.0 years (range 34–47). Expert authority was assessed using the authority coefficient (Cr), calculated as the mean of the judgment basis coefficient $Ca = 0.918$ and the familiarity coefficient $Cs = 0.92$, yielding an overall Cr of 0.919, indicating a high level of expertise. Panel members rated their familiarity with the subject matter as very familiar $n = 6$, familiar $n = 4$, or generally familiar $n = 1$.

The review was conducted in one round. Each item was rated on a 5-point Likert scale (1 = very unimportant to 5 = very important). Item importance was evaluated using the mean score, standard deviation, and coefficient of variation (CV). Items with a mean score < 3.5 or CV > 30% were flagged for discussion and revision. Disagreements were resolved through research team discussion, with items meeting the retention threshold $mean >= 3.5\ and\ CV <= 30$ retained, items with borderline statistics revised for clarity, and items with mean < 3.5 considered for removal.

Measures and scoring

Knowledge

The formal survey contained 20 knowledge items addressing drug classification and mechanisms, clinical indications, use in special populations, adverse effects and contraindications, and medication combinations. Each item was weighted equally. For single-response items, a correct response was assigned 1 point and an incorrect or 'do not know' response 0 points. Multiple-response items were scored using a dichotomous all-or-none rule: 1 point was awarded only when all correct options and no incorrect options were selected; all other response patterns received 0 points. The total knowledge score ranged from 0 to 20, with a higher score indicating greater knowledge. Item-level accuracy was also reported to preserve clinical interpretability. This rule was selected a priori to avoid unequal weighting across items and to prevent credit from being gained by indiscriminate option selection.

Belief-related items

Seven Likert-type items assessed perceived effectiveness, trust in safety, concern about adverse effects, intention to prescribe, perceived price or reimbursement restrictions, self-reported guideline mastery, and perceived long-term patient benefit. Consistent with the conceptual content and preliminary reliability findings, five positively oriented items were considered a potential benefits-confidence-intention domain, whereas the two concern or barrier items were analyzed separately. A single undifferentiated attitude score was not prespecified.

Prescribing practices and barriers

Participants reported whether they had prescribed DPP-4 inhibitors, GLP-1RAs, SGLT2is, glucokinase activators, or none of these during the preceding 3 months. They also reported clinical decision factors, assessment of liver and kidney function, information sources, training participation, perceived patient concerns, medication supply, and barriers to use. The principal behavioral outcomes were recent prescribing of any surveyed novel agent, an SGLT2i, and a GLP-1RA.

Statistical analysis

Categorical variables were summarized as frequencies and percentages. Continuous variables were summarized as means and standard deviations or medians and interquartile ranges, according to their distributions. Knowledge performance was reported as the total score and item-level accuracy. Internal consistency of the dichotomously scored knowledge items was assessed using Kuder-Richardson formula 20. Cronbach's alpha was used for the belief-related domains. The completeness of all variables was assessed before analysis. No values were missing for the core demographic variables, 20 knowledge items, seven belief-related items, principal prescribing outcomes, or training variables among the 444 included questionnaires; therefore, no missing-value imputation was performed.

Group comparisons used the chi-square test or Fisher's exact test for categorical variables and the independent-samples t test, one-way analysis of variance, Mann-Whitney U test, or Kruskal-Wallis test for continuous variables, as appropriate. Correlations involving ordinal or nonnormally distributed measures were assessed using Spearman's rank correlation coefficient. Unadjusted comparisons were treated as exploratory; no formal adjustment for multiple testing was applied, and effect estimates with 95% confidence intervals were emphasized.

Separate random-intercept logistic regression models were initially attempted for prescribing an SGLT2 inhibitor and prescribing a GLP-1 receptor agonist during the preceding 3 months. These models did not meet the prespecified numerical convergence criterion; therefore, the prespecified alternative generalized estimating equation (GEE) models were used. Institution was specified as the subject variable, with an exchangeable working correlation structure and empirical robust standard errors, to account for physicians nested within 36 institutions and unequal institutional sample sizes. Covariates were selected a priori and comprised the continuous knowledge score, benefits-confidence-intention score, perceived barrier score, training frequency (none, 1–2, or at least 3 activities during the preceding

year), sex, educational level, professional title, department (general practice versus other), years in medical practice, and reported frequency of medication supply limitations. Age was not entered together with years in practice because of collinearity. Adjusted odds ratios (aORs) with 95% confidence intervals were reported. Analyses were specified for IBM SPSS Statistics for Windows, version 26.0. All tests were two-sided, and $P < 0.05$ was considered statistically significant.

Ethics approval and consent procedures

Electronic informed consent was obtained from all participants before they accessed the questionnaire. Participation was voluntary, responses were collected for research purposes, and no compensation was provided. The analytic dataset contained no direct personal identifiers.

Results

Participant characteristics

A total of 458 questionnaires were submitted. After application of eligibility and quality criteria, 444 questionnaires were included (questionnaire inclusion proportion, 96.9%). Participants were drawn from 36 community healthcare institutions. The median age was approximately 43 years (range, 24–60), and the mean duration of medical practice was 18.6 years. Most participants held a bachelor's degree (353/444, 79.5%). General practice was the largest departmental group (256/444, 57.7%), and attending physicians constituted the largest professional-title group (282/444, 63.5%). Institutional contributions were markedly unbalanced, consistent with voluntary-response recruitment. Participant characteristics are summarized in Table 1, and the participant inclusion process is shown in Fig. 1.

Table 1
Characteristics of 444 community physicians in Pudong, Shanghai

Characteristic	Category or summary	n (%) or value
Age, years	Median (range)	43 (24–60)
Years in medical practice	Mean (SD); median (IQR)	18.6 (9.7); 18 (10–27)
Education	Junior college or equivalent	27 (6.1)
	Bachelor's degree	353 (79.5)
	Master's degree	60 (13.5)
	Other	4 (0.9)
Professional title	Resident physician	48 (10.8)
	Attending physician	282 (63.5)
	Associate chief physician	105 (23.6)
	Chief physician	9 (2.0)
Department	General practice	256 (57.7)
	Traditional Chinese medicine	74 (16.7)
	Inpatient department	26 (5.9)
	Other departments	88 (19.8)
Institution	Number of institutions	36

Data are n (%) unless otherwise indicated. Percentages may not total 100 because of rounding.

Knowledge performance

The mean knowledge score was 11.40 (SD 3.41; median 12; range 1–18) of 20, corresponding to a mean item accuracy of 57.0%. The KR-20 coefficient was 0.741. Accuracy was high for the mechanisms of GLP-1RAs (90.5%) and SGLT2 inhibitors (88.7%) and management of persistent vomiting after GLP-1RA use (94.1%). The lowest accuracy was observed for once-weekly insulin icodec use in special populations (3.6%), DPP-4 inhibitors not requiring dose adjustment in kidney impairment (14.9%), GLP-1RA selection in severe kidney impairment (13.7%), and common adverse effects of GLP-1RAs (21.2%). Multiple-response items were scored correct only when every correct option and no incorrect option was selected. Item-level accuracy is presented in Table 2.

Table 2
Accuracy for 20 knowledge items among 444 community physicians

Item	Abbreviated content	Domain	Correct, n (%)
1	Identification of novel glucose-lowering medications	Classification/mechanism	263 (59.2)
2	Main glucose-lowering mechanism of SGLT2 inhibitors	Classification/mechanism	394 (88.7)
3	Main mechanisms of GLP-1 receptor agonists	Classification/mechanism	402 (90.5)
4	Agent class with blood pressure- and urate-lowering effects	Clinical application	335 (75.5)
5	Preferred medication in chronic kidney disease	Clinical application	322 (72.5)
6	Preferred medication in diabetes with heart failure	Clinical application	360 (81.1)
7	Medication class with benefit evidence after ischemic stroke	Clinical application	166 (37.4)
8	Recommended agents in established ASCVD	Clinical application	167 (37.6)
9	Insulin icodec use in special populations	Special populations	16 (3.6)
10	DPP-4 inhibitors not requiring dose adjustment in kidney impairment	Special populations	66 (14.9)
11	DPP-4 inhibitor use in liver impairment	Special populations	282 (63.5)
12	Contraindications to DPP-4 inhibitors	Adverse effects/contraindications	244 (55.0)
13	Common adverse effects of GLP-1 receptor agonists	Adverse effects/contraindications	94 (21.2)
14	GLP-1 receptor agonists in severe kidney impairment	Special populations	61 (13.7)
15	Common adverse effect of SGLT2 inhibitors	Adverse effects/contraindications	354 (79.7)
16	Patients in whom SGLT2 inhibitors are contraindicated/not recommended	Adverse effects/contraindications	228 (51.4)
17	Glucokinase activator use in liver disease	Special populations	378 (85.1)
18	Initial response to persistent vomiting after GLP-1RA use	Adverse effects/contraindications	418 (94.1)
19	Glucose-lowering combination not recommended	Drug combinations	237 (53.4)

Item	Abbreviated content	Domain	Correct, n (%)
20	Treatment choice in obesity, eGFR 50, and coronary heart disease	Clinical application	276 (62.2)

ASCVD, atherosclerotic cardiovascular disease; DPP-4, dipeptidyl peptidase-4; eGFR, estimated glomerular filtration rate; GLP-1RA, glucagon-like peptide-1 receptor agonist; SGLT2, sodium-glucose cotransporter 2. Multiple-response items used an all-correct-and-no-incorrect option rule. Item wording is abbreviated; the full questionnaire should be supplied as a supplement.

Beliefs, confidence, and prescribing intention

Most respondents expressed favorable views regarding the effectiveness and long-term clinical value of novel glucose-lowering medications. For example, 79.7% agreed or strongly agreed that these agents were generally more effective than traditional agents, 80.9% considered their safety worthy of trust, 78.4% were willing to prioritize them for eligible patients, and 80.4% considered them important for long-term cardiovascular or kidney outcomes. However, only 60.8% agreed or strongly agreed that their guideline knowledge was sufficient to support prescribing decisions. Concern about adverse effects and perceived price or reimbursement restrictions were also common. The distribution of responses to all seven belief-related items is shown in Table 3.

Table 3
Beliefs about novel glucose-lowering medications among community physicians

Belief-related statement	Agree/strongly agree, n (%)
Overall effectiveness exceeds that of traditional agents	354 (79.7)
Safety is trustworthy	359 (80.9)
Concern that adverse effects impair adherence	232 (52.3)
Willing to prioritize use in eligible patients	348 (78.4)
Price or reimbursement restricts clinical use	272 (61.3)
Guideline knowledge is sufficient for decisions	270 (60.8)
Important for long-term cardiovascular/kidney outcomes	357 (80.4)

Recent prescribing practices and perceived barriers

During the preceding 3 months, 306 physicians (68.9%) reported prescribing an SGLT2i, 292 (65.8%) a DPP-4 inhibitor, 172 (38.7%) a GLP-1RA, and 49 (11.0%) a glucokinase activator. Eighty physicians (18.0%) reported no use of the surveyed novel agents. Because participants could select more than one class, percentages exceeded 100% when summed.

High medication cost was the most frequently reported influence on use (381/444, 85.8%), followed by low patient acceptance (295/444, 66.4%), insufficiently clear guideline recommendations (242/444, 54.5%), and lack of awareness of the institution's current medication availability (228/444, 51.4%). When asked about difficulties encountered during use, lack of prescribing experience, insufficient knowledge updating, low patient acceptance, reimbursement restrictions, and medication supply were also commonly selected. Recent prescribing practices and the principal reported barriers are summarized in Table 4.

Table 4
Recent prescribing practices and barriers among community physicians

Measure	**n (%)**
Prescribed SGLT2 inhibitor in preceding 3 months	306 (68.9)
Prescribed DPP-4 inhibitor in preceding 3 months	292 (65.8)
Prescribed GLP-1 receptor agonist in preceding 3 months	172 (38.7)
Prescribed glucokinase activator in preceding 3 months	49 (11.0)
Prescribed none of the surveyed novel agents	80 (18.0)
High medication cost influenced use	381 (85.8)
Low patient acceptance influenced use	295 (66.4)
Guideline recommendations perceived as insufficiently clear	242 (54.5)
Unaware of institution's latest medication availability	228 (51.4)

The random-intercept models did not meet the prespecified convergence criterion, so the institution-clustered GEE models were retained. In the adjusted SGLT2i model, higher knowledge score, stronger benefits-confidence-intention beliefs, general-practice department, longer practice duration, and reporting rare or occasional supply limitations were associated with higher odds of prescribing; female sex and stronger perceived barriers were associated with lower odds. In the adjusted GLP-1RA model, participation in at least three training activities and intermediate or senior professional title were associated with higher prescribing odds. Knowledge score showed a small inverse association with GLP-1RA prescribing. These cross-sectional associations do not establish temporality or causality. Full adjusted estimates for both models are presented in Table 5.

Table 5
Adjusted associations with SGLT2 inhibitor and GLP-1 receptor agonist prescribing

Predictor	SGLT2i aOR (95% CI)	P value	GLP-1RA aOR (95% CI)	P value
Knowledge score, per point	1.09 (1.02–1.17)	0.014	0.97 (0.94-1.00)	0.026
Benefits-confidence-intention, per point	2.00 (1.33–2.99)	0.001	1.20 (0.75–1.93)	0.453
Perceived barriers, per point	0.53 (0.37–0.76)	0.001	1.07 (0.74–1.54)	0.717
Training: 1–2 vs none	1.62 (0.94–2.79)	0.085	1.39 (0.84–2.30)	0.203
Training: >=3 vs none	2.04 (0.97–4.31)	0.061	2.21 (1.19–4.10)	0.012
Female vs male	0.51 (0.31–0.85)	0.009	0.68 (0.43–1.08)	0.101
Postgraduate vs bachelor or lower	1.83 (0.87–3.82)	0.109	0.87 (0.45–1.67)	0.671
Title: intermediate vs junior	1.25 (0.68–2.28)	0.477	2.76 (1.41–5.41)	0.003
Title: senior vs junior	1.44 (0.74–2.77)	0.280	3.07 (1.49–6.32)	0.002
General practice vs other	4.37 (2.85–6.70)	< 0.001	1.42 (0.83–2.43)	0.197
Years in practice, per 5 years	1.16 (1.01–1.32)	0.030	0.97 (0.84–1.12)	0.706
Supply limitation: rare vs never	3.49 (1.40–8.74)	0.008	1.19 (0.63–2.24)	0.598
Supply limitation: occasional vs never	3.43 (1.87–6.26)	< 0.001	1.22 (0.73–2.03)	0.455
Supply limitation: frequent vs never	2.36 (0.99–5.61)	0.052	1.58 (0.92–2.73)	0.099

GEE models used institution as the subject variable, an exchangeable working correlation structure, and empirical robust standard errors. SGLT2i outcome: 306 yes and 138 no; GLP-1RA outcome: 172 yes and 272 no. aOR, adjusted odds ratio; CI, confidence interval; GEE, generalized estimating equation.

Discussion

Principal findings

In this survey of 444 community physicians across 36 primary healthcare institutions in Pudong, the mean strictly scored knowledge result was 11.40 of 20, with acceptable internal consistency and marked variation across clinical domains. Participants generally recognized mechanisms and common cardiorenal indications, whereas performance was lower for special populations and several multiple-response clinical decisions. In adjusted institution-clustered models, SGLT2i prescribing was independently associated with knowledge, beliefs, sex, department, practice duration, perceived barriers,

and medication supply experience. GLP-1RA prescribing was most clearly associated with frequent training and professional title. These findings identify correlates rather than causal determinants.

These findings support a central implementation message: improving prescribing cannot be reduced to increasing general awareness of new medications. Basic mechanism knowledge was already strong. The more important educational need concerned translation of evidence into patient-specific decisions, while the more important system needs concerned affordability, access, and communication.

From mechanism knowledge to complex clinical decisions

The contrast between high accuracy for basic mechanisms and low accuracy for several special-population items is clinically plausible. Guideline updates have rapidly expanded indications for SGLT2is and GLP-1RAs on the basis of cardiovascular and kidney outcome evidence [1–10, 13–15]. Applying these recommendations requires integration of kidney function, cardiovascular phenotype, adverse-effect risk, drug labeling, and patient preferences. Such decisions are more demanding than recognizing a mechanism of action.

Nevertheless, extremely low accuracy should not automatically be interpreted as a pure knowledge deficit. Several low-performing items were multiple-response questions scored only when every correct option was selected and no incorrect option was chosen. Strict scoring is defensible, but it can magnify small uncertainties and item ambiguity. The item concerning insulin icodec also addressed a recently introduced medication, for which labeling and clinical familiarity may have been evolving during the survey period. Item-level interpretation should therefore be anchored to the exact guideline and label sources used by the expert panel, and sensitivity analyses should examine partial-credit or option-level performance.

The low accuracy observed for medication selection after ischemic stroke and for several multiple-response special-population items also deserves careful interpretation. Contemporary guidelines distinguish established atherosclerotic cardiovascular disease, heart failure, and chronic kidney disease, and benefits are not identical across drug classes and individual outcomes [1–4]. Strict all-or-none scoring further penalizes otherwise partially correct responses. Training should therefore use case vignettes that require physicians to distinguish heart failure, kidney disease, coronary disease, and cerebrovascular disease rather than presenting 'cardiovascular benefit' as a single undifferentiated concept.

Prescribing patterns

Reported SGLT2i prescribing was common, consistent with the increasingly prominent role of these agents in diabetes complicated by heart failure or chronic kidney disease [1–4, 6–9]. The adjusted model showed higher SGLT2i prescribing odds among general practitioners and physicians with higher knowledge and more favorable benefits-confidence-intention scores, whereas stronger perceived barriers were associated with lower odds. The positive associations with reported supply limitations should not be interpreted as a beneficial effect of shortages; physicians who prescribe these agents

more often may simply have more opportunities to encounter supply constraints. GLP-1RA prescribing was less common and was positively associated with frequent training and higher professional title. The small inverse adjusted association between knowledge score and GLP-1RA prescribing was unexpected and should be interpreted cautiously because of the cross-sectional design, strict scoring, and possible residual confounding.

Because prescribing was self-reported over the preceding 3 months, these results indicate physician-level exposure to each drug class rather than prescription volume or prescribing quality. A physician who prescribed a class once was classified in the same way as a physician who used it frequently. Future studies should link survey responses to aggregated prescription data, indication appropriateness, kidney function, and patient outcomes.

Implications for primary care

The barrier profile extended across physician, patient, institution, and health-system levels. High medication cost and limited patient acceptance were the most common influences, while more than half of respondents perceived guideline recommendations as insufficiently clear and approximately half reported limited awareness of their institution's current medication availability. Although the organization and financing of primary care differ across health systems, the need to align clinician capability, patient feasibility, local formularies, and specialist support is internationally relevant. The findings therefore support multicomponent implementation strategies rather than education-only interventions.

Educational activities should therefore be redesigned around high-risk prescribing decisions rather than repeating basic pharmacology. Short, case-based modules could focus on kidney impairment, heart failure, prior atherosclerotic events, adverse-effect mitigation, contraindications, and deprescribing or combination choices. Institution-level strategies should include frequently updated formulary notices, referral pathways, specialist case consultation, and clinical decision support. Patient-facing education and shared decision-making materials may help address concerns about injections, adverse effects, and treatment changes.

Strengths and limitations

This study has several strengths. It included a relatively large sample of physicians from 36 primary healthcare institutions, focused on clinicians who directly participated in diabetes treatment and routine prescribing, and assessed specific knowledge items together with recent prescribing and implementation barriers. The knowledge answers were reviewed by endocrinology specialists and clinical pharmacists, and a pilot survey informed feasibility and questionnaire refinement.

The findings should also be interpreted in light of important limitations. First, convenience and voluntary-response sampling may have preferentially recruited physicians with greater interest in diabetes or novel medications. Second, the number of physicians who received or viewed the WeChat link was not recorded; therefore, neither an overall response rate nor institution-specific response rates could be

calculated. Third, sample sizes differed markedly across institutions, precluding direct institution rankings and requiring clustering to be addressed statistically. Fourth, all institutions were located in Pudong New Area, limiting generalizability to other districts, rural settings, or China as a whole. Fifth, prescribing practices were self-reported and may be affected by recall and social desirability bias. Sixth, although the platform prevented repeated submission by the same user, an anonymous design may not completely exclude cross-device participation unless a stable technical identifier was used. Seventh, the pilot and final questionnaires differed, and the instrument has not undergone comprehensive psychometric validation. Eighth, strict all-or-none scoring of multiple-response items may underestimate partial knowledge. Finally, the cross-sectional design does not establish whether knowledge or training causes differences in prescribing.

Conclusions

Community physicians demonstrated good understanding of the basic mechanisms and common benefits of novel glucose-lowering medications, but substantial knowledge gaps remained in special populations, kidney-related drug selection, and complex clinical scenarios. Recent prescribing of GLP-1 receptor agonists was less common than prescribing of SGLT2 inhibitors and DPP-4 inhibitors. Medication cost, patient acceptance, guideline translation, and institutional formulary awareness jointly constrained implementation. Primary care improvement programmes should combine case-based continuing professional development with formulary communication, patient support, specialist-primary care collaboration, and evaluation using objective prescribing data.

Abbreviations

ASCVD
atherosclerotic cardiovascular disease
CKD
chronic kidney disease
DPP-4
dipeptidyl peptidase-4
eGFR
estimated glomerular filtration rate
GLP-1RA
glucagon-like peptide-1 receptor agonist
KR-20
Kuder-Richardson formula 20
SGLT2i
sodium-glucose cotransporter 2 inhibitor
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of Shanghai Pudong Hospital (Approval No. 2026-R-Q-002). Electronic informed consent was obtained from all participants before they accessed the questionnaire.

Consent for publication

Not applicable; no identifiable individual information is reported.

Competing interests

The authors declare that they have no competing interests.

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Author Contribution

Yanru Liu and Xiaolin Liu developed the questionnaire and drafted the manuscript.Jingru Gong and Huiping Lu were responsible for project planning, implementation coordination, and task allocation. Peipei Gao and Tongtong Zhang distributed the questionnaire and coordinated questionnaire collection. Tao Yang, Zhe Jiang and Bijun Zuo contributed to questionnaire collection and statistical analysis. All authors reviewed and approved the final manuscript.

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Availability of data and materials

The datasets generated and analysed during the current study are not publicly available because they contain institution-level and professional information that may permit indirect identification, but a de-

identified minimum dataset may be available from the corresponding authors on reasonable request and subject to approval by Shanghai Pudong Hospital.

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Figures

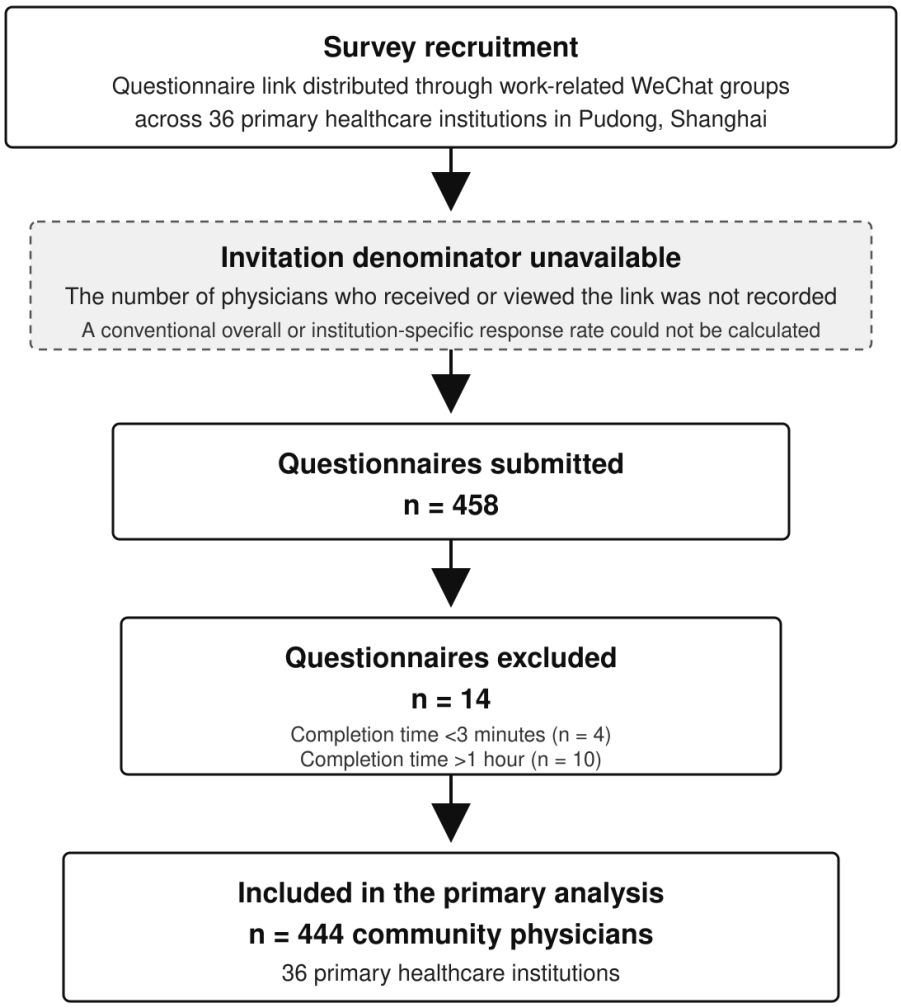


Figure 1

Participant inclusion flow. The questionnaire link was distributed through work-related WeChat groups across 36 primary healthcare institutions. Because the invitation denominator was unavailable, a conventional response rate could not be calculated. Of 458 submitted questionnaires, four completed in less than 3 minutes and ten completed in more than 1 hour were excluded; 444 community physicians were included in the primary analysis.

Supplementary Files

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- BMCPrimaryCareCombinedSupplementaryTables.docx