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ORIGINAL RESEARCH

Effectiveness of Pharmacist-Led Training Regarding Medication for Type 2 Diabetes, Based on Patient and Physician Medication-Related Issues Identified in China

Zhong Hui Yang[1,*], Chang Juan Cheng[1], Guo Mei Chen[1], Ji Huang[1,*], Hai Zhou[2], Jie Jiang[3], Zhen Ye[4], Yu Fang Weng[5], Hai Hong Tan[1]

[1]Department of Pharmacy, Taicang First People's Hospital, Soochow University, Taicang, Jiangsu, People's Republic of China; [2]Health Service Center of Chengxiang Town, Taicang, Jiangsu, People's Republic of China; [3]Taicang Port District People's Hospital, Taicang, Jiangsu, People's Republic of China; [4]Huangjing People's Hospital of Taicang City, Taicang, Jiangsu, People's Republic of China; [5]Taicang Shuangfeng People's Hospital, Taicang, Jiangsu, People's Republic of China

*These authors contributed equally to this work

Correspondence: Chang Juan Cheng; Guo Mei Chen, Department of Pharmacy, Taicang First People's Hospital, Soochow University, No. 58, Changsheng South Road, Taicang City, Jiangsu Province, People's Republic of China, Tel +86 13915495574; +86 13776297087, Email 532782210@qq.com; 23451210@qq.com

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Aim: To determine the effect of pharmacist-led specialized medication training on rational drug prescription by family physicians, and to characterize the drug-related issues and glycemic control of patients.

Methods: We performed a study led by clinical pharmacists. Using surveys of medication use by doctors and patients, a 1-year training program was developed to improve the knowledge of family physicians regarding appropriate drug use. It consisted of an initial survey to assess both physician knowledge and patient medication use, followed by a training program designed to address the identified deficiencies. The program comprised quarterly group training sessions focusing on medication updates, guidelines, and clinical case discussions. Cross-sectional sampling was performed before and after doctors' intervention, carry out a questionnaire survey and compare the questionnaire scores. Patients were randomly sampled before intervention, medication problems were investigated before and after intervention. The effects of the intervention were evaluated by comparing the survey results before and after, with focuses on drug knowledge, rational prescribing, and patient outcomes such as blood glucose control.

Results: Before and after the intervention, 120 valid questionnaires were collected from family doctors in each group. Both groups were principally composed of general practitioners with primary titles, but most had 0–5 years of experience, followed by >20 years. A total of 361 patients were sampled (174 men; mean age 66.8±9.62 years), of whom 215 (59.6%) had had type 2 diabetes for 6–15 years, and 126 (34.9%) had had the disease for ≤5 years. After the training, the score had significantly improved, from 32.67±6.14 to 37.12±6.24 ($P<0.05$), and there were fewer misunderstandings about oral and injectable medications ($P<0.05$). The number of patients with medication issues decreased by 55.0% (from 171 to 77, $P<0.05$), and their mean fasting plasma glucose concentration (FPG) had also significantly decreased ($P<0.05$).

Conclusion: The intervention studied improved family physicians' knowledge of medication for type 2 diabetes, reduced the number of medication issues for patients, and improved their FPG concentrations. It should provide a valuable reference for chronic disease management. This pharmacist-led training approach could be expanded to improve medication practices and patient outcomes on a larger scale, particularly for the purposes of chronic disease management. By including such programs, medication-related issues could be reduced in number and overall treatment effectiveness could be enhanced.

Plain Language Summary:

What is already known about this subject?

- The training of family doctors regarding type 2 diabetes focuses on patient education and health guidance. There is a lack of specialized training regarding the use of specific medications.

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- Interventions by pharmacists regarding rational drug use mainly involve prescription reviews and audits, with only limited provision of training for family doctors regarding the use of medication. In addition, there have been few investigations regarding the misconceptions held by both doctors and patients regarding specific medications.

What does this study add?

- This study adds valuable insight into the current gaps in the knowledge of family doctors regarding medication, particularly regarding the treatment of type 2 diabetes. It highlights the need for dedicated training regarding the management of medication use and provides evidence that pharmacist-led interventions can improve understanding and reduce the number of errors made.

Keywords: type 2 diabetes mellitus, clinical pharmacist, primary healthcare, chronic disease management, specialized medication training

Introduction

By 2040, the number of patients with diabetes worldwide is expected to reach 629 million, with approximately 90% of these having type 2 diabetes mellitus (T2DM). In 2021, China contained the largest number of people with diabetes (140.9 million individuals).[1] Diabetes has already imposed heavy economic and social burdens on China. For example, patients with T2DM have an incidence of the most common cardiovascular diseases (CVDs) two-to-four times higher than those without.[2–5] Furthermore, a 1-mmol/l increase in FPG is associated with a 17% higher risk of future cardiovascular events or death.[6] In addition, patients with T2DM are at a high risk of developing complications, such as retinopathy, neuropathy, and nephropathy.[3,7,8] Therefore, the strengthening of blood glucose control in patients with T2DM is very important.

Long-term medication is crucial for the prevention of adverse clinical events,[9,10] but the misuse, underuse, and overuse of medication contribute to poor quality healthcare. Previous studies have shown that an inadequate amount of high-quality training regarding medication and a lack of self-efficacy represent significant challenges for family physicians.[11,12] In addition, the cost of medication often accounts for a significant proportion of overall healthcare costs. Thus, the effective management of medication use is essential for the control of chronic diseases, such as T2DM. However, some previous studies have shown that continuing education may not significantly improve the knowledge of family physicians about diabetes,[13] and the results of training regarding drug therapy are often poorer than that regarding other topics.[14] In contrast, pharmacist-led interventions have been widely recognized for their effectiveness in improving adherence to medication, enhancing patient outcomes, and reducing medication-related problems, particularly during the management of chronic diseases, such as type 2 diabetes mellitus (T2DM). These interventions often involve targeted training, and aim to improve the management of medical therapy and address gaps in the knowledge of prescribers. Studies performed in developed countries have demonstrated that such programs lead to significant improvements in glycemic control and medication safety.[15–17]

Given the potential benefits of the approach, we designed a study aiming to implement and evaluate a pharmacist-led training program tailored to the needs of family doctors that focused on improving their knowledge and competence regarding the management of medication for T2DM.

Material and Methods

Participants

According to data from the Taicang City Center for Disease Control and Prevention, there were approximately 200 family physicians in the city, and we grouped them by jurisdiction for training. We conducted a cross-sectional survey of these professionals before and after the training course. The physicians were required to complete a clear and comprehensive questionnaire, which permitted objective responses to be provided, during a 10–30-minute period. A total of 120 valid completed questionnaires were collected before and after the intervention.

We also selected 361 patients with T2DM from the chronic disease management system of Jiangsu Province who lived in the Taicang area. Their health records were reviewed, face-to-face interviews were conducted to better

understand their medication, and their fasting plasma glucose (FPG) concentrations were recorded before and after the intervention.

Sample Size Calculation

The questionnaire completed by the family physicians comprised 16 questions regarding their knowledge of drug use. The number of physicians required to participate to ensure the validity of the study was 5–10 times the number of questions; therefore, a sample size of 80–160 was required. Previous studies[18,19] have shown that the prevalence of problems with medication in patients with diabetes is ~45%. The formula used to calculate the required sample size for the patients was $N=\mu\alpha^2\times\pi(1-\pi)/\delta^2$, and the loss to follow-up was anticipated to be 15%. Therefore, we aimed to recruit 361 patients.

Research Design and Questionnaire

The study was led by pharmacists and comprised questionnaire design, survey implementation, training content design, training delivery, and follow-up survey phases. We used various guidelines and expert consensus statements regarding diabetes prevention and treatment as reference materials[20–24] and jointly developed the "Family physician T2DM medication questionnaire" with endocrinologists from tertiary hospitals. The content of the training program was designed on the basis of the results of the patient and physician surveys. The training was then conducted by means of four small-group sessions held in each district.

The questionnaire consisted of two sections, one in which basic information was collected, and a second in which knowledge of antidiabetic medication was evaluated (Please refer to Appendix 1 for detailed information). After the researchers developed the second section in the initial questionnaire, two senior endocrinologists, two attending endocrinologists, two senior pharmacists, and some general practitioners were invited to repeatedly discuss and revise the content of the questionnaire, on the basis of which the 16 items and their wording were finalized. The level of mastery of the physician was assessed using a 3-point Likert scale, in which higher scores indicated a higher level of mastery. The content validity index (I-CVI) for each item, which was based on expert evaluations, ranged from 0.83 to 1, with an average value of 0.97, and the unweighted validity score was 0.81, confirming the questionnaire's reliability. The structural validity was assessed using exploratory factor analysis. The KMO was 0.805 (>0.7) and the Bartlett's test result was 452 (df=120, $P<0.001$), indicating good structural validity and its suitability for factor analysis. Four common factors were identified, which had a cumulative variance contribution of 71.1% after rotation. The loading for each item on the corresponding common factor was >0.6. The overall Cronbach's α was 0.899, with each dimension having a value >0.8, and Cronbach's α remained >0.8 after the deletion of any item, confirming high reliability of the questionnaire.

The training content primarily provided a detailed introduction to the pharmacological characteristics and pharmacokinetics, the dosage and administration, the necessary precautions, selection for special patient populations, adverse reactions, and combination therapy options for various antidiabetic medications (both oral and injectable formulations). It also covered the drug treatment regimens recommended by guidelines, explaining the multidrug therapy approaches and medication strategies for patients who require concurrent treatment for common CVDs.

The training content was divided across four sessions, which were conducted once per quarter, with each session lasting approximately 40–50 minutes. Small groups were organized by health service centers for the training. After the sessions, at the group training site, we provided feedback on the medication issues identified by means of the initial patient-side survey, without disclosing specific patient information. Case analysis discussions also took place within the groups and were based on the training content, to encourage interactions and make the learning experience more engaging and enjoyable.

Questionnaire Survey and Quality Control

The survey was conducted by 10 investigators (the coordinators of chronic disease management in each health center) and two survey supervisors who were members of the study group. Prior to the survey being administered, rigorous training was conducted. Primary healthcare institutions were encouraged to participate and pre-survey publicity was used to ensure that there were a sufficiently large number of volunteers. To be valid, the questionnaire had to be completed

independently by each of the family physicians, all the sections had to be completed, and the required response time was between 10 and 30 minutes. After the survey had been completed, supervisors reviewed the questionnaires for their accuracy and completeness. The survey of the patients was conducted by the study supervisors, who were assisted by other staff.

To reduce potential sources of bias and ensure the accuracy and completeness of the survey data, we ensured that the participants completed the survey independently and without interference, emphasized the anonymity of the responses to reduce the pressure on the participants, and used a dual-entry system with double verification to ensure the accuracy of data entry. This process ensured the completeness and accuracy of the data.

Statistical Analysis

Statistical analysis was conducted using SPSS v.23.0 (IBM, Inc., Armonk, NY, USA). Quantitative datasets are summarized as the mean ± standard deviation or ratios/rates, and were compared using the independent samples *t*-test, one-way ANOVA, or the Mann–Whitney *U*-test, as appropriate. Qualitative data are summarized using a qualitative descriptive approach. Binary logistic regression analysis was used to identify the factors influencing the scores achieved by the family physicians on the survey questionnaires. Cox regression analysis was used to identify the factors influencing FPG in the patients. Statistical significance was accepted at $P<0.05$.

Results

Results of the Preliminary Survey

Basic Information Regarding the Patients

The 361 patients with T2DM included 174 men (48.2%). Their mean age was 66.8±9.62 years (range: 41–92 years); 133 were <65 years old (36.8%) and 162 were aged 65–75 years (44.9%). With respect to educational level, 173 (47.9%) had only a primary school education and 119 (33.0%) had not progressed beyond junior high school. Regarding the duration of T2DM, 215 (59.6%) had had diabetes for 6–15 years and 126 had had the disease for ≤5 years (34.9%).

Basic Information Regarding the Family Physicians

Two groups of family doctors were selected through cross-sectional sampling and were designated as the control group and the intervention group. The two groups showed no significant differences in their baseline characteristics ($P>0.05$). The pre-intervention analysis showed that the family doctors primarily comprised general practitioners (74.2%), with nurses and other medical staff accounting for 13.3% and 12.5%, respectively. Most of the professionals were relatively junior, and there were no significant differences in the proportions with secondary vocational qualifications, associate level qualifications, or bachelor's degrees or above. The family doctors most frequently had <5 years of experience, followed by >20 years.

Issues with Medication and the Factors Influencing FPG

The pre-intervention FPG concentration of the patients was used as the dependent variable for one-way ANOVA, and we found that hidden medication issues, the type of medication, and the use of combination therapy were significantly associated with FPG concentration ($P<0.05$). However, there were no associations of the fasting FPG with sex, age, smoking status, alcohol consumption, disease duration, educational level, employment status, or the use of medication for the treatment of other diseases ($P>0.05$). The occurrence of hidden medication problems was related to the type and number of antidiabetic drugs administered ($P<0.05$).

Cox regression was used to analyze the relationships between potential risk factors and FPG concentration. The likelihood ratio test for the Cox regression model yielded $P=0.002$ and the fraction test yielded $P=0.002$. Hidden medication issues had the largest effect on FPG, and the two variables showed a negative association ($B=0.619$, $P=0.000$) (Table 1).

Kaplan–Meier curves were then used to analyze the relationship between hidden medication issues and the FPG concentrations of patients in various age groups. Figure 1 shows that there was a significant difference ($P=0.000$) in the

Table 1 Results of the Cox Regression Analysis of the Relationship of FPG with Potential Risk Factors

Project	B	Wald	*df*	P	Exp(B)	Exp(B)95.0%	
						Lower Limit	Upper Limit
Hidden medication issues	0.619	15.949	1	0.000	1.856	1.370	2.515
Medication type							
Taken orally		0.433	2	0.805			
Injection	−1.46	0.278	1	0.598	0.864	0.502	1.487
Taken orally+injection	−0.036	0.009	1	0.925	0.965	0.456	2.041
Number of hypoglycaemic drugs							
A drug		2.000	2	0.368			
Two drugs	−0.129	0.157	1	0.692	0.879	0.464	1.663
Three drugs or above	−0.111	0.139	1	0.719	1.117	0.612	2.041

prevalence of FPG ≥7 mmol/L between the participants with hidden medication issues (0) and those without (1), with the latter having a lower prevalence of FPG ≥7 mmol/L.

Principal Roles of and Training Needs Assessment for Family Physicians

The survey showed that the three most common roles of family physicians were the follow-up of FPG data, health education, and the provision of guidance for patients regarding their medication (Figure 2). The family physicians ranked their need for further knowledge regarding medication for T2DM first.

Factors Influencing the Knowledge of Family Physicians About Medication

Family physicians scored a mean of 32.7 ± 6.14 out of 48 in the preliminary survey of knowledge about medication. We performed one-way ANOVA regarding the effects of sex, qualifications, educational level, professional experience, occupation, and other factors on the knowledge scores, and found that professional title, educational level, and professional experience were significantly associated with the score ($P<0.05$). On the basis of the results of this analysis, we included professional title, educational level, and professional experience as independent variables, and knowledge

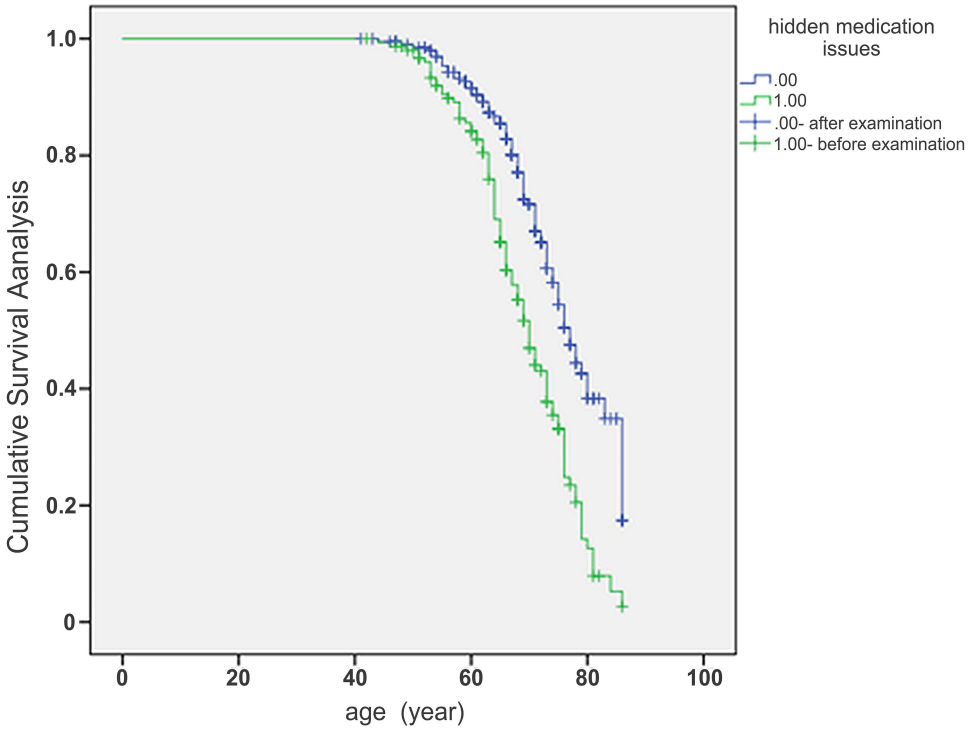

Figure 1 Kaplan–Meier curves for the relationship between hidden medication issues and the proportion of patients with FPG ≥7 mmol/L.

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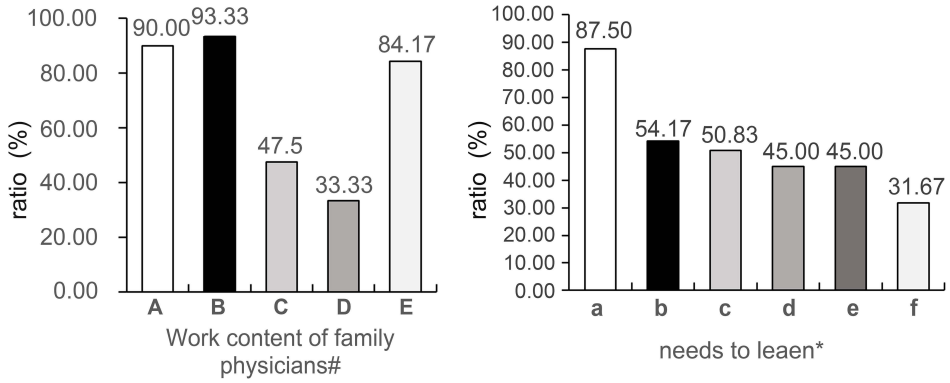

Figure 2 Results of the survey of the roles and training needs of family physicians. #A: Blood glucose follow-up; B: health education; C: comprehensive treatment of the disease; D: prescription of medication; E: guidance of patients regarding medication. *a: Rational drug therapy for T2DM; b: blood glucose monitoring; c: analysis of diagnostic indices for patients with T2DM; d: health education regarding T2DM; e: screening and diagnosis of complications regarding T2DM; f: diagnosis of T2DM.

level (total score ≥ 70% of the maximum score, indicating a high level of knowledge) as the dependent variable in binary logistic regression analysis (method: backwards LR). This revealed that professional title and professional experience were significantly associated with the questionnaire score (both $P<0.05$) (Table 2).

We next plotted a ROC (Receiver Operating Characteristic) curve, with the predicted probability yielded by the binary logistic regression analysis as the test variable. The area under the curve was 0.743 (95% CI [0.654, 0.831]) (within the range of 0.7–0.9), the SE was 0.045, and the *P*-value was < 0.001 (Figure 3).

Effects of the Intervention

Effects of Training on the Questionnaire Scores for the Family Physicians

There was a significant difference in the mean score for the family physicians on the questionnaire before and after the intervention (32.67 ± 6.14 vs 37.12 ± 6.24, respectively; $P<0.001$). In addition, several individual scores were significantly higher after the intervention ($P<0.05$) (Table 3).

The 16 questions could be divided into four dimensions. To make the results more easily interpretable, we converted the scores to percentages, and the mean scores for each dimension and the overall mean scores are shown in Table 4. The dimensions of medication strategy, knowledge of oral medication, and knowledge of injectables showed significant improvements after the intervention ($P<0.05$).

Table 2 Factors Influencing the Questionnaire Scores for Family Physicians, According to the Results of Binary Logistic Regression Analysis

Variables	Classification	B	SE	Wald	*df*	P	OR	95% CI of OR	
								Lower Limit	Upper Limit
Professional title									
	Junior			10.07	2	0.007			
	Intermediate	−1.449	0.778	3.465	1	0.063	0.235	0.051	1.08
	Senior	0.479	0.841	0.325	1	0.569	1.615	0.311	8.393
Work experiences									
	0–5 years			11.365	4	0.023			
	6–10 years	1.67	0.517	10.453	1	0.001	5.313	1.93	14.624
	11–15 years	0.551	0.795	0.482	1	0.488	1.736	0.366	8.237
	16–20 years	−0.4	0.893	0.201	1	0.654	0.67	0.116	3.859
	>20 years	0.694	0.727	0.909	1	0.34	2.001	0.481	8.328
Education									
	Secondary Specialized School			0.980	2	0.613			
	Associate degree	0.728	0.840	0.752	1	0.386	2.072	0.399	10.742
	Bachelor's degree or above	−0.077	0.565	0.018	1	0.892	0.926	0.306	2.801

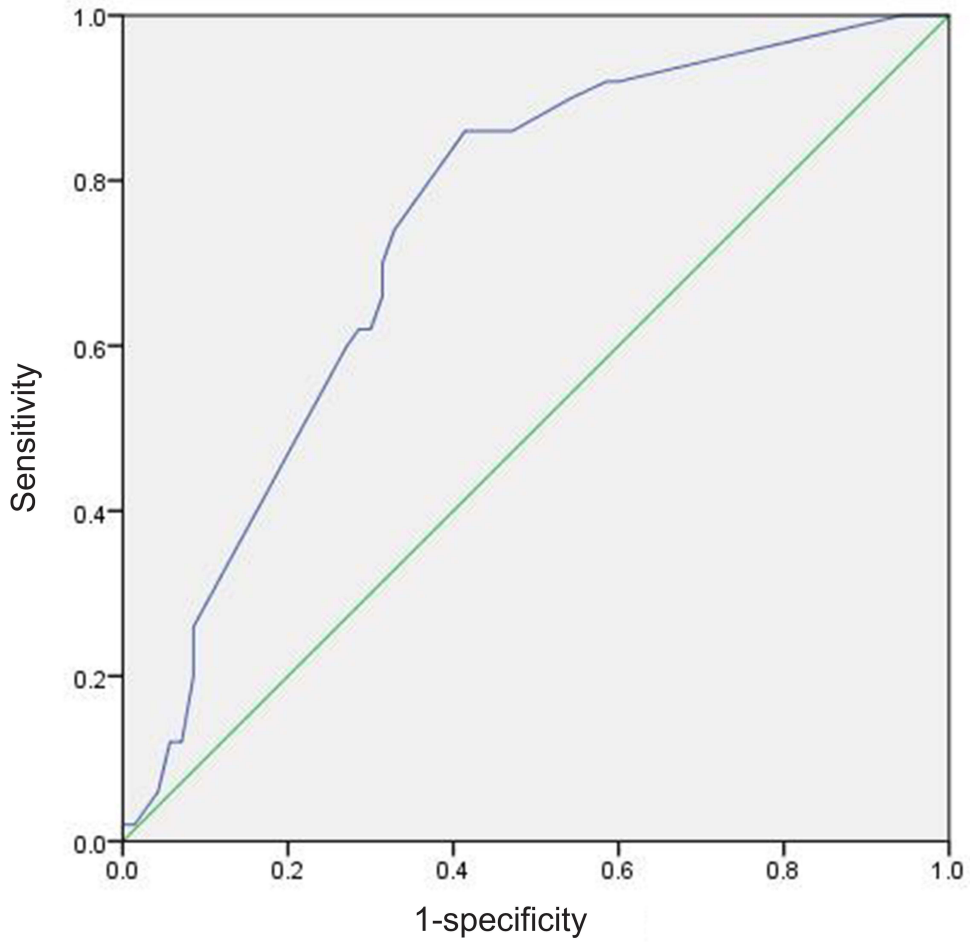

Figure 3 ROC curve generated using the results of the binary logistic regression analysis.

Effect of Training on the Preferences of Family Physicians for Injectable or Oral Medication

We surveyed the family physicians regarding their use of injectable and oral medication. Some had inappropriate preferences, but most believed that the treatment used should depend on the patient's condition. There were significant differences in these preferences after the intervention ($P<0.001$) (Table 5).

Table 3 Analysis of the Questionnaire Scores for the Intervention and Control Groups

Dimensions	Title	Group	Score			Average Score	*P*
			1(%)	2(%)	3(%)		
Dimension one							
Medication strategy	Q1	Control group	25.6	39.7	33.9	2.08±0.77	0.001
		Observation group	13.2	32.2	53.7	2.41±0.72	
	Q2	Control group	11.6	70.2	17.4	2.06±2.41	0.000
		Observation group	5.8	47.1	46.3	2.41±0.60	
	Q3	Control group	33.1	45.5	20.7	1.88±0.73	0.001
		Observation group	18.2	44.6	36.4	2.18±0.72	
	Q4	Control group	18.2	55.4	25.6	2.08±0.66	0.002
		Observation group	9.1	47.9	42.1	2.33±0.64	

(*Continued*)

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Table 3 (Continued).

Dimensions	Title	Group	Score			Average Score	*P*
			1(%)	2(%)	3(%)		
Dimension two							
Oral medication knowledge	Q5	Control group	7.4	79.3	12.4	2.05±0.45	0.000
		Observation group	9.1	48.8	41.3	2.33±0.64	
	Q6	Control group	9.9	38.0	51.2	2.42±0.67	1.000
		Observation group	8.3	41.3	49.6	2.42±0.64	
	Q7	Control group	5.0	52.1	42.1	2.38±0.58	0.029
		Observation group	5.0	35.5	58.7	2.54±0.59	
	Q8	Control group	7.4	59.5	32.2	2.25±0.58	0.363
		Observation group	12.4	42.1	44.6	2.33±0.69	
	Q9	Control group	34.7	52.9	11.6	1.77±0.65	0.000
		Observation group	14.9	39.7	44.6	2.30±0.72	
	Q10	Control group	5.8	43.0	50.4	2.45±0.01	0.917
		Observation group	7.4	38.8	52.9	2.46±0.63	
Dimension three							
Knowledge of injectables	Q11	Control group	51.2	43.0	51.2	1.62±0.58	0.000
		Observation group	3.3	67.8	28.1	2.25±0.51	
	Q12	Control group	38.0	46.3	14.9	1.77±0.69	0.000
		Observation group	11.6	61.2	26.4	2.15±0.60	
	Q13	Control group	43.0	50.4	5.8	1.63±0.59	0.000
		Observation group	18.2	55.4	25.6	2.08±0.66	
	Q14	Control group	49.6	42.1	7.4	1.58±0.63	0.000
		Observation group	16.5	60.3	22.3	2.06±0.63	
Dimension four							
Medication for stroke prevention	Q15	Control group	1.7	69.4	28.1	2.27±0.48	0.029
		Observation group	4.1	49.6	45.5	2.42±0.57	
	Q16	Control group	1.7	54.5	43.0	2.42±0.53	0.473
		Observation group	2.5	47.9	48.8	2.47±0.55	

Table 4 Overall Scores and Scores for Each Dimension for the Family Physicians on the Questionnaire Regarding T2DM Medication

Group	Medication Strategy	Oral Medication Knowledge	Knowledge of Injectables	Medication for Stroke Prevention	Mean Score
Control group	67.43±15.62	73.94±14.04	54.86±17.67	78.06±14.97	68.05±12.80
Observation group	77.78±16.22	79.82±15.07	71.11±15.16	81.39±16.76	88.37±14.86
t	−5.034	−3.127	−7.645	−1.625	−11.349
P	<0.001	0.002	<0.001	0.106	<0.001

Changes in FPG Concentrations and the Issues with Medication in the Patients Under the Care of the Family Physicians After Training

The total number of patients with medication issues after the intervention was significantly lower (55.0%; 171 vs 77; $P<0.05$), as were their mean FPG concentrations ($P<0.05$) (Table 6).

Table 5 Preferences of Family Physicians for the Use of Oral Versus Injectable Medication

Understanding Oral Antidiabetic Regimens	Control Group	Observation Group	P
Orals better than injections	26	16	0.033
Injections better than orals	15	13	
Orals and injections medications do not require combination use	15	13	
I disagree with the above viewpoint; treatment should be chosen based on the specific condition.	73	92	

Table 6 Medication Issues of the Patients Before and After the Intervention [n(%)]

Project	Preintervention (361)	Postintervention (361)	χ2/Z	P
Hidden medication issues	153(42.38%)	72(19.94%)	40.202	0.000
a. Precautions are not fully known	44	15	15.437	0.000
b. Drug-induced hypoglycaemia	33	9	7.178	0.007
c. Failure to adjust the blood glucose control plan in a timely manner when it fails to meet the standard	31	23	1.257	0.263
d. When blood glucose control is poor, treatment plans are not developed in time	21	11	3.241	0.072
e. Lack of attention to the impact of medication on body weight	21	11	3.241	0.072
f. Incomplete medication assessment	8	5	0.697	0.404
g. Patients are unable to accurately identify drugs	7	3	1.611	0.204
h. The treatment plan is not well executed by the patient	5	2	1.290	0.256
i. Poor management of diet, exercise, and blood glucose monitoring	28	16	3.450	0.063
Medication issues with prescriptions	36 (9.97%)	20 (5.54%)	51.64	0.000
a. Inappropriate combination of medications	8	2		
b. Inappropriate selection of medications	2	0		
c. Inappropriate dosage and administration of medication	26	18		
Total number of medication issues	171 (47.40%)	77 (21.30%)	54.270	0.000
Adverse drug reactions	99 (27.42%)	36 (9.97%)	35.958	0.000
a. Digestive system	27	2		
b. Endocrine and metabolic system	70	31		
c. Nervous system	3	0		
d. Others	8	6		
The average FPG level	7.28(4.9,19.3)[#]	7.00(5.1,14.0)[#]	−4.298	0.000

Note: [#]Minimum and maximum values.

Discussion

Necessity for Specialized Training Regarding the Use of Medication for T2DM, According to the Patient and Provider Survey Data

Previous studies have shown that compliance with medication and self-management regimens for T2DM are closely associated with the blood glucose concentrations of patients.[25] In the present study, we found that of the 361 patients surveyed, 171 had one or more medication-related issues. Cox analysis showed that this type of issue had the largest effect on FPG concentration and that there was an inverse relationship between these variables (B=0.619, P=0.000). Therefore, efforts should be made to resolve the hidden medication issues. Family physicians are typically the first professionals to prescribe medication for patients with T2DM, and their ability to prescribe medication appropriately is of great concern. Of the studied family physicians, 87% expressed a need for training regarding rational drug therapy for T2DM, making it their top priority. Therefore, it is essential to provide training regarding such medication for family physicians. However, some studies have shown that routine continuing education for family physicians has no significant effect on their knowledge of diabetes, and of the various topics involved, the score for "drug therapy" is usually lower

than that for other topics.[13,14] Therefore, it is necessary to innovate the training mode and improve the training provided. Pharmacists are trained professionals who have been systematically educated regarding medication, and are responsible for recording medication-related issues and consulting with physicians regarding medication on a daily basis. Therefore, they are ideal candidates to lead educational initiatives regarding medication. Previous research has shown that two-thirds of physicians hope to receive medication training from pharmacists.[26]

In the present study, we aimed to design appropriate training content and training models. Before the training, we conducted a survey to identify the medication issues experienced by family physicians and their patients, allowing us to create targeted training. The use of small groups as training units should enhance the participation of family physicians, increase the attention paid to those with a lower level of knowledge, and promote the expansion of pharmaceutical services. Therefore, this model has significant research value.

Analysis of the Reasons for the Differences in Knowledge Scores Among Family Doctors

We found that the professional title of physicians, the length of their professional experience, and their educational level independently affected their knowledge of T2DM medication, consistent with the findings of previous studies.[27,28] Lower levels of professional title were associated with lower scores on the questionnaire. The scores of family doctors depended on the length of their professional experience. Specifically, the scores of those with 6–20 years of experience gradually seemed to have declined, because those with 15–20 years of experience scored lower than those with <5 years of experience. However, those with >20 years of experience had higher scores, and these were notably higher than those with 10–20 years of experience. This suggests that family doctors with 10–20 years of experience may require additional training and support to improve their prescribing practice.

The analysis of the effect of educational level revealed a close association with the extent of professional experience. In China, general practitioners comprise the majority of family physicians in community health centers, and most of these have associate degrees. Those with bachelor's degrees or higher have only recently joined this profession, and therefore, they have shorter periods of relevant professional experience, which may explain the fact that they achieved lower scores than associate degree holders. According to the 2018 Chinese health statistics,[29] 55.2% of general practitioners in urban health centers and 82.4% of those in rural health centers do not have an undergraduate medical degree from a medical university. In the present study, general practitioners comprise 70% of the primary healthcare team (84/120), and only 36.7% of the participants had bachelor's degrees. These findings permitted us to focus training on the groups of professionals who achieved lower scores and provide recommendations for clinical leaders regarding personnel allocation.

Addressing Medication Issues and Knowledge Gaps in Diabetes Care: A Training Approach

The survey showed that medication prescription errors were principally related to inappropriate dosage and administration of the medication. For this reason, during the training process, we paid special attention to explaining the use and dosage of the medication. The hidden medication issues included incomplete understanding of the precautions to be taken, medication-induced hypoglycemia, failure to adjust the treatment regimen in a timely fashion, poor management of diet and exercise, poor blood glucose monitoring, and insufficient attention to the effects of the medications on body weight (n>20 instances each). We summarized the relevant issues and provided feedback during the group training, and also discussed any mistakes made with the doctors. With respect to the family physicians, the lowest score was for the knowledge of injectables dimension, followed by the medication strategy dimension. The primary healthcare system seldom provides injectable hypoglycemic medications, resulting in a significant knowledge gap among healthcare providers. This was particularly evident in their understanding of the differences between various types of insulin, pre-injection handling procedures, and post-opening storage requirements. To address this deficiency, we organized specialized lectures on insulin-based hypoglycemic medications. These sessions included practical demonstrations and group discussions, which were designed to systematically enhance the proficiency of the physicians in these areas.

Nevertheless, our findings indicate that the advancement in knowledge regarding injectables remains suboptimal. This situation may be attributed to the relatively infrequent use of injectable medication, as well as the inadequate structure and limited duration of the current training courses regarding such medication. In the future, we plan to refine the course structure by systematically decomposing each knowledge point into smaller, more digestible components. In terms of medication strategies, although there are various guidelines for the treatment of T2DM, the implementation of these guidelines in practice is poor, and doctors often rely on their previous experience of prescribing medication, resulting in significant differences in the knowledge levels of various groups. Although family doctors attend relevant training every year, traditional training does not yield optimal results. In contrast, the number of participants in our group training is limited to approximately 20 on each occasion, which permits the pharmacists and physicians to interact effectively, and when combined with simulations of specific cases, the training is clearly more effective. In addition, the problems faced by each group differ, and the preliminary survey provides an important means of improving the pertinence of the training content, which further improves the effectiveness of the training.

Effect of Training Regarding the Use of Medication

The training of physicians regarding the use of specialized drugs has a significant effect to improve prescribing by physicians and the safety of drug administration by patients.[30,31] The total number of patients who reported issues with medication after the intervention was 55.0% lower ($P<0.05$), and their mean FPG concentration was also significantly lower ($P<0.05$). This study demonstrates that pharmacist-led training can significantly improve the scores of family physicians regarding specialized T2DM medication. Furthermore, our findings indicate that the medication management issues and fasting blood glucose concentrations of patients with T2DM who are under the care of family physicians can also be significantly improved. The significant improvement achieved in the knowledge scores highlights the effectiveness of pharmacist-led training to address knowledge gaps among family physicians. This improvement likely contributed to the observed reduction in the number of medication issues, and this underscores the importance of the use of targeted education to improve the quality of care. Similar findings have been made in previous studies, in which pharmacist-led interventions led to measurable improvements in prescribing practices and patient outcomes.[26,32] However, the clinical impacts of these changes, and particularly the modest reduction in FPG, are worthy of further investigation.

Strengths and Limitations

The present study involved a comprehensive investigation of the issues with medication encountered by both healthcare providers and patients. It employed a targeted training program tailored to local needs that incorporated guidelines, expert consensus, and manufacturer recommendations, which together increased participant acceptance. The use of group training improved physician engagement, and the pharmacist-led training model was effective at addressing gaps in medication knowledge and patient medication issues.

The study had a small sample size and primarily focused on FPG as an endpoint, rather than including a more comprehensive assessment. The knowledge of healthcare professionals was evaluated using a questionnaire rather than through an assessment of their professional performance, which will be addressed in future research. Furthermore, the validity and reliability of the questionnaire need to be evaluated in a larger study.

Implications for Future Research and Clinical Practice

The benefits of the involvement of pharmacists in the patient-centered management of chronic disease have been repeatedly demonstrated in studies performed in developed countries;[33,34] however, this model is difficult to implement in less well-developed countries. In China, for example, the main roles of pharmacists are related to conventional drug management, and therefore these professionals are not involved throughout the process of treatment.[35] Family physicians typically prescribe the medication used for the treatment of most patients with T2DM, and especially for those with mild-to-moderate T2DM and those receiving their initial treatment. Therefore, it is imperative to improve the overall competence of the family physician team with respect to antidiabetic medication. Our results are consistent with those

of previous studies demonstrating the effectiveness of pharmacist-led education for the improvement of clinical outcomes,[36,37] but the present study uniquely focused on family physicians in primary care settings.

The Chinese authorities have become concerned about the weakness of the overall professional capacity of medical personnel in primary health care institutions, and a model of medical consortia or medical communities comprising primary healthcare institutions and regional high-level hospitals has been developed. As part of this model, specialist pharmacists in high-level hospitals carry out professional training for pharmacist groups with the help of regional pharmaceutical associations, but it is difficult to integrate into the family physicians team. To promote the present project, the researchers sought funding support, communicated with the leaders of several health service centers, and obtained corresponding support. However, the promotion of follow-up projects needs more policy support from the government, as well as funding for the work of the pharmacists.

The present study also faced many challenges, such as the existence of different medication errors in different health service centers. Therefore, although a unified training course was developed during the early stages of the study, targeted training should be carried out according to the results of a survey performed at each health service center as part of the actual training process. This requires the trainers to be fully aware of the survey results in each center and to plan ahead regarding the specific training priorities. Misunderstandings regarding the use of some drugs have existed for a long time, and it is necessary to strengthen communication with physicians during the training process, in order to correct some common errors. Through the series of measures discussed above, the present project has laid a solid foundation for pharmacists to expand the connotation of pharmaceutical care and integrate this into the chronic disease management process. It should also alert local health authorities to the role of pharmacists and the rational use of drugs for the treatment of chronic disease. This should pave the way for the subsequent promotion of training for patients with other or multiple diseases regarding their treatment. The present model may also be useful in other countries facing similar challenges.

Conclusions

In the present study, we have shown that family physicians have insufficient knowledge regarding the optimal use of medication for T2DM and would like additional training in this area. The development of a training program based on a survey of issues regarding medication and subsequent targeted group training significantly improves their knowledge, as well as reducing the incidence of medication-related issues and improving the FPG concentrations of their patients. Therefore, this approach may be of great value for the improvement of diabetes care.

Data Sharing Statement

All the relevant data are within the paper and the Supporting Information.

Ethics Approval and Informed Consent

The study was performed in compliance with the ethical principles outlined in the Declaration of Helsinki. Approval for the study was obtained from the Medical Ethics Committee of Taicang First People's Hospital (date of approval: June 3, 2017; approval number: 2017-ky-001).

This study was led by two pharmacists, Yang Zhonghui and Cheng Changjuan. The participants were fully informed regarding the study objectives, outcomes, and screening procedures before data collection, and their written informed consent was obtained by the data collectors. Detailed information was collected from their medical records, and questionnaire surveys were conducted. Interviews were conducted in private to ensure confidentiality, and the data collected were anonymized and the participants were identified by numbers. The data were used solely for research purposes, and the diagnoses made and the treatment of the patients were not affected by the research.

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Disclosure

The authors declare that they have no conflicts of interest relevant to this work.

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