



## Research article

# Diabetes knowledge and training needs among non-endocrinology nurses

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## ABSTRACT

**Background:** It is necessary to determine the diabetes knowledge level among non-endocrinology nurses in primary care hospitals to develop continuing education strategies.

**Method:** A questionnaire survey was conducted among 6819 non-endocrinology nurses in 70 primary hospitals in the Guangxi Zhuang Autonomous Region to assess their diabetes knowledge level and training needs. Factors affecting knowledge level were analyzed using multiple linear regression models.

**Results:** Diabetes knowledge was low, particularly for diabetes monitoring. Knowledge was higher in nurses who had in-service education and training in diabetes; most believed that training was necessary and hoped to improve their ability to care for diabetic patients. The most suitable training method was considered to be each nurse was taught by an assigned person after centralized specialized education and training.

**Conclusion:** Non-endocrinology nurses in primary care hospitals lack knowledge of diabetes and have a strong need for training. Systematic training is required to ensure that patients receive high-quality and comprehensive care.

## 1. Introduction

The International Diabetes Federation estimates that by 2030, 643 million adults worldwide will have diabetes, with more than three-quarters residing in low-income and middle-income countries [1]. Diabetes education plays an important role in the management of this condition, as it not only improves treatment adherence but also reduces the risk of complications [2]. Such education can also decrease the incidence of complications and is cost effective [3,4].

Previous surveys have shown that Chinese patients with diabetes have a low awareness of diabetes and that nurses have a low level

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of knowledge regarding diabetes management [5,6]. In China, a large number of diabetic patients are currently hospitalized in non-endocrine units due to diabetic complications or other co-morbidities, and non-endocrine nurses are unable to provide standardized diabetes specialist treatment and care to patients due to a lack of diabetes-related knowledge and skills [7]. Inadequate training of healthcare practitioners can lead to ineffective diagnosis, treatment, and control of the disease. Indeed, inappropriate use of insulin by untrained healthcare providers can have serious adverse consequences [8]. Clinical care by trained nurses in non-endocrine units can reduce medication errors and length of stay for patients with diabetes, as well as improve glycated hemoglobin levels and follow-up adherence after discharge [9,10]. Nevertheless, the prevalence of diabetes is increasing, and this poses a tremendous challenge to healthcare professionals, systems, and management policies [11].

Previous studies have reported deficiencies in diabetes knowledge among non-endocrinology nurses [12]. Notably, it has been shown that negative experiences with training methods and content can discourage nurses from participating in continuing education [13]. Given the increasing need for diabetes knowledge training among non-endocrinology nurses [14], it is pertinent that their current level of knowledge be evaluated, in order to inform the development of continuing education programs.

## 2. Methods

### 2.1. Aim

The objectives of this study were to (a) investigate the level of diabetes knowledge and training needs of non-endocrinology nurses in primary care hospitals and (b) explore the factors affecting the level of diabetes knowledge.

### 2.2. Design

This study was a multicenter, large sample cross-sectional survey.

### 2.3. Participants

In February 2022, the investigators recruited non-endocrinology nurses in 14 cities across the Guangxi Zhuang Autonomous Region using a multistage stratified sampling method. In the first stage, five primary hospitals were randomly selected from each city. In the second stage, five non-endocrine departments were randomly selected from each hospital selected in the first stage, and all nurses in the departments were required to participate in the survey. In total, 70 hospitals in 14 cities were selected, and a total of 6963 nurses from 350 non-endocrine departments were included in the questionnaire survey. The inclusion criteria were (a) age  $\geq 18$  years; (b) having obtained a nurse practitioner's license, and working in the hospitals included in this study; (c) nurses were placed in non-endocrine units by the hospital, rather than in endocrine clinics or wards, and worked in non-endocrine clinics and wards during the investigation; and (d) directly engaged in nursing care for patients.

### 2.4. Data collection

#### 2.4.1. Questionnaire

The Diabetes Knowledge Level and Training Needs Questionnaire for Non-Endocrine Nurses was used and consent was obtained from the developers. This questionnaire was developed by Xiong and put into use in 2012. It was demonstrated to have good reliability (Cronbach's  $\alpha = 0.83$ ) and validity (content validity index = 0.91) among 362 non-endocrinology nurses in 36 non-endocrine departments [14]. This questionnaire comprises two main components: (a) training needs, including the necessity of diabetes knowledge training, aspects of diabetes knowledge training that should be focused on, and the method of training; and (b) the current level of diabetes knowledge. There are 21 multiple-choice questions (1 point each, 21 points in total). Diabetes knowledge content is evaluated across six dimensions that pertain to basic knowledge of diabetes, as well as knowledge of diet, exercise, monitoring, medication, and complications. There are 3–5 questions in each dimension, and the rate of correct answers (%) = the number of correct answers to the question/survey respondents  $\times 100\%$ .

#### 2.4.2. Data collection

An anonymous, web-based approach was used to collect questionnaire responses in February 2022. The directors of nursing departments in 70 hospitals were contacted and informed of the purpose of the study. We set up an online questionnaire through *Wen Juanxing* [15] (the most commonly used online questionnaire distribution method in China) and sent the online questionnaire to the mobile phones of the participants included in this study via the internet. Participants completed the questionnaires anonymously by clicking on the online survey link and scanning the quick response code. The questionnaire data were only accessible for download by the first author using a password through an administrator account. The study data were extracted into an Excel spreadsheet for storage, and all information was kept confidential.

### 2.5. Ethical considerations

We obtained approval from the ethics committee of Guangxi Academy of Medical Sciences and the People's Hospital of Guangxi Zhuang Autonomous Region (approval number: KY-KJT-2021-26) prior to study commencement. The voluntary nature of

**Table 1**  
Sample characteristics and univariate analysis.

	Mean (SD)	N (%)	Overall score of diabetes knowledge	Statistics	P
Gender					
Male		191 (2.80)	12 (10,14)	−5.324 <sup>a</sup>	<0.001
Female		6628 (97.20)	13 (12,15)		
Age					
Mean (SD)	31.84 (7.55)		–	0.763 <sup>c</sup>	<0.001
Range	18–60				
Ethnicity					
Han		3527 (51.72)	13 (12,15)	59.554 <sup>d</sup>	<0.001
Zhuang		2424 (35.55)	13 (11,14)		
Other		868 (12.73)	14 (12,16)		
Marital status					
Unmarried		2123 (31.13)	13 (11,14)	−7.299 <sup>a</sup>	<0.001
Married		4696 (68.87)	13 (12,15)		
Number of children					
None		2514 (36.86)	13 (11,14)	21.933 <sup>b</sup>	<0.001
1		2215 (32.48)	13 (12,15)		
2		2039 (29.90)	13 (12,15)		
≥3		51 (0.76)	13 (11,15)		
Educational level					
Technical secondary school degree and below		211 (3.09)	13 (11,15)	22.025 <sup>b</sup>	<0.001
Associate degree		2621 (38.44)	13 (11,15)		
Bachelor degree		3978 (58.34)	13 (12,15)		
Master degree and above		9 (0.13)	14.67 ± 2.00		
Title					
Junior Nurse		1600 (23.46)	12 (11,14)	411.147 <sup>d</sup>	<0.001
Senior Nurse		3083 (45.21)	13 (11,15)		
Charge Nurse		1650 (24.20)	14 (12,15)		
Associate Nurse Practitioner		465 (6.82)	14 (13,16)		
Chief Nurse Practitioner		21 (0.31)	15 (13.5,15)		
Position					
No		6280 (92.09)	13 (12,15)	32.697 <sup>b</sup>	<0.001
Deputy head nurse		174 (2.55)	15 (13,16)		
Head nurse		332 (4.86)	14 (13,16)		
Head nurse of major department		8 (0.12)	15.5 (12.75,16)		
Deputy director of nursing department		13 (0.19)	14.08 ± 2.43		
Director of nursing department		12 (0.18)	14.83 ± 1.64		
Duration of clinical experience (years)					
Mean (SD)	10.30 (7.97)		–	0.193 <sup>c</sup>	<0.001
Range	0–40				
Clinical Lead Teaching Experience					
No		2927 (42.92)	13 (11,14)	−16.058 <sup>a</sup>	<0.001
Yes		3892 (57.08)	14 (12,15)		
Duration of clinical lead teaching (years)					
Mean (SD)	8.69 (7.05)		–	0.227 <sup>c</sup>	<0.001
Range	1–39				
Diabetes in-service education and training					
No		6158 (90.31)	13 (12,15)	−13.759 <sup>a</sup>	<0.001
Yes		661 (9.69)	15 (13,16)		
Approaches to in-service diabetes education and training					
No		6158 (90.31)	13 (12,15)	51.510 <sup>b</sup>	<0.001
Intra-departmental business studies		284 (4.16)	14 (13,16)		
In-hospital special lectures		280 (4.11)	14 (13,16)		
Out-of-hospital refresher studies		41 (0.60)	16 (14.5,17)		
Diabetes specialist nurse training		56 (0.82)	15 (13.25,17)		
Duration of diabetes in-service education and training (Months)					
Mean (SD)	3.15 (3.06)		–	0.167 <sup>c</sup>	<0.001
Range	1–12				
Internship or work experience in endocrinology					
No		5703 (83.63)	13 (11,15)	−11.481 <sup>a</sup>	<0.001
Yes		1116 (16.37)	14 (12,16)		
Duration of Endocrinology Working (Months)					
Mean (SD)	12.84 (17.19)		–	0.145 <sup>c</sup>	<0.001
Range	1–96				
Willingness to attend training					
Not necessary		8 (0.12)	12.50 ± 2.56	16.875 <sup>b</sup>	<0.001
General		259 (3.80)	12 (11,14)		
Necessary		3177 (46.59)	13 (12,15)		
Very necessary		3375 (49.49)	13 (12,15)		

**Note:** a: Mann-Whitney U test, b: ANOVA, c: Spearman correlation test, d: Kruskal-Wallis test.

participation and the confidentiality of responses were described in the online questionnaire, and informed consent was provided by all participants and care managers.

## 2.6. Data analysis

Data were entered and analyzed using IBM SPSS 26.0 (SPSS Inc.). Prior to analysis, we excluded 144 participants with incomplete information (hospital name not identifiable [N = 75], ethnicity could not be determined from the participant [N = 5], department name not identifiable [N = 6], and general information section of the questionnaire filled in incorrectly [N = 58]). The following continuous variables are presented as means and standard deviations (SDs): age, duration of in-service education and training in diabetes specialties, and diabetes knowledge questionnaire scores in the general information section. Categorical variables (sex, experience with in-service education and training in diabetes specialties, and experience in endocrinology) are presented as composition ratios. The normality of the data was checked before analysis. Continuous variables were analyzed using Spearman correlation, while dichotomous variables were analyzed using nonparametric tests. Hierarchical and categorical data were analyzed using analysis of variance; nonparametric tests were used when the variance was not equal. The effect of demographic variables on the level of diabetes knowledge was assessed using one-way analysis of variance. Factors that differed in the one-way analysis of variance were included in the multiple linear regression model, which was used to evaluate the association between demographic variables and the level of diabetes knowledge.  $P < 0.05$  was considered statistically significant.

## 2.7. Validity, reliability, and rigor

The validated questionnaire was carefully selected for data collection purposes. The objective of the study was communicated to the directors of nursing departments in the 70 contacted hospitals. The content of the questionnaire and instructions for completing it were explained, in order to ensure validity and consistency of the data across different hospitals. After the questionnaires were collected, all data were independently checked by two researchers and entered into SPSS for statistical analysis.

**Table 2**  
Current knowledge of diabetes mellitus among non-endocrinology practicing nurses in primary hospitals [N = 6819, N(%)].

Items	Number of correct responses(N)	Correctness rate (%)	MD(SD)	Correctness rate (%)
basic knowledge of diabetes				
What factors increase the risk of developing type 2 diabetes	6212	91.10%	2.19 (0.70)	73.14%
Which measures should be taken first to treat type 2 diabetes	3045	44.65%		
The current methods that can cure diabetes are	5705	83.66%		
knowledge of diet				
Foods not suitable for diabetic patients	5976	87.64%	2.23 (0.65)	74.27%
Under which conditions can diabetics drink low beer in small quantities	6497	95.28%		
Dietary requirements for diabetic patients	2721	39.90%		
knowledge of exercise				
The right way to exercise for diabetes	6354	93.18%	2.06 (0.81)	68.63%
Exercises suitable for elderly diabetics	3813	55.92%		
Duration of exercise for diabetic patients	3872	56.78%		
knowledge of monitoring				
Frequency of glyated hemoglobin testing	1036	15.19%	0.84 (0.97)	21.12%
Frequency of urine microalbumin testing	587	8.61%		
Frequency of fundus examination test	1724	25.28%		
Fasting blood glucose control standards for diabetic patients	2414	35.40%		
knowledge of medication				
Types of hypoglycemic drugs	6642	97.40%	2.09 (0.69)	69.78%
The sites available for insulin injections	5203	76.30%		
Insulin storage methods	2430	35.64%		
knowledge of complications				
The first steps to take for hypoglycemia	3346	49.07%	3.74 (0.88)	74.87%
Complications that can result from diabetes	6406	93.94%		
Under which conditions diabetic eye disease can occur	6389	93.69%		
The principle of choosing shoes for diabetic patients	6298	92.36%		
Precautions for diabetic patients when washing their feet	3089	45.30%		
Total score			13.16 (2.36)	62.68%

### 3. Results

#### 3.1. Participant characteristics

The mean age of the 6819 participants was 31.84 (SD, 7.55; range, 18–60) years, and the majority were females (N = 6628; 97.20%). The mean number of years of work was 10.30 (SD, 7.97; range, 0–40), and the most frequent level of education was a bachelor degree (N = 3978; 58.34%). Only 1116 (16.37%) nurses had a prior internship or work experience in endocrinology, and under a tenth (N = 661; 9.69%) had received in-service education and training in diabetes through intra-departmental business studies, in-hospital special lectures, out-of-hospital refresher courses, or diabetes specialist nurse training. The demographic characteristics of the participants are shown in [Table 1](#).

#### 3.2. Diabetes knowledge level of non-endocrinology nurses in primary hospitals

The mean diabetes knowledge score was 13.16 (SD, 2.36; range, 2–20). The mean scores for basic knowledge of diabetes, as well as knowledge of diet, exercise, monitoring, medication, and complications were 2.19 (SD, 0.70), 2.23 (SD, 0.65), 2.06 (SD, 0.81), 0.84 (SD, 0.97), 2.09 (SD, 0.69), and 3.74 (SD, 0.88), respectively. The item pertaining to the type of glucose-lowering drug was most frequently answered correctly (97.40%); the item on the frequency of urine microprotein detection had the lowest score, with only 8.61% of participants providing a correct answer ([Table 2](#)).

#### 3.3. Diabetes mellitus knowledge training needs among non-endocrinology nurses in primary hospitals

In this survey, 96.08% of the nurses thought it was necessary to provide uniform training on diabetes-related knowledge; 94.22% thought that diabetes specialist training should include content for improving the theoretical knowledge of diabetes. Most of the nurses felt that diabetes specialist training should focus on health education skills (89.60%) and nursing knowledge (88.50%) for diabetic patients. The large majority of nurses also hoped that such training would improve their health education capabilities (93.05%). Over three-quarters (77.18%) of nurses considered that each nurse was taught by an assigned person would be suitable for clinical practice, while 89.68% preferred the provision of each nurse was taught by an assigned person after centralized specialized education and training. The main obstacle to participation in training (reported by 91.36% of the nurses) was “busy work and no time” ([Table 3](#)).

**Table 3**  
Training needs of diabetes knowledge of non-endocrine practice nurses in primary hospitals [N = 6819, N(%)].

Items	Number of options selected (N)	%
Which of the following aspects do you think diabetes education and training needs to include?		
Improve the overall quality of nurses	2587	37.94%
Improve the theoretical knowledge of diabetes	6425	94.22%
Learn new techniques and advances in diabetes specialties	6229	91.35%
Improve the clinical work ability of nurse practitioners	4411	64.69%
What you hope to gain from your diabetes education and training?		
Improve health education capacity for diabetic patients	6345	93.05%
Obtained “Diabetes Professional Training” certificate	2625	38.50%
Improve the level of care for diabetic patients	6330	92.83%
Acquire new business and new knowledge	4501	66.01%
What areas would you like to see diabetes education and training focus on?		
Focus on theoretical knowledge of diabetes	3714	54.47%
Focus on diabetes health education skills	6110	89.60%
Focus on diabetes care knowledge	6035	88.50%
Focus on diabetes care skills	3697	54.22%
What do you think are the appropriate ways to lead clinical practice?		
Follow one work: Different people work in the hospital at different times and nurses are taught by the person who is working at that time throughout their clinical practice	2124	31.15%
Follow one person: nurses are taught by one designated teacher throughout their clinical practice	5263	77.18%
Nurses receive intensive education and training first, then follow one person	6115	89.68%
Nurses receive intensive education and training first, then follow one work	3343	49.02%
What do you think are the factors that influence your participation in education and training?		
Busy work and lack of time	6230	91.36%
Training content is less used in the workplace	5671	83.16%
Section does not pay attention	2763	40.52%
Other factors	606	8.89%
What do you think about attending diabetes specialist training?		
Very necessary	3375	49.49%
Necessary	3177	46.59%
General	259	3.80%
Not necessary	8	0.12%

3.4. Factors influencing diabetes knowledge scores of non-endocrinology nurses in primary care hospitals

The results of the univariate analysis of each variable are shown in Table 1, and the variables were assigned values prior to the multiple linear regression analysis (Table 4). Multiple linear regression analysis showed that the following factors influenced diabetes knowledge scores: age, sex, number of children, education, title, position, years of experience, clinical teaching experience, experience in in-service education and training in diabetes specialties, time spent practicing or working in an endocrinology unit, and nurses' willingness to participate in training (Table 5). Females had a higher knowledge level than males. Higher diabetes knowledge levels were associated with increased clinical teaching experience, in-service education and training experience, and internship or work time in the endocrinology department. Diabetes knowledge levels were also positively associated with age, education, title, and position and willingness to participate in training. In contrast, diabetes knowledge was poorer among nurses with more children and years of work experience.

4. Discussion

This study provides evidence for the current status of diabetes knowledge and training needs of non-endocrinology nurses in primary care hospitals in less developed areas of China. The results of this study suggest that non-endocrinology nurses have an inadequate knowledge of diabetes and a strong need for diabetes knowledge training. Training and continuing education can improve the professional practice of healthcare practitioners, as well as patient prognosis [16]. In addition, nurses play an important role in diabetes education, and enhance the training of nurses to provide care to individuals, families and communities for the purpose of

**Table 4**  
Assigning values to variables.

Gender	Male = 0; Female = 1
Marital status	Unmarried = 0; Married = 1
Number of children	None = 0; 1 = 1; 2 = 2; 3 or more = 3
Ethnicity	Han (Z1 = 0, Z2 = 0); Zhuang (Z1 = 1, Z2 = 0); Other (Z1 = 0, Z2 = 1)
Educational level	Technical secondary school degree and below = 0; Associate degree = 1; Bachelor degree = 2; Master degree and above = 3
Title	Junior Nurse = 0; Senior Nurse = 1; Charge Nurse = 2; Associate Nurse Practitioner = 3; Chief Nurse Practitioner = 4
Position	No = 0; Deputy head nurse = 1; Head nurse = 2; Head nurse of major department = 3; Deputy director of nursing department = 4; Director of nursing department = 5
Clinical Lead Teaching Experience	No = 0; Yes = 1
Diabetes in-service education and training	No = 0; Yes = 1
Internship or work experience in endocrinology	No = 0; Yes = 1
Approaches to in-service diabetes education and training	No (Z1 = 0, Z2 = 0, Z3 = 0, Z4 = 0); Intra-departmental studies (Z1 = 1, Z2 = 0, Z3 = 0, Z4 = 0); In-hospital lectures (Z1 = 0, Z2 = 1, Z3 = 0, Z4 = 0); Out-of-hospital refresher studies (Z1 = 0, Z2 = 0, Z3 = 1, Z4 = 0); Diabetes specialist nurse training (Z1 = 0, Z2 = 0, Z3 = 0, Z4 = 1)
Willingness to attend training	Not necessary = 0; General = 1; Necessary = 2; Very necessary = 3

**Note:** There was a covariate relationship between the presence or absence of clinical teaching experience and clinical teaching time, the presence or absence of in-service diabetes education experience and in-service education time, and the presence or absence of endocrinology experience and endocrinology time. Therefore, we set the “none” option to “0” and included it as a continuous variable in the multiple linear regression model.

**Table 5**  
Associated Factors of overall score of diabetes knowledge of non-endocrinology nurses.

Variables	B	SE	$\beta$	t	P
Constants	5.378	0.169	–	31.779	<0.001
Age	0.231	0.003	0.737	80.987	<0.001
Gender	0.397	0.118	0.028	3.372	0.001
Marital status	–0.003	0.068	–0.001	–0.051	0.959
Number of children	–0.104	0.036	–0.037	–2.872	0.004
Educational level	0.096	0.038	0.023	2.506	0.012
Title	0.266	0.040	0.098	6.558	<0.001
Position	0.096	0.040	0.022	2.404	0.016
Duration of clinical experience	–0.063	0.006	–0.211	–11.008	<0.001
Duration of clinical lead teaching	0.011	0.006	0.033	2.027	0.043
Duration of diabetes in-service education and training	0.041	0.020	0.023	2.014	0.044
Duration of Endocrinology Working	0.007	0.002	0.025	2.965	0.003
Willingness to attend training	0.102	0.034	0.025	3.011	0.003
Ethnicity:Han	0				
Zhuang	–0.219	0.042	–0.044	–5.188	<0.001
Other	0.333	0.061	0.047	5.479	<0.001
Approaches to in-service diabetes education and training: No	0				
Intra-departmental studies	0.239	0.116	0.020	2.058	0.040
In-hospital lectures	0.298	0.118	0.025	2.527	0.012
Out-of-hospital refresher studies	0.709	0.258	0.023	2.751	0.006
Diabetes specialist nurse training	0.888	0.221	0.034	4.016	<0.001

**Note:** Adjusted  $R^2 = 0.546$ ,  $F = 457.243$ ,  $p < 0.001$ .

promoting, restoring and maintaining people's health [17]. Diabetologists provide continuing education to improve professional knowledge among healthcare practitioners, which not only increases staff self-efficacy, but also reduces the risk of making mistakes during clinical care [3]. Indeed, a previous study reported that clinical care provided by nurses, who were trained and knowledgeable about diabetes, reduced hospital injuries and length of stay for patients with diabetes compared to standard inpatient care [3]. Meta-analyses have also shown that health system interventions can improve glycemic control [18]. These interventions, in addition to the implementation of health promotion policies based on reducing gaps in diabetes expertise and care, could have wide-ranging benefits for patients with diabetes in the future [8]. Nurses play a key role in the prevention and management of all types of diabetes, and current training is rapidly evolving to meet the challenges of increased knowledge needs and expanded nursing roles [19, 20]. Our survey of the training needs of non-endocrinology nurses may inform recommendations for ways and means of improving continuing diabetes education.

Our observation of an inadequate level of diabetes knowledge among non-endocrinology nurses is supported by previous studies [21]. While we found that non-endocrinology nurses were able to accurately identify glucose-lowering drugs, they were less knowledgeable about diabetes monitoring and insulin storage methods. Diabetes poses a serious economic burden in terms of reduced personal and social productivity. Nevertheless, improved management practices have been demonstrated to reduce mortality and productivity loss among patients with diabetes [22]. While diabetic patients are often admitted to the hospital for the treatment of other diseases, diabetes management can be equally as important for patient recovery. Such management requires that non-endocrinology nurses have an adequate diabetes knowledge level. A previous study reported that the presence of a diabetes specialist nurse in a pediatric unit not only reduces the length of stay of children with diabetes, but also improves glycosylated hemoglobin levels and follow-up compliance after discharge [10].

Pharmacologic interventions are one of the main tools in the treatment of diabetes [23]. Non-endocrinology nurses have an important role in monitoring diabetic patients after medication administration. This may explain our observation that they were able to accurately identify diabetic medications. Their low level of knowledge regarding diabetes monitoring may be due to the fact that these nurses were not responsible for out-of-hospital management or follow-up monitoring of diabetes. Therefore, it is essential that hospital administrators provide diabetes knowledge training programs that address current knowledge deficits among non-endocrinology nurses and related influencing factors, in order to facilitate the provision of high-quality and comprehensive patient care.

The present study found that non-endocrinology nurses had a strong demand for diabetes knowledge training. In addition, the nurses hoped to improve their theoretical knowledge level, the ability of nurses to teach patients, and health promotion skills by first attending centralized specialized operation training, followed by further teaching by a specialist. In recent years, the demand for skilled nurses with prior diabetes training in primary non-endocrine departments has increased; this has in turn increased the importance and urgency of developing and implementing an adequate training system [24]. During the COVID-19 pandemic, social isolation and the redistribution of medical resources reduced self-management support for diabetic patients; this led to a significant increase in health problems and serious disruptions in nurse-patient communication, which put greater work pressure on nurses [25]. Diabetes specialty training can improve nurses' knowledge and clinical care competencies [26]. Nurses play an important role in preventing the onset and progression of diabetes, and nurse-led models of care have been shown to be effective in the management of diabetes, with diabetes specialist nurses can provide expertise to support the multidisciplinary care of patients with diabetes [20]. When patients with diabetes are admitted to hospital for other non-diabetic conditions and cared for by primary care nurses, it is

important that non-endocrinology nurses have specialized knowledge of diabetes care in this setting. Studies have shown that health education provided by nurses can reduce long-term glycosylated hemoglobin and basal glucose levels in patients with diabetes, as well as increase the proportion of patients who are able to reach their glycosylated hemoglobin treatment goals [27]. Therefore, providing education and training to non-endocrinology nurses not only helps them meet the challenges of disease management, but also facilitates the provision of comprehensive patient care.

Factors affecting the level of diabetes knowledge of non-endocrinology nurses in primary care hospitals were age, sex, number of children, education, title, position, years of experience, clinical teaching experience, experience in endocrinology, experience in in-service education and training in diabetes specialties, and nurses' willingness to participate in training. Nurses with more clinical teaching experience had a higher level of diabetes knowledge. This may be due to the fact that nurses with teaching experience need to continuously improve their knowledge in order to provide more comprehensive education to trainee nurses. The level of knowledge acquisition gradually decreased with increasing years of work experience, a finding similar to that reported by Ewa et al. [28] This may be explained by the phenomenon of burnout, which causes nurses to be progressively less motivated to acquire new knowledge [29]. Increases in the number of children were also associated with lower knowledge levels, which may be due to increases in family responsibilities and parenting pressures, these factors likely limit the time available for nurses to improve their theoretical knowledge [30]. Nursing is a highly feminine profession and previous research has suggested that the low level of support from the male partners of female nurses in marriage for their career progression hinders their progress [31], however in this study it was found that being married or not was not an influencing factor on the level of knowledge of the nurses, implying that the pressure to raise children was a hindrance to the career progression of female nurses after marriage rather than marriage itself. An increased willingness to participate in training led to higher diabetes knowledge scores. This implies that willingness to learn can motivate nurses to improve their nursing skills in the workplace [32]. Nurses who received in-service education training in diabetes specialties had higher levels of diabetes knowledge. This finding is supported by a previous study, which reported that knowledge among primary nurses was significantly higher after the provision of continuing education on diabetes [33]. This reflects the importance of nurses' participation in continuing education. Our study also found that nurses with higher education levels had better diabetes knowledge, which demonstrates the importance of improving nurses' education. Higher levels of diabetes knowledge were associated with longer internship periods and a greater degree of work experience in endocrinology, thus indicating that the nurses' knowledge structure was specialized. Thus, the placement of non-endocrinology nurses in endocrinology internships may be effective for skill improvement. These findings can help managers understand the ability of non-endocrinology nurses to care for patients with diabetes and the potential effects of influencing factors. This would facilitate the development and provision of targeted continuing education programs to improve nursing skills.

#### 4.1. Limitations

This study selected 70 primary care hospitals for the questionnaire survey. We did not collect data in rural clinics (because such institutions often have only 1–2 staff members). Due to the Covid-19 epidemic, policies have restricted the range of movement of people and this has led to the regulation of researcher travel. We were unable to visit 70 hospitals to send questionnaires face-to-face, so we used an online questionnaire to survey nurses. However, as our study was conducted in a rigorous manner and included a large number of hospitals and nurses, this reduced the potential study bias.

## 5. Conclusion

The level of diabetes knowledge among non-endocrinology nurses in primary care hospitals is poor, and there is a strong need for diabetes knowledge training. Against the backdrop of a global shortage and uneven distribution of total quality healthcare resources, the lack of knowledge and experienced personnel in primary hospitals compared to large general hospitals has led to a lack of health management for medically disadvantaged rural and community populations in less economically developed areas. Healthcare organizations need to adopt appropriate methods to provide continuing education to nurses in the future. This would enhance the comprehensive care competencies of nurses and help them meet the challenges posed by disease management.

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#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e15985>.

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