ORIGINAL ARTICLE

Incidence, prevalence, and factors predicting diabetic retinopathy among type 2 diabetes mellitus patients in public health centers, Bangkok metropolitan administration

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ABSTRACT

The Objectives this research were 1) to explore incidence and prevalence of diabetic retinopathy (DR) among Type 2 Diabetes Mellitus (T2DM) patients, and 2) to study the predictive power of Hemoglobin A1c, fasting blood sugar, duration of having T2DM, health behaviour, health literacy, genetics, and income to the occurrence of DR among T2DM patients receiving care from public health centers. A retrospective study design was conducted from 1,084 chart records to explore the incidence and prevalence of DR. Then 153 participants were recruited to study predicting factors for the occurrence of DR. Data were collected from chart reviews and self-reported questionnaires; then analyzed using descriptive and logistic statistics analysis. The findings showed that the incidence rate of DR was 3 per 1,000 population, and the prevalence rate of DR was 134 per 1,000 population. Hemoglobin A1c, fasting blood sugar, duration of having T2DM, health behaviour, health literacy, genetics, and income altogether could predict the occurrence of DR by 47% (R^2 = 0.47, p < .05). Hemoglobin A1c, fasting blood sugar, duration of having T2DM, and health literacy could reduce the risk of DR significantly (OR = 1.51, 95%CI = 1.04, 2.21, p < .05;OR = 1.01, 95%CI = 1.00, 1.02, p < .05; OR = 1.30, 95%CI = 1.16, 1.47, p < .05; and OR = 0.95, 95%CI = 0.92, 0.98, p < .05). The incidence and prevalence of DR were the important health index reflecting a serious complication among uncontrolled T2DM patients. Success in controlling blood sugar level and gaining health literacy helped patients reduce the risk for DR. Nurse practitioners could take the messages from this study to create proactive interventions/services for promoting healthy behaviour and health literacy to prevent or delay the occurrence of DR among T2DM patients.

Key words: diabetic retinopathy, incidence, prevalence, T2DM

INTRODUCTION

Diabetic retinopathy (DR) is a significant complication among Type 2 Diabetes Mellitus (T2DM). Symptoms of DR start with blurred vision and seeing dark strings floating in the vision. When the symptoms become more severe, vision loss will occur, which results in patients having difficulty in reading and taking care of themselves. Moreover, having difficulty with physical movement will result in increasing the risk of accidents.[1] The number of patients with blindness from DR was approximately 285 million.[2] In the United States, there were 7.70 million DR patients, and the prevalence rate of DR was between 30-50%. DR was a significant cause of vision loss in diabetes patients, second to cataracts.[3] In Asia, recent reports showed that the prevalence rate of DR in China was 28.00-43.00%,Thailand 31.40%, Singapore 25.40-35.00%, South Korea 15.80%, and Hong Kong 12.10%.[4,5] Recent evidence also showed that DR made up 5.17% of causes of vision loss within the study population.[6] One survey research from government hospitals under the Ministry of Public Health Administration in Thailand reported that 29,511 diabetes patients had diabetic complications (6.50%). Of all the complications, 9,831 cases (33.10%) reported having DR.[7] A recent study from public health centers, Bangkok Metropolitan Administration revealed that the prevalence rate of DR was 28.66%.[8] It was slightly lower than the national DR prevalence. However, DR is a serious complication led to vision impairment and blindness. It is necessary for nurse practitioners working for public health centers to keep tracking on the prevalence rate of DR because this health index is used to reflect whether practitioners can successfully help their T2DM patients control blood sugar and health status. Moreover, practitioners can used this health index to drop ineffective interventions and create more effective interventions for T2DM patients.

DR is considered a severe complication of T2DM. It is one of the main causes of blindness in patients affecting their daily lives and their families. Several factors needed to be studied and in order to be able to predict the occurrence of DR. In this study, an epidemiologic triad model was used as a conceptual framework to determine a set of predicting factors related to DR. The model comprises 3 components in terms of agents, host, and environment. In the disequilibrium stage, interactions among the 3 components cause diseases/disorders among humans.[9] From the literature review, haemoglobin A1c (HbA1c), fasting blood sugar (FBS), duration of having T2DM, health behaviour, and health literacy were identified as predicting factors from a host component; genetic history was included in the study as an agent factor; and financial income was also included in the study as an environmental factor. Recent evidence was found to support the relationship among these factors and the incidence/ prevalence rate of DR. These factors are briefly explained as follows:

HbA1c and FBS have been proven to affect the development of DR in many studies. A level of HbA1c over 7% increased the risks of developing DR by 2 times (HR = 1.59, 95% CI = 1.20, 2.10, $p < .001$, OR = 1.88, 95%CI = 1.47, 2.40, $p < .001$).[10,11] The level of FBS over 130 mg/dl was found to relate to an increase in the risk of developing DR among T2DM patients by 2 times as well (OR = 1.82, 95%CI = 1.10, 2.90, $p < .05$).[12] Another study in China also supported that higher FBS increased the risk of developing DR by 1.33 times (OR = 1.33, 95%CI = 1.12, 1.59, $p < .001$).[13] Duration of having T2DM from 5-10 years was found to elevate the risk of developing DR by 2 to 4 times (OR = 1.76,

95%CI = 1.02, 3.04, p < .05, OR = 4.13, 95%CI = 3.22, 5.30], p < .001).[11,14]

Health behaviour is defined as how an individual acts which can have good or bad effects on one's health. Poor health behaviour will make T2DM patients be unable to control their blood glucose, resulting in hyperglycemia. If the blood glucose level remains high for a prolonged period of time, DR will occur. A study revealed a significant correlation between food intake behaviour and FBS (r = -0.35, p < .05). Participants with good food intake behaviour would be able to decrease their FBS better than those with poor food intake behaviour.[15] Exercise was also found as a factor that had a statistically significant relationship with uncontrolled FBS in T2DM patients by 2 to 5 times (OR = 5.21, 95%CI = 1.15, 23.64, p < .05). In addition, emotional and stress management were found to be associated with the inability to control FBS by 9 times (OR = 8.99, 95%CI = 1.61, 50.14, p < .05). Regular medication consumption behaviour was also found to be associated with the ability to control FBS by 10 times (OR = 10.16, 95%CI = 2.03, 50.79, p < .05).[16]

Health literacy is the ability of T2DM patients to access, understand, and act on health-related knowledge in order to maintain good self-management for their own health.[17] Recent evidence has found that people with high health literacy were able to take care of themselves and had better blood glucose level than those with low health literacy.[18] Patients with high health literacy were able to control their blood glucose because they had knowledge and understanding about good self-care. Therefore, they were able to choose appropriate food consumption and medication for their disease status.[19]

Genetics have been found to relate to DR. A study on the relationship between genetics and occurrence of DR found that a family with a history of DR would have a 2-3 times greater risk of developing DR than those without history of DR (OR = 2.76, 95%CI= 1.20, 6.11, p < .01 , OR = 2.10, 95%CI = 1.07, 4.12, p < .001).[20,21]

According to the model, financial income was defined as an environmental factor. Studies have found that T2DM patients were often unemployed. Most of them had no active income or had low income, which could affect their blood glucose control. Patients with low income were not able to control their blood glucose level, and so they were at higher risk of developing complications than those with high income.[22] Another study found that high monthly household incomes were statistically significant related to the occurrence of no DR (p < .001).[23]

The risk factors evaluated in this study have all been shown to be associated with development of DR in previous studies in other populations. By researching data from national health region 13, it was found that there was no data of diabetic retinopathy in diabetes type 2 patients. These factors also demonstrate statistically significant association with development of DR the findings from this study will inform us of the current situation of diabetic retinopathy within a specific diabetes type 2 patients in public health centers within Bangkok Metropolitan area.

DR is an important public health problem to which nurse practitioners should pay attention in order to explore its incidence and prevalence rate and investigate factors relative to the occurrence of DR. Until recently, little has been known about incidence and prevalence rate of T2DM and its complications from patients receiving services and care from public health centers, Bangkok Metropolitan Administration (BMA). Therefore, the

researchers would like to carry out an incidence and prevalence survey and a study on predicting factors for DR among T2DM patients. The findings from this study will inform the situation of DR, distribution of DR, and its causal factors. This information could then be used to develop campaigns/interventions to help patients control their blood glucose level, and prevent/delay the occurrence of DR among T2DM patients in public health centers, BMA. The findings would also help health care provider develop health services appropriate to the context of T2DM patients in order to prevent/delay DR thoroughly and efficiently. This would reduce visual impairment, leading to a better quality of life.

METHODS

Study design

A Retrospective study design was conducted to explore the incidence and prevalence rate of DR, and to examine the predictive factors for the occurrence of DR among T2DM patients receiving health services and care at diabetic clinics in public health centers, Bangkok Metropolitan Administration (BMA).

Sample size

The study population were 21,679 T2DM patients both male and female, aged 18 and above receiving services and care at diabetic clinics, in public health centers, BMA. Sample population were T2DM patients both male and female, aged 18 and above from the population. Simple random sampling without replacement was used to select samples from the population. Inclusion criteria were participants with complete consciousness. They were able to listen to, read, and write Thai language. Exclusion criteria were T2DM with diabetic foot and diabetic nephropathy.

Participants aged above 60 years had Thai Mental State Examination (TMSE) score less than 23.[24]

According to the survey research, 5% was selected for calculation of a sample size when the study population is more than 10,000.[25,26] Therefore, the sample size calculation for exploring incidence and prevalence rate of DR would be 1,084. Sample size calculation for predicting factors for the occurrence of DR was calculated using the formula from a simulation study of the number of events per variable in logistic regression analysis.[27] The sample size calculation was 153.

Assessing instruments

1. Data record form was used to collect data from the medical records. It comprised 9 questions.

2. Thai Mental State Examination (TMSE) sheets were used to screen participants' mental status. The scores must be over 23 points to fulfil the inclusion criteria.[24]

3. A set of questionnaires was used to assess factors to predict DR. The questionnaires comprised 3 parts:

Part 1 was demographic data; it comprised 9 questions.

Part 2 was health behaviour instrument. Researchers created this instrument based on literature reviews. The instrument consisted of 22 questions with 4-level rating scales. There were 7 questions about food behaviour, 3 questions about exercise behaviour, 3 questions about stress and coping behaviour, 4 questions about taking medication, 3 questions about health/disease follow-up behaviour, 1 question about smoking and 1 question about alcohol drinking. Range of scores were 22-88. Higher scores meant better health behaviour.

Part 3 was health literacy instruments. Researchers adopted existing

instruments and created new instruments based on literature reviews. Details of the instruments were described as follows:

3.1) The Rapid Estimate of Adults Literacy in Medicine (REALM) scale[28] in Thai version: It was an existing instrument used to assess the reading and language understanding skill. Kuder-Richardson reliability of REALM was 0.95.[29] Participants were asked to read 66 words within 2 minutes. Scores would be given according to the number of words the patients could read. Range of scores were 0-66. Scores 0-44 meant low reading and language understanding skill. Scores 45-60 meant medium reading and language understanding skill. Scores 61-66 meant high reading and language understanding skill.

3.2) A cognitive and decision making skills instrument: It was a new developed instrument. There were 20 multiple-choices with 4 answers questions. Participants were asked to choose the single best answer. Correct answer scored 1 point. Incorrect answer scored 0 point. Range of scores were 0-20. Higher scores meant better cognitive and decision making skills.

3.3) A health-related information skill, communication skill, self-management skill, and media literacy skill instrument: Researchers developed this instrument. This instrument was composed of 14 questions with 4-level rating scales assessing health-related information, communication, self-management, and media literacy skills. Range of scores were 14-64. Higher scores meant better health literacy.

Quality of assessment instruments

1. Content validity evaluation was carried out by 3 experts. The health behaviour questionnaires had a content validity index (CVI) of 0.80.[30] Health literacy questionnaires had a CVI of 0.96.

2. To calculate the reliability of the questionnaires, the researchers carried out a pilot study for reliability testing. The study samples were 30 DR patients with similar characteristics to the study sample. Cronbach's alpha coefficient was used to test the reliability of behaviour and patients' skills in terms of health-related information, access to health care, communication skill, self-management skill, and media literacy skill. The Cronbach's alpha coefficient was 0.75 behaviour and 0.89 skills[30,31], respectively. Kuder-Richardson 20 (KR20) was used to test the reliability of patients' cognitive and decision-making skills. The reliability of the questionnaires was 0.71.

Data collection

After receiving the approval letter from the Institutional Review Board, Faculty of Nursing, Mahidol University, Bangkok, Thailand (IRB-NS 2019/08.0701RS1), researchers informed the public health centers' directors, related health care providers, and participants about the scope of the study, data collection, and pinning the information leaflet in order to recruit participants for the study. Data were collected from the medical records which were stored in an excel database for incidence and prevalence study. Self-reported questionnaires were collected for a predictive study. Data for exploring incidence and prevalence rate of DR were collected from January 1st – December 31st, 2018. Data for studying the predictive factors for DR were collected from self-reported questionnaires during April – June 2019.

Data analysis

Incidence and prevalence formula were used to calculate incidence and prevalence rate of DR. A computer program, SPSS version 19, was used to analyse data. Descriptive statistics were used to analyse general characteristics. Logistic regression analysis was used to analyse the predicting factors for the occurrence of DR.

ETHICS APPROVAL

This study was approved by the Institutional Review Board Human Research Protection Unit, Faculty of Nursing, Mahidol University (IRB-NS 2019/08.0701RS1). Written informed consents were obtained from participants who decided to join the study. Participants' names and health identification numbers were deleted from the data-based files to protect the participants' privacy and confidentiality. Refusing to participate in the study would not have any effects on participants and services receiving from the public health centers.

RESULT

The results showed that 1,084 study samples were included for exploring the incidence and prevalence rate of diabetic complications. Of all the participants, 990 of them had diabetic complications (91.33%). Within the having complication group, 394 of them had diabetic nephropathy (39.80%), 327 cases had diabetic foot (33.03%), 145 cases had DR (14.65%), and 124 cases had more than one complication (12.52%). Majority of the participants were 762 female participants (70.30%). The mean age was 64.82 years (SD = 9.95, Range 33-93). Almost all of them (988 cases, 91.1%) used universal health care coverage to cover their health services expenditure. A total of 974

participants had already done a retinal examination (89.90%). The incidence rate of DR was 3 per 1,000 population, and the prevalence rate of DR was 134 per 1,000 population. Among the DR participants, 112 participants had mild non-proliferative DR (NPDR), which accounted for 77.24%, Eighteen participants had moderate NPDR, which accounted for 12.41%; 10 participants had severe NPDR, which accounted for 6.90%; and 5 participants had proliferative DR (PDR), which accounted for 3.45%.

One hundred fifty-three participants were recruited to participate in the predicting factors for the occurrence of DR. General characteristics information of the participants are described as follows: the mean age was 62.81 years (SD = 10.49, Range 30-86). The majority of participants were female (105 cases, 68.63%). Most participants had their primary education completion (101 cases, 66.01%). A number of them were unemployed (81 cases, 52.94%). The average financial income was 6,384.90 Baht (SD = 7,530.3, Range 500-50,000). The average duration of having diabetes was 8.33 years (SD = 4.87, Range 1-28). The average of FBS was 155.64 (SD = 44.47, Range 88-444). The average of HbA1c was 8.11 (SD = 1.46, Range 5.70-12.90). One hundred thirty-six participants (88.90%) received oral diabetes medication. The leading co-morbidity were hypertension and dyslipidemia (76 cases, 49.68%). Information regarding DR showed that 66 participants (43.10%) already had blurred vision. Fifty-nine participants (38.60%) informed that the blurred vision took place right after rest. Thirty-eight participants (24.80%) had floaters. The mean health behaviour score was 54.42 (SD = 5.41, Range 42-72). The mean health literacy score was 101.84 (SD = 14.80, Range 64-135).

The findings from logistic regression analysis revealed that HbA1c, FBS, duration of having diabetes, health

behaviour, health literacy, genetics, and income altogether were able to predict the occurrence of DR by 47% significantly (R^2 = .47, p < .05). Participants whose HbA1c increased by 1% would increase the risk to develop DR by two times (OR = 1.51, 95%CI = 1.04, 2.21, p < .05). Those whose FBS increased by 1 mg/dl would increase the risk to develop DR by 1.01 times (OR =

1.01, 95%CI = 1.00, 1.02, p < .05). Those whose duration of having diabetes increased by 1 year would elevate the risk to develop DR by 1.30 times (OR = 1.30, 95%CI = 1.16, 1.47, p < .05). Those whose health literacy increased by 1 point would decrease the risk to develop DR by 0.95 times (OR = 0.95, 95%CI = 0.92, 0.98, p < .05) as shown in Table 1.

Table 1 The results from logistic regression analysis of between independent variables - HbA1c, FBS level, duration of diabetes mellitus, health behaviour, health literacy, genetics and financial income and the occurrence of DR in T2DM patients (n = 153)

Variables	B	SE	Ward	df	p	OR	95%Cl	
							LL	UL
Constant	-4.86	2.96	2.69	1	.101	0.00		
HbA1c	0.41	0.19	4.73	1	.030*	1.51	1.04	2.21
Fasting blood sugar	0.01	0.00	4.73	1	.047*	1.01	1.00	1.02
Duration of having diabetes	0.26	0.05	20.67	1	.000***	1.30	1.16	1.47
Health behaviour	0.01	0.03	0.17	1	.680	1.01	0.941	1.09
Health literacy	-0.04	0.01	7.47	1	.006**	0.95	0.92	0.98
Genetics None[Ref]								
Available	0.50	0.45	1.25	1	.262	1.66	0.68	4.02
Financial income	0.00	0.00	0.62	1	.428	1.00	1.00	1.00

*p <.05, **p<.01, ***p<.001, -2 Log likelihood 144.26, Cox & Snell R^2 0.35, Nagelkerke R^2 0.47, Hosmer and Lemeshow Test p = 0.182, Predictive correct=76.50%

DISCUSSION

The findings from this study revealed that the incidence rate of DR was 3 per 1,000 population. This incidence rate was lower than one study which investigated the causes of global vision loss and found that the incidence rate of DR was 200 per 1,000 population.[32] From a recent survey study in government hospitals, Thailand found that the incidence rate of DR among T2DM patients was 24 per 1,000 population.[33] The incidence rate of DR found in this study was lower than that of the government hospitals. Empirical

evidence showed that DR made up 5.17% of blindness.[6] It is considered a severe complication that affects both physical, mental, and socioeconomic status of patients and their families. Therefore, DR screening in T2DM is important to delay the progress of the complications and reduce their severity because early detection brings early treatment and helps reduce the likelihood of blindness in the long run.

The prevalence rate of DR in this study was 134 per 1,000 population or 13.4%. This finding was consistency with

many studies conducted in primary care service delivery that revealed that the prevalence rate of DR was between 13-14%.[34-37] The prevalence rate of DR in this study was also lower than the study reported by the Ministry of Public Health, which stated that the prevalence rate of DR in Thailand was 33.31%.[7] The prevalence of DR in this study was different from that of the Ministry of Public Health because this study collected data from primary care service centers. There were no ophthalmologists in many primary care service centers; therefore, screening of DR could be underestimated. Nurse practitioners in the primary care service delivery would be able to help fill the gap of delayed detection of DR by performing and interpreting eye exams for T2DM patients. When they find abnormal findings, they would refer patients for further treatment at hospitals in which appropriate care could be provided by ophthalmologists in order to treat, monitor, and slow the progression of the disease. Results from the incidence and prevalence rate of DR in this study revealed a trend of DR patients receiving service and care in public health centers, BMA. Although the incidence rate of DR was low, the prevalence rate of DR was moderate. As a result, a policy should be prepared to support DR screening by nurse practitioners in the primary care service delivery system. It is important to strengthen the abilities and skills of DR screening to reduce the severity of DR, which was a cause of patients' blindness. Moreover, medical devices and budgets should be allocated to apply DR screening in order to undergo effective assessments and treatments for T2DM patients to improve the quality of life in the long run as well.[37]

Logistic regression analysis showed that HbA1c, FBS, duration of having diabetes, health behaviour, health literacy, genetics, and financial income altogether could significantly predict the occurrence of DR among T2DM patients by 47% (R^2 = .47, p < .05). HbA1c, FBS, and duration of having diabetes factors were proven to be the risk factors for the occurrence of DR, whereas health literacy was proven to be a protective factor for DR reduction. It is important to bring these messages to create interventions to improve health literacy among T2DM patients. However, helping patients to be able to control their HbA1c and FBS level is also important because it was one cause of DR, especially for those who have had diabetes for a long time. Interventions should match the context of patients living in a big city in which life is more stressful. Duration of having diabetes should brought to attention since it was one factor that could predict the occurrence of DR.[11,14,39] The longer duration of having diabetes, the higher rate of atherosclerosis happening in small arteries and capillaries. This leads to retinal ischaemia, haemorrhage, and aneurysm. Therefore, it is important that patients should receive DR screening in the early stage, which helps prevent blindness in the long run. Health behaviours, genetics, and financial income did not have a significant effect to predict the occurrence of DR in this study. This was different from other studies. For example, some studies demonstrated that appropriate health behaviours help patients control FBS.[40-41] Some studies showed that genetics had a significant effect on increasing the risk of DR.[20-21] Lastly, financial income could not predict the occurrence of DR in this study as well. It could be explained that this study took place in Bangkok, which has an urban environment. Most T2DM patients in this study had similar lifestyles. Their eating and exercise habits were similar. The majority of the participants had universal health coverage, and so they had access to health care services. Therefore, they did not have financial problems regarding health care costs. Despite differences in income within the sample group, the members of

the sample group all exhibited similar lifestyles and so their level of blood glucose control did not differ.

CONCLUSION

The incidence and prevalence rate of DR in this study provided an important message that helped researchers learn the trend of DR among T2DM patients receiving services and care in public health centers, BMA. Therefore, policies should be prepared to foster enough health care providers, budget, and materials that would enable the comprehensive, fast, and effective assessment of DR in T2DM patients. HbA1c, FBS, duration of having diabetes, health behaviour, health literacy, genetics, and income were significantly able to predict the occurrence of DR among T2DM patients by 47% ($R^2 = .47$, $p < .05$). HbA1c, FBS, duration of having diabetes, and health literacy were independent factors with statistically significant effects on the occurrence of DR among T2DM patients in public health centers, BMA ($p < .05$). The findings from the study agreed with the epidemiologic triad model. This model stated that the occurrence of disease is a result of an interaction among the model's components, which are host, agent, and environmental factors. This study demonstrated that a disequilibrium of host factors including HbA1c, FBS, duration of having diabetes, and health literacy were the cause of DR. It could be concluded that the incidence and prevalence rates of DR were the important information from which it can be inferred that the complications occurred among uncontrolled T2DM patients. Success in controlling blood glucose could decrease the risk for DR, while enhancing health literacy could prevent the occurrence of DR. Nurse practitioners should take the findings from this study to develop an effective and appropriate DR screening, especially those

working at the settings without ophthalmologists. It was also necessary to create effective health promotion programs to foster healthy behaviour such as proper diet intake, exercise, and stress reduction to help T2DM patients to control their blood sugar. Health literacy should be included in the promotion program as well because it was proven to help patients makeup their healthy behaviour to prevent or delay the occurrence of DR among T2DM patients.

RECOMMENDATIONS

1. Nurses practitioners at the diabetic clinics should provide health promotion programs
for their T2DM patients in order to enhance healthy behaviour and be able to control their blood sugar, especially those who had diabetes for a long time.

2. Enhancing T2DM patients' health literacy was also important since it was a protective factor that helped patients select appropriate actions to prevent the occurrence of DR.

3. The results from this study could be used to guide all stakeholders in planning a preventive strategies/interventions against the occurrence of diabetic retinopathy. Helping T2DM patients to control their blood sugar is still the most important factor to prevent or delay the developing diabetic retinopathy.

STUDY LIMITATIONS

Majority of the study participants were older patients. This pose a limitation for generalizing study information to other populations.

ACKNOWLEDGMENTS

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