

# Prevention of complications and several other relevant risk factors of Type 2 Diabetes (T2D) at a hospital in Vietnam

N. V. Chinh<sup>1</sup>, P. H. T. Kiet<sup>2</sup>, P. B. Diep<sup>3</sup>, N. T. B. Yen<sup>4</sup>, Dong Wang<sup>5</sup>, L. D. P. Cuong<sup>6</sup>, P. D. Trung<sup>7</sup>, L. M. N. Uyen<sup>8</sup>, N. H. Tu<sup>9</sup>

<sup>1</sup>*Dr.LABO Medical Test Center, Hanoi Medical Laboratory Diagnostic Joint Stock Company, Hanoi, Vietnam.*

<sup>2,4</sup>*Department of Health Economics, Hanoi Medical University, Hanoi, Vietnam*

<sup>3</sup>*Department of Health Education, Hanoi Medical University, Hanoi, Vietnam*

<sup>5,6</sup>*College of Computer Science and Electronic Engineering, Hunan University, Changsha 410082, China*

<sup>6,7,8</sup>*Yersin University, Vietnam*

<sup>8</sup>*College of Life Science, Hunan Normal University, Changsha 410082, China*

<sup>9</sup>*Hanoi University of Industry, Hanoi, Vietnam*

*Email: cuongldp@yersin.edu.vn*

***ABSTRACT: Diabetes has a significant incidence of illness, health care effects and lead to a high mortality rate due to its complications in both developed and developing countries so far. Diabetes can be divided into three main types: Type 1 diabetes, Type 2 diabetes and Gestational diabetes, the most common type is Type 2 diabetes (T2D). Our work focuses on researching the relationship of complications and their cost of treatment in order to make the treatment plan and minimize its costs in at the Thanh Nhan hospital in Hanoi, Vietnam. Therefore, the research results show that there are many different types and rates of complications of T2D depending on key factors such as: age and duration of the disease, by determining the complication rate and analyzing multivariate logistic regression models to find the risk factors associated with an increase in the number of complications of the disease from the Social Science Package Statistics (SPSS) software and other.***

***Keywords: Type 2 Diabetes (T2D), complications, risk factor, public health, Thanh Nhan hospital.***

## 1. INTRODUCTIONS

Diabetes Mellitus (DM) has become popular public health issues in developing and developed countries around the world [1]. The International Diabetes Federation (IDF) estimated that roughly 425 million people have suffered from diabetes in 2017 and this statistics is predicted to increase significantly to 629 million across globe in 2045 [2-3]. In Vietnam, the estimated number of diabetes mellitus was 2.5 million in 2010 and continued growing to 3.5 million in 2017 [4-5]. There are many complications which were caused by

diabetes mellitus such as retinopathy, neuropathy, nephropathy, cardiovascular, cerebrovascular disease and kidney failure, which lead to decline in their quality of life, disability and even death [6-12]. Complications are one of reasons to rises treatment cost which accounts for about 25% of total hospital costs of diabetes care, 70% of total direct costs and diabetes' expenditure in complications are higher than patients without complications [5-13-18]. Diabetic patients in three or more complications spending US\$ 1351.5 annually were about 2.5 times higher than people without any complications (US\$ 532.2) [1-19]. According to a study of [10] in urban China, the prevalence of cardiovascular and cerebrovascular conditions, neuropathy, nephropathy, ocular lesions and foot disease were 30.1%, 6.8%, 17.8%, 10.7%, 14.8% and 0.8%, respectively; the rate of chronic complications increases with age and duration of diabetes and vary depending on region. In Vietnam, indentifying risk factors and prevent irreverible complications of T2DM are really necessary, but this issue is not pupular. Therefore, this study analysed the prevalence of complications and some factors relating to type 2 diabetes mellitus at Thanh Nhan hospital in Hanoi, Vietnam.

## 2. METHODS

A cross-sectional analytical descriptive study carried out at Thanh Nhan hospital throughout a two-month period from December 2017 to January 2018.

Diabetes patients who have been diagnosed in T2DM and have been curing outpatient at Examination Department, Thanh Nhan hospital in Hanoi, Vietnam were invited to take part in this study. Total 440 cases in T2DM were conducted at this time.

Social-demographic characteristics of T2DM patients such as age, sex, area of residence, level of education, occupation, economic status of households, support of health insurance and clinical characteristics as duration in diabetes were reported through interviewing face-to-face by a questionnaire information at an individual room between researchers and diabetes or their close people at Examination Department.

Clinical features of T2D are specified such as duration of diabetes, number of complications, name and type of complication extracted from Thanh Nhan hospital database in Vietnam. Specially, complications were coded by ICD-10 2<sup>nd</sup> version such as dyslipidemia (E78), hypertension (I10), coronary artery disease (I20) and angina (I25) which were installed in the databate of Thanh Nhan hospital in Vietnam [5-20]. The total of 482 people with T2DM was invited to participate in this study during the period from December, 2017 to January, 2018.

After we processed the collected data through the survey, we eliminated 42 cases that were not true for diabetes. Therefore, total 440 rows of diabetes dataset has extracted in Microsoft Office Excel 2013 with "data.CSV" format to support for this study.

By doing many repetitive steps, specifically, data input, cleaning, preprocessing, coding were done by Microsof Office Excel 2013. Identifying prevalence of complications and analysing multivariate logistic regression model to find risk factors related to increase the number of complications of T2DM were conducted by the Statistical Package for Social Sciences (SPSS) software version 25.0. Chi square ( $\chi^2$ ) statistic (1) is a test function that

measures how a model compares to actual observed data. Therefore, it compares the size any discrepancies between the expected results and the actual results, given the size of the sample and the number of variables such as sex, age group, area of residence, level of education in the relationship [40].

$$\chi^2 = \sum \frac{(O - E)^2}{E} \quad (1)$$

With

E is expected value

O is observed value

The p-value is less than 0.05 (< 0.05) which we used as a level of significance. The Odds ratio (OR) with their 95% confidence interval (CI) were used to look for the risk factors of T2D complications. In using adjusted OR value in multivariate logistic regression analysis' model check for any potential confounders [21].

### 3. RESULTS

The total 440 studied T2DM, with 279 (63.4%) patients were female and primary group age was above 60 years (83.9%); with 429 (97.5%) diabetes lived at Hanoi is the capital city of Vietnam; the highest number of people who complete high school is 198 (45%); 313 (71.1%) diabetes in retired status; only with 1.1% T2DM in poverty to near poverty; the average income per month of diabetes was 2.744±1.878VND; 58 (13.2%) diabetes did not have any an resource of income; 100% patients were supported by health insurance agency shows in Table 1.

Table 1: Social-demographic characteristics of T2DM patients

Variable name	n (%)	Mean ±Standard deviation (Min and Max)
<b>Age group (Years)</b>		
≤60	71 (16.1%)	68.4 ± 9.2 (19 and 93)
61-70	162 (36.8%)	
71-80	161(36.6%)	
>80	46 (10.5%)	
<b>Sex</b>		
Female	279 (63.4%)	
Male	161 (36.6%)	
<b>Area of residence</b>		
Urban area	429 (97.5%)	

<b>Variable name</b>	<b>n (%)</b>	<b>Mean ±Standard deviation (Min and Max)</b>
Rural area	11 (2.5%)	
<b>Level of education</b>		
Illiterate	6 (1.4%)	
Completed primary school	45 (10.2%)	
Completed secondary school	138 (31.4%)	
Completed high school	198 (45.0%)	
Intermediate or above	53 (12.0%)	
<b>Occupation</b>		
Farmer	42 (9.5%)	
Worker	5 (1.1%)	
Retired people	313 (71.1%)	
Others	80 (18.2%)	
<b>Household economic status</b>		
Poor to near poor	5 (1.1%)	
Normal or above	435 (98.9%)	
<b>Monthly private income (million VND)</b>		2.744±1.878
Do not have not any resource of income	58 (13.2%)	(0 and 19.5)
<b>Support of health insurance</b>		
0%	0 (0%)	
80%	94 (21.4%)	
95%	98 (22.3%)	
100%	248 (56.4%)	
<b>Duration of diabetes (years)</b>		
1 year	59 (13.4%)	8.1±6.9 (1 and 41)
2-5 years	151 (34.3%)	
6-10 years	109 (24.8%)	
>10 years	121 (27.5%)	
<b>Complications</b>		
Absent	33 (7.5%)	

<b>Variable name</b>	<b>n (%)</b>	<b>Mean ±Standard deviation (Min and Max)</b>
Present	407 (92.5%)	
<b>Number of complications</b>		
None	33 (7.5%)	1.5±0.8 (0 and 4)
One	213 (48.4%)	
Two	140 (31.8%)	
Three	52 (11.8%)	
Four	2 (0.5%)	
<b>Heart diseases</b>		
Hypertension	187 (42.5%)	
Coronary artery disease	42 (9.5%)	
Angina	9 (2.0%)	
Chronic heart failure	3 (0.7%)	
<b>Neuropathy</b>		
Cerebrovascular disease	24 (5.5%)	
Peripheral Neuropathy	14 (3.2%)	
<b>Eye diseases</b>		
Retionpathy	5 (1.1%)	
Cataract	5 (1.1%)	
<b>Metabolic disorders</b>		
Dyslipidemia	369 (83.9%)	
Disorders of protein metabolism	12 (2.7%)	

Table 1 described clinical characteristics of T2DM patients of T2DM. The average duration of diabetes was 8.1±6.9 years (Min: 1 year and Max: 41 years).

The rate of T2DM in complications was large and accounted significantly for 94.1%, the average number of complications was 1.5±0.8 complications per patient and 33 (7.5%) diabetes had no any complications. There was a lot of types of complications and different rate of T2DM such as hypertension, cerebrovascular disease, coronary artery disease, peripheral neuropathy, angina, retinopathy and cataract which accounted for 42.5%, 9.5%, 5.5%, 3.2%, 2.0%, 1.1%, 1.1% and 0.7%, respectively. Specially, with 83.9% and 2.7% complications belonged to dyslipidemia and disorders of protein metabolism.

Table 2: Clinical characteristics of T2DM patients

Complications of T2DM	Coronary artery disease			
	Present n (%)	Absent n (%)	OR (95% CI)	P-value
<b>Dyslipidemia</b>				
Present	35 (8.0%)	334 (75.9%)	0.96 (0.41-2.35)	0.922
Absent	7 (1.6%)	64 (14.5%)	Ref.	
<b>Hypertension</b>				
Present	41 (9.3%)	146 (33.2%)	70.77 (9.63-519.86)	<b>0.000</b>
Absent	1 (0.2%)	252 (57.3%)	Ref.	
<b>Hypertension and Dyslipidemia</b>				
Present	35 (8.0%)	119 (27.0%)	11.72 (5.06-27.14)	<b>0.000</b>
Absent	7 (1.6%)	279 (63.4%)	Ref.	
With: <b>Ref</b> - Reference group <b>P-value</b> < 0.05 is considered <b>OR</b> - Odds ratio adjuste				

Table 2 and Figure 1, there was not relationship between dyslipidemia complication and coronary artery disease complication of T2DM (OR: 0.96, 95% CI: 0.41 - 2.35, p=0.922). However, the high blood pressure complications of diabetes affect the increase in coronary artery disease complications (OR: 70.77, 95% CI: 9.63 -519.86, p=0.000). At the same time, complications of hypertension and dyslipidemia in diabetes increase complications of coronary artery disease of T2DM (OR: 11.72, 95% CI: 5.06 - 27.14, p=0.000).

Table 3: Patient's characteristics and Complications and associated diseases of diabetes

Variables	Number of complications						Hypertension	Dyslipidemia	Hypertension and Dyslipidemia	Coronary artery disease
	≥1		≥2		≥3					
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value				
<b>Age group</b>										

<b>(years)</b>														
>80	0.4 (0.1-1.5)	0.17 5	2.4 (1.1-5.5)	<b>0.03</b>	1.8 (0.4-8.4)	0.43 7	2.4 (1.1-5.3)	<b>0.03</b>	0.6 (0.2-1.7)	0.38 0	3.0 (1.2-7.0)	<b>0.01</b>	2.0 (0.1-29.2)	0.61 1
71-80	1.2 (0.4-3.3)	0.77 2	2.2 (1.2-4.1)	<b>0.01</b>	3.4 (1.0-11.9)	0.05 8	2.1 (1.1-3.8)	<b>0.02</b>	1.1 (0.5-2.3)	0.80 9	2.5 (1.2-4.9)	<b>0.01</b>	15.2 (1.6-145.3)	<b>0.01</b>
61-70	1.4 (0.5-4.0)	0.55 6	2.0 (1.0-3.7)	<b>0.03</b>	3.8 (1.1-13.3)	<b>0.03</b>	1.6 (0.8-2.9)	0.15 5	1.8 (0.8-4.0)	0.12 4	2.2 (1.1-4.5)	<b>0.02</b>	13.0 (1.4-125.8)	<b>0.02</b>
≤60	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<b>Sex</b>														
Female	0.9 (0.4-2.1)	0.85 0	1.1 (0.7-1.6)	0.69 3	2.3 (1.2-4.6)	<b>0.01</b>	1.0 (0.7-1.6)	0.88 1	1.0 (0.6-1.7)	0.96 2	1.1 (0.7-1.7)	0.67 5	2.5 (1.1-5.5)	<b>0.02</b>
Male	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<b>Household economic status</b>														
Poor up to near poor	0.5 (0.0-9.3)	0.60 7	2.7 (0.3-20.4)	0.34 8	3.1 (0.3-30.7)	0.34 0	3.7 (0.5-29.7)	0.22 1	0.6 (0.0-8.3)	0.71 2	4.4 (0.5-36.4)	0.16 7	59.7 (2.2-1,623.0)	<b>0.01</b>
Normal or above	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
<b>Duration of diabetes (years)</b>														
>10	12.1 (3.6-40.9)	<b>0.00</b>	2.4 (1.2-4.8)	<b>0.01</b>	2.5 (0.8-7.4)	0.09 8	2.1 (1.0-4.2)	<b>0.03</b>	6.2 (2.6-15.0)	<b>0.00</b>	3.0 (1.4-6.4)	<b>0.00</b>	1.4 (0.5-3.9)	0.54 7
6-10	11.3 (3.0-42.3)	<b>0.00</b>	2.8 (1.4-5.6)	<b>0.00</b>	1.4 (0.4-4.3)	0.58 6	2.4 (1.2-4.9)	<b>0.01</b>	2.8 (1.3-6.2)	<b>0.01</b>	2.5 (1.1-5.5)	<b>0.02</b>	0.7 (0.2-2.1)	0.48 4
2-5	4.3 (1.8-10.3)	<b>0.00</b>	1.7 (0.8-3.3)	0.14 2	1.0 (0.3-3.1)	0.98 9	1.8 (0.9-3.4)	0.10 3	2.5 (1.2-5.0)	<b>0.01</b>	2.0 (0.9-4.3)	0.07 4	0.4 (0.1-1.3)	0.14 5

≤1	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
----	------	--	------	--	------	--	------	--	------	--	------	--

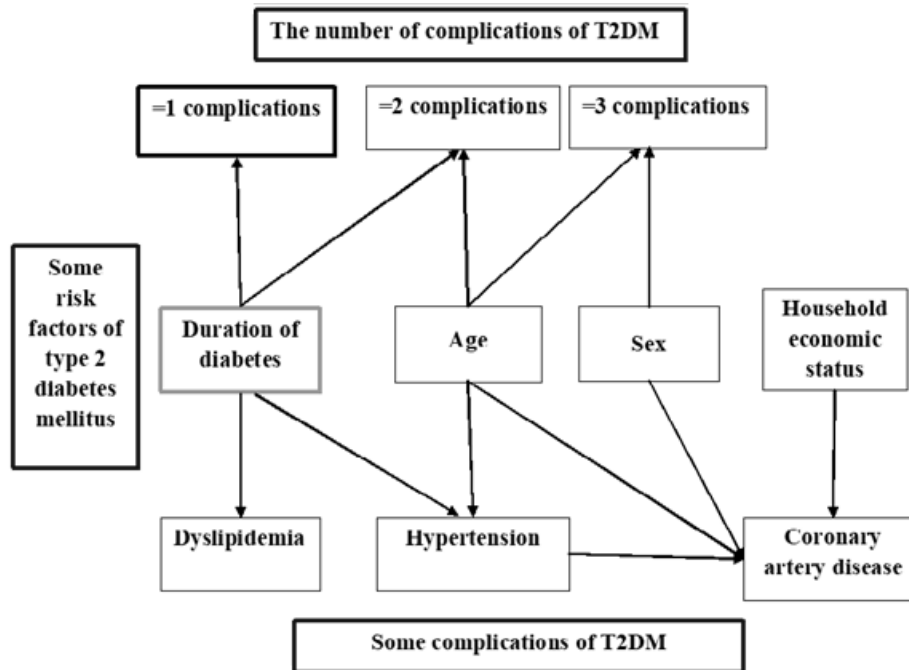


Figure 1: Relationship between some risk factors and complication of T2DM

In Table 3 and Figure 1 illustrated that the first complication were caused the duration of diabetes ( $p < 0.01$ ). Age and the duration of diabetes were causes of leading to second complication ( $p < 0.05$ ). The age group 61-70 and female gender generated the third complication or plus (OR: 3.8, 95% CI: 1.1 - 13.3,  $p = 0.039$ ; and OR: 2.3, 95% CI: 1.2 - 4.6,  $p = 0.018$ ; respectively). The patients is over 80 years and the age range 71-80 are associated with hypertension complication (OR: 2.4, 95% CI: 1.1 - 5.3,  $p = 0.034$ ; and OR: 2.1, 95% CI: 1.1 - 3.8,  $p = 0.022$ ; respectively). After 10 years and from 6 to 10 years suffering diabetes, patients with complications of hypertension (OR: 2.1, 95% CI: 1.0 - 4.2,  $p = 0.036$ ; and OR: 2.4, 95% CI: 1.2 - 4.9,  $p = 0.013$ ; respectively). Complications of dyslipidemia have been created during diabetes ( $p < 0.05$ ). Age and duration of diabetes are risk factors for both hypertension and complications of dyslipidemia ( $p < 0.05$ ). Complications of coronary artery disease occur in the age group 61-70 and 71-80, female sex and patients with economic circumstances from poor to near poor ( $p < 0.05$ ).

#### 4. DISCUSSION

The rate of diabetes in complications was 92.5% compared with 7.5% in Table 1, which was 12.3 times higher than patients had no complications (92.5%) in Table 1. According to International Diabetes Federation, the result reported similarly that there was 95% of cases of T2DM (11-12 million T2DM patients) suffered from at least one diabetic co-morbidity across mainland China and about 6 million simultaneously suffer from more than one co-morbidity [8-10]. The prevalence of diabetic complications in this study was higher than some presented studies [5-10]. In addition, the increase number of complications decreased in quality of life, rised treatment costs and went up burden on patients and pressured on the state health care



system and health insurance fund [5-18]. So, this really makes sense when it comes to finding the cause of the increased diabetes complications.

The rate of diabetes having from one, two, three, four and five accounted for 48.4%, 31.8%, 11.8% and 0.5%, respectively. The number and prevalence of complications in this study were higher in study of Zhaolan, L. et al. (2010) which diabetes had single-category complications while the percentage of complications such as 2, 3 and 4 plus were 15.4%, 4.9% and 1.3%, respectively [10].

The proportion of complications of T2DM such as hypertension, cerebrovascular disease, coronary artery disease, peripheral neuropathy, angina, retinopathy and cataract accounted for 42.5%, 9.5%, 5.5%, 3.2%, 2.0%, 1.1%, 1.1% and 0.7% in Table 1, respectively. This rate has a significant difference with the prevalence of cardiovascular and cerebrovascular complications, neuropathy and nephropathy, ocular lesions and diabetes foot disease were 30.1%, 6.8%, 17.8%, 10.7%, 14.8% and 0.8%, respectively; besides, there were angina (14.2%), cataract (9.8%) and retinopathy (6.1%) which studied in China [10].

Specially, percent of complications of dyslipidemia and protein metabolism disorders in Table 1 with 83.6% and 2.7%, respectively. According to Huy Tuan Kiet Pham et al (2017) performed in Vietnam in 2017 that 2% only diabetes had metabolic disorders included protein and lipoprotein [5]. Lipoprotein was a new risk factor in T2DM [28]. Therefore, two complications such as dyslipidemia and disorders of protein metabolism which mentioned in this study need to take care more in the future.

In Table 3 and Figure 1, we show that the age, sex and duration of diabetes as risk factors leading to an increase of 1 to 3 in the number of complications of T2D. Many studies have found similar results that age groups over 60 are independent factors that increase the incidence of complications in T2D [10-25-28]. The results are consistent with many other studies that the duration of diabetes is one of the reasons for the increased number of diabetes complications [10-12-18-21-27]. Neuropathy complications of diabetes sensation occur with diabetes duration of 5 years or until 10 years [29-30]. The duration of diabetes is one of the main reasons for appearing of the first complication of diabetes, the second complication was created by the duration of diabetes and age, third complication was generated by female genders and age, but female genders are distinct results from other presented studies [10-12-18-21-25-30].

Dyslipidemia complication is related to duration of diabetes in Table 3 and Figure 1. This is supported by a study by Shabana, S. and Sasisekhar, T. V. D. (2020) that complains about dyslipidemia in T2D is significantly increased with an increase in the duration of diabetes in both male and female gender [31].

Complications of high blood pressure in diabetes and duration of diabetes, age is closely related to the promotion of hypertension in diabetes. According to Iraj Heydari et al (2020), the rate of hypertension in diabetes tends to increase significantly with age [32-33].

The coronary artery disease complications of diabetes have an association between age, sex, household economic status and hypertension. The difference in our study is that household economic status increases the incidence of coronary artery disease. This may explain that poor and near-poor economic conditions will lack living conditions, limited

health care conditions lead to the risk of stress and coronary artery disease. Stress is also one of the reasons for coronary artery disease [34]. There are many risk factors for coronary artery disease: age, sex, family history and hypertension, stress [34-35-36]. Age and gender are not controlled, while high blood pressure is one of the risk factors for developing coronary and controllable disease [34-37]. In Table 2, diabetes with both hypertension and dyslipidemia are associated with the occurrence of coronary artery disease (OR: 11.72, 95% CI: 5.06 - 27.14,  $p=0.000$ ), there was no association between dyslipidemia and coronary artery disease ( $p>0.05$ ), however, hypertension is significantly associated with coronary artery disease (OR: 70.77, 95% CI: 9.63 - 519.86,  $p=0.000$ ). Therefore, dyslipidemia was random and had no affected to the occurrence of coronary artery disease. Controlled overweight and obesity in the community plays an important role in the prevention of cardiovascular diseases such as hypertension and coronary artery disease [34-41-42].

## 5. CONCLUSIONS

The result of study showed a lot of types of complications of T2DM and the prevalence is variation. Age, duration in diabetes and female gender were significant risk factors to relate to increase the number of diabetic complications. There are lots of reasons for occurring of diabetes such as dyslipidemia, hypertension, coronary, artery disease were age, gender, duration in diabetes, hypertension and economic status of T2DM. Today, the proportion of the population over 60 years old is increasing in the community, many people living in urban areas, inactive lifestyles and obesity rates are increasing [41-42]. People might be trained to change their habits such as weight control, raised physical exercise, restricting smoking, which are positive benefits to decrease appearing diabetes in public health. Furthermore, it needs to raise people's awareness in community about diabetes and its complications, regularly examine and early detect risk factors which lead to suffer from diabetes and its complications. Besides, we will apply some new methods such as an R programming language for Statistical Computing to develop statistical software and data analysis in Data Science and available AutoML Cloud technology in Artificial Intelligence to our public health research for the best results [38-39] that are consistent with our ability to research the medical information systems field.

*CONFLICT OF INTEREST*: No potential conflict of interest was reported by the authors.

## 6. REFERENCES

- [1] Afsana, A., Khurshid, A., & Liaquat, A., et al. "Type 2 diabetes mellitus Bangladesh: a prevalence based cost-of-illness study". *BMC Health Serv Res* 19 (2019), 601. <https://doi.org/10.1186/s12913-019-4440-3>
- [2] Sanne, A. E. P., & Mark, W. "Sex differences in the burden and complications of diabetes". *Current Diabetes Reports* 18 (2018), 33, <https://doi.org/10.1007/s11892-018-1005-5>.
- [3] International Diabetes Federation. *IDF Diabetes Atlas* 8<sup>th</sup> edition (2017).
- [4] Whiting D. R., Guariguata L., Weil C., & Shaw J. "IDF diabetes atlas: global estimates of the prevalence of diabetes for 2011 and 2030". *Diabetes Res Clin Pract* (2011), 94(3), <https://doi.org/10.1016/j.diabres.2011.10.029>.
- [5] Huy Tuan Kiet Pham, Thi Tuyet Mai Kieu, & Tuan Duc Duong et al. "Direct medical

- costs of diabetes and its complications in Vietnam: A national health insurance database study”, *Diabetes Research and Clinical Practice* (2020), 162.
- [6] American Diabetes Association. “Diagnosis and Classification of Diabetes Mellitus”. *Diabetes Care* (2014), 37.
- [7] Konstantinos, P., Nikolaos, P., & Maciej B., et al. “Complications of Diabetes”. *Journal of Diabetes Research* (2016), <https://dx.doi.org/10.1155/2016/6989453>.
- [8] Gan D. “IDF Diabetes Atlas 2003”. International Diabetes Federation 2<sup>nd</sup> (2003).
- [9] Geiss, L. S., William, H. H., & Smith, P. J. “Mortality in Non-Insulin-Dependent Diabetes”. *Diabetes in America* (1995), 2.
- [10] Zhaolan, L., Chaowei, F., Weibing, W. & Biao, X. “Prevalence of chronic complications of type 2 diabetes mellitus in outpatients - a cross - sectional hospital based survey in urban China”, *Health Qual Life Outcomes* (2010), 8.
- [11] Chawla, A., Chawla, R., & Jaggi, S. “Microvascular and macrovascular complications in diabetes mellitus: Distinct or continuum?”. *Indian J Endocrinol Metab* (2016), 20(4), 546-551.
- [12] Huyen Dieu Thi Bui, Xiyue, J., & Rui, L. et al. “Prevalence of and factors related to microvascular complications in patients with type 2 diabetes mellitus in Tianjin, China: a cross-sectional study”. *Annals of Translational Medicine* (2019), 7(14). <https://dx.doi.org/10.21037/atm.2019.06.08>.
- [13] Cheng, S., Wang C., Chen, J., & Ko, Y. “Healthcare costs and utilization of diabetes-related complications in Taiwan”. *Medicine* (2018), 97(31).
- [14] Alva, M. L., Gray, A., Mihaylova, B., Leal, J., & Holman, R. R. “The impact of diabetes-related complications on healthcare costs: new results from the UKPDS (UKPDS 84)”. *Diabetic Medicine* (2015), 32(4), <https://doi.org/10.1111/dme.12647>.
- [15] Chen, H., & Hsiao, F. “Risk of hospitalization and healthcare cost associated with diabetes complication severity index in Taiwan'd national health insurance research database”. *Journal of Diabetes and its Complications* (2014), 28(5), 612-616, <https://doi.org/10.1016/j.jdiacomp.2014.05.011>
- [16] Zhuo, X., Zhang, P., Baker, L., & Albright, A., et al. “The lifetime costs of diabetes and its imcomplications for diabetes prevention”. *Dia Care* (2014), 37(9), 57-64.
- [17] Nguyen Van Chinh, Pham Bich Diep, Pham Huy Tuan Kiet, & Nguyen Thi Bach Yen. “Some factors relating to direct medical cost and direct non medical cost for treatment per visit of type 2 diabetes outpatients at Thanh Nhan hospital-Hanoi 2018”. *Vietnam Medical Journal* (2020), 2.
- [18] Fatma A., & Mohamed, E. “Prevalance of risk factors for diabetes foot complications”. *BMC Family Practice* (2007), 8.
- [19] Kwan, W. L. “Costs of Diabetes Mellitus in Korea”. *Diabetes & Metabolism Journal* (2011), 35(6), 567-570, <https://dx.doi.org/10.4093/dmj.2011.35.6.567>.
- [20] Glasheen, W. P., Renda A., & Dong. Y. “Diabetes Complications Severity Index (DCSI)-Update and ICD-10 translation”. *Journal of Diabetes and its Complications* (2017), 31(6).
- [21] Khalid, A., Mohammad, A. D., & Samir, O., et al. “Diabetes foot complications and their risk factors from a large restrospective cohort”. *PLOS ONE* (2015). <https://doi.org/10.1371/journal.pone.0124446>.

- [22] Morgan CL, Currie CJ, Stott NC, Smithers M, Butter CC, Peters JR: The prevalence of multiple diabetes-related complications. *Diabet Med* 2000, 17(2):146-151.
- [23] Chen, S, J, Liu, J. H., Shih, H. C., Chou, P., Tsai, C. Y., & Tung, T. H. "Prevalence and associated factors of lens opacities among Chinese type 2 diabetes in Kinmen, Taiwan". *Acta Diabetologica* (2008), 45(1), 7-13.
- [24] Cyganek K., et al. "Clinical risk factors and the role of VDR gene polymorphisms in diabetes retinopathy in Polish type 2 diabetes patients". *Acta Diabetologica* (2006), 43(4).
- [25] Chew, B. H., Ghazali, S. S., Ismail, M., Haniff, J., & Bujang, M. A. "Age  $\geq$  60 years was an independent risk factor for diabetes-related complications despite good control of cardiovascular risk factors in patients with type 2 diabetes mellitus". *Experimental Gerontology* (2013), 48(5), 485-491, <https://doi.org/10.1016/j.exger.2013.02.017>.
- [26] Sophia, Z., Mark, W., & Qiang, L., et al. "Impact of age, age at diagnosis and duration of diabetes on the risk of macrovascular and microvascular complications and death in type 2 diabetes". *Diabetologia* (2014), 57, 2465-2474.
- [27] Elbert S. H., Neda, L., & Jennifer, Y., L., et al. "Rates of complications and mortality in older patients with diabetes mellitus: the diabetes and aging study". *JAMA Intern Med* (2014), 174(2).
- [28] Rajbharan, Y., Pramil, T., & Ethiraj, D. "Risk factors and complications of type 2 diabetes in Asians". *CRIPS* (2008), 9(2).
- [29] Piran P., et al. "The evaluation of effective risk factors for foot skin in diabetes patients". *J Holist Nurs Midwifery* (2005), 25(4), 29-36.
- [30] Knuiman, M. W., et al. "Constable. Prevalence of diabetes complications in relation to risk factors". *DIABETES* (1986), 35(12).
- [31] Shabana, S., & Sasisekhar, T. "Effect of gender, age and duration on dyslipidemia in type 2 diabetes mellitus". *Int J Cur Res Rev* (2013), 5(6), 104-107.
- [32] Iraj, H., et al. "Chronic complications of diabetes mellitus in newly diagnosed patients". *Int J of Diabetes Mellitus* (2010), 2(1), 61-63.
- [33] Sprafka, J. M., Bender, A. P., & Jagger, H. G. "Prevalence of hypertension and associated risk factors among diabetic individuals: the three-city study". *Diabetes care* (1988), 11(1), 17-22.
- [34] Hajar, R. "Risk factors for coronary artery disease: historical perspectives". *Heart views: the official journal of the Gulf Heart Association* (2017), 18(3).
- [35] Turner, R. C., et al. "Risk factors for coronary artery disease in non-insulin dependent diabetes mellitus: United Kingdom Prospective Diabetes Study (UKPDS: 23)". *Bmj* (1998), 316(7134), 823-828.
- [36] MacMahon, Stephen, et al. "Blood pressure, stroke, and coronary heart disease: part 1, prolonged differences in blood pressure: prospective observational studies corrected for the regression dilution bias". *The Lancet* (1990), 335(8692), 765-774.
- [37] Stratton, I., et al. "Hypertension in Diabetes Study IV. Therapeutic requirements to maintain tight blood pressure control". *Diabetologia* (1996), 39, 1554-1561.
- [38] Cuong, L. D. P., & Dong Wang, et al. "Advanced Cloud Computing Services: The Evaluation of a development roadmap for emerging fields in Vietnam". *Journal of Critical Reviews* (2020), 7 (17), 3085-3105.

- [39] Cuong, L. D. P., & Wang Dong, et al. "Breast Cancer Prediction based on Deep Neural Network Model Implemented AWS Machine Learning Platform". *Int. J. Recent Technol. Eng.* (2020), 9(2).
- [40] Chi square statistic. Available at [https://en.wikipedia.org/wiki/Chi-squared\\_test](https://en.wikipedia.org/wiki/Chi-squared_test).
- [41] Lama, More RA, et al. "Childhood obesity. Recommendations of the nutrition committee of the Spanish association of pediatrics. Part I. Prevention. Early detection. Role of the pediatrician". *Anales de pediatria* (2006), 65(6).
- [42] US Preventive Services Task Force. "Screening for obesity in adults: recommendations and rationale". *Annals of internal medicine* (2003), 139(11), 930.

#### AUTHOR BIOGRAPHIES

1. **N. V. Chinh** is currently a deputy director of Dr.LABO Medical Test Center, Hanoi Medical Laboratory Diagnostic Joint Stock Company, Hanoi, Vietnam. He received his Master degree in Health Management in 2018, Hanoi Medical University, Vietnam. The main research subjects of his interested are Health Economics, Public Health and Health Management (*Type 2 Diabetes Mellitus*). Contact him at: [giaosuchinh@gmail.com](mailto:giaosuchinh@gmail.com).
2. **P. H. T. Kiet** received the Ph.D degrees in Internal Medicine from the University Leipzig, both Postdoc in Medical Sociology in the University of Freiburg and Postdoc in Health Economics in the University of Heidelberg, in 1996, 2002 and 2003, respectively. He is also a lecturer and expert of the Ministry of Finance - Ministry of Health, Head of Health Economics Department, holding the position of Professor of Health Economics Department, Hanoi Medical University, Vietnam; Head of Faculty of Economics and Health Management, Thang Long University, Hanoi; Head of Marketing, Marketing and Communication VKT Js.His interested research is Health Economics, Public Health, Health Management, Clean water and Environment. Contact him at: [phamhuytuankiet@hmu.edu.vn](mailto:phamhuytuankiet@hmu.edu.vn).
3. **P. B. Diep** is currently a lecture and deputy head of the Department of Health Education, Hanoi Medical University, Vietnam. She is focusing on Public Health, Health Education and Health Management. Contact her at: [phambichdiep@hmu.edu.vn](mailto:phambichdiep@hmu.edu.vn).
4. **N. T. B. Yen** is currently a lecture and former head of Department of Health Economics, Hanoi Medical University, Vietnam. She received the Ph.D degrees in Health Economics from Hanoi Medical University in 2010, Vietnam. Her main research interests include Health Economics, Health Cost and Management Cost. Contact her at: [yen1958@gmail.com](mailto:yen1958@gmail.com).
5. **Dong Wang** received the B.S. and Ph.D. degrees in computer science from Hunan University, in 1986 and 2006, respectively. From 2004 to 2005, he was a Visiting Scholar with the University of Technology Sydney, Australia. Since 1986, he has been with Hunan University, China, where he is currently a Professor. His main research interests include network test and performance evaluation, wireless communications, and mobile computing. Contact him at: [wangd@hnu.edu.cn](mailto:wangd@hnu.edu.cn).

6. **L. D. P. Cuong** is currently a PH.D candidate in Computer Science from College of Computer Science and Electronic Engineering, Hunan University, Changsha 410082, China. He is also a lecturer in Department of Information Technology, Yersin University, Vietnam. He received his Master degree in Information Technology, Paris VI University. His research interests include Cloud Computing, Wireless Network, Data Analytics, Artificial Intelligence, Bioinformatics and Information System. Contact him at: [cuongldp@yersin.edu.vn](mailto:cuongldp@yersin.edu.vn) or [ledinhphucuong.dalat@gmail.com](mailto:ledinhphucuong.dalat@gmail.com).
7. **P. D. Trung** is currently a rector of Yersin University, Vietnam. He received a PhD in Intelligent System in 2012 by Cardiff University, United Kingdom and a Master degree in Mechatronics in 2007 from Institute of Asian Technology, Thailand. The main research topics of his interested are Artificial Intelligence, Intelligent System, Data Mining, Machine Learning, Biomedical Engineering, Mechanical Engineering and Information System. Contact him at [pre@yersin.edu.vn](mailto:pre@yersin.edu.vn) or [phdtrung2018@gmail.com](mailto:phdtrung2018@gmail.com).
8. **L. M. N. Uyenis** currently a PH.D candidate in Biochemistry and Molecule Biology from College of Life Science, Hunan Normal University, Changsha 410082, China. She is also a lecturer in Department of Nursing, Yersin University, Vietnam. She received her Master degree in Biology, Dalat University. Her research interests include Life Sciences, Biotechnology and General Health. Contact her at: [uyenlmn@yersin.edu.vn](mailto:uyenlmn@yersin.edu.vn).
9. **N. H. Tu** is currently a lecturer in Center for Information Technology and Faculty of Information and Technology, Hanoi University of Industry, Vietnam. He received his PhD, Master degree in Computer Science from College of Computer Science and Electronic Engineering, Hunan University, China. His research interests include Intrusion detection and prevention, Vulnerability analysis, Network Security, Bioinformatics, and Data mining. Contact him at [hoangtu8081@yahoo.com](mailto:hoangtu8081@yahoo.com).