



Hypertension prevalence and associated factors among patients with diabetes: A retrospective cross-sectional study from Jordan

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ABSTRACT

Background: Hypertension (HTN) is a common comorbidity among diabetic patients. Studies reported that HTN prevalence in patients with diabetes mellitus (DM) depends on many risk factors related to the disease (the type and duration of DM), patients (age, sex, race/ethnicity, BMI), and medical history (glycemic control, renal problems). Best to our knowledge, limited evidence is available in this regard among Jordanian population.

Objectives: This retrospective cross-sectional study aimed to determine the prevalence of HTN among patients with DM in Jordan and factors that might be associated with the concurrence of both diseases.

Materials and methods: A cross-sectional study was conducted to determine HTN prevalence and risk factors among diabetic outpatients in Jordan. Patients were asked about their sociodemographic information and medical history. A descriptive analysis was used to determine HTN prevalence and a fit bivariate logistic regression model was used to identify the significant risk factors of HTN in patients with type 2 DM (T2DM).

Results: HTN was found to be concurrently occurring in approximately 80% of T2DM patients. This was found to increase with age. In addition, dyslipidemia, gout disease, ischemic heart disease, renal impairment, or a family history of HTN were found to be associated with the concurrence of HTN among T2DM patients.

Conclusion: Findings from this study highlight the need for proper monitoring of DM patients to reduce the co-occurrence of HTN. Specific attention should be directed to control the patients' glycemic and lipid profiles as well as the cardiac and renal health using non-pharmacological and pharmacological measures. This is of particular importance in T2DM patients at old age and with family history of HTN, to reduce patients' deterioration. Results from this study will also be informative for the development of public health strategies to increase the awareness of the general population regarding T2DM and HTN since both diseases are very common among Jordanian population.

1. Introduction

Diabetes mellitus (DM) is a heterogeneous chronic metabolic disorder, and it is amongst the most prevalent and challenging diseases during the 21st century. DM is characterized by chronic high blood glucose levels caused by deficient insulin secretion (Type 1 DM) [1] and/or resistance to insulin action combined with an inadequate compensatory insulin secretory response (Type 2 DM) [2]. According to the World Health Organization (WHO) reports, DM is the seventh leading cause of death due to short and long-term complications [3]. In addition, the International Diabetes Federation (IDF) reports showed

that almost 10% of individuals around the world are diabetic and the number of cases is expected to reach 642 million by 2040 [4].

Substantial evidence indicates that uncontrolled DM can lead to many long-term micro- and macro-vascular complications including retinal damage, kidney dysfunction, vascular defects, and neural problems. Further, DM was reported to be associated with defective lipoprotein metabolism and an increased risk of cardiovascular problems such as hypertension (HTN) [5].

HTN is considered as one of the most common comorbidities in DM patients. Previous studies estimated variable prevalence of HTN in patients with DM among different populations with some studies

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suggesting 60–65% co-occurrence [6,7]. Among DM patients in Cameroon, the prevalence of HTN was reported as 86.2% [8].

HTN has been recognized as a major risk factor for atherosclerotic cardiovascular disease (ASCVD), heart failure, and microvascular complications. ASCVD includes acute coronary syndrome, myocardial infarction (MI), angina, coronary or other arterial revascularization, stroke, transient ischemic attack, or peripheral arterial disease caused by atherosclerosis. Of note, ASCVD has been revealed as the leading cause of high morbidity and mortality rates among patients with DM and is the main cause of direct and indirect costs of DM [9,10]. Further to the aforementioned complications, chronic kidney diseases, as a complication of both HTN and DM, were reported to be associated with the high mortality and morbidity rates among DM patients [11]. Microvascular complications including nephropathy and retinopathy were also found to be associated with both diseases [12].

Studies showed that increased peripheral vascular resistance and/or increased exchangeable sodium might be involved in the etiopathology of HTN in DM patients [13]. In addition, physiological changes at the cellular level such as altered endothelial function and platelet activity were suggested to contribute to the increased risk of coronary heart diseases among DM patients with HTN [12,14].

Risk factors of HTN in the general population are well studied. These include a family history of HTN, body weight, psychological factors, metabolic disorders, physical activity, and environmental factors [15]. However, few studies were conducted to determine the risk factors of HTN among diabetic patients. HTN was found to occur more frequently in diabetic females than in males. This was strongly correlated with the family history of HTN and independently correlated with age, body mass index (BMI), increased urinary albumin excretion, and triglycerides. On the contrary, there was no correlation between HTN and waist-hip ratio [16]. Another study among DM patients in Cameroon reported that gender, smoking, number of meals, and the duration of being diabetic might have a role in modulating the patient's susceptibility to having HTN [8]. Age and T2DM duration were also found to be risk factors for development of HTN in the United Arab Emirates [38]. Further, diabetic foot and history of stroke were determined as risk factors for HTN in diabetic Benin patients [17].

Regarding the management of HTN in patients with T2DM, changing the lifestyle is considered an essential intervention strategy at the early stages of the disease. It was found that intake of a diet that is high in fiber and potassium and low in saturated refined carbohydrates and salt can significantly reduce blood pressure. Pharmacological therapeutic interventions are also needed to control the disease and prevent subsequent complications [18]. However, the type of hypotensive drug in DM patients might have significant therapeutic implications. Some hypotensive agents might aggravate insulin resistance and affect the glucose level, and thus are better to be avoided during the treatment of HTN in patients with DM [19]. Targeting the renin-angiotensin system was found to have beneficial outcomes in patients with DM. Angiotensin receptor-blocking agents were reported to reduce the occurrence of proteinuria and diabetic renal disease [20]. In addition, the use of a diuretic agent to control the systolic blood pressure reduced the risk of development of cardiovascular problems such as stroke.

Jordan is the 26th in highest rates of DM worldwide according to the IDF reports [4]. Ajlouni, K, group reported a 17.1% prevalence of T2DM among Jordanian population in 2004 [21]. In 2017, the same group reported an increase in DM prevalence reaching 23.7% [22]. A recent publication by the same group as well revealed that almost one-third of Jordanian adults had HTN [23]. However, best to our knowledge, limited evidence is available regarding the co-occurrence of HTN in patients with DM in Jordan. Accordingly, this study aimed to determine the prevalence of HTN in diabetics and to determine the risk factors that might be associated with increased HTN co-occurrence along DM. This is highly valuable to encourage monitoring and management strategies of DM patients using both non-pharmacological and pharmacological measures to reduce the development of HTN. In addition, findings from

this study will be informative for the conduction of national health education programs to improve the knowledge and awareness of the general population regarding DM and HTN, both of which are very common among Jordanian population.

2. Materials and methods

2.1. Ethical statement

This study was approved by the Deanship of Research and the Institutional Review Board of King Abdullah University Hospital, University of Jordan Hospital, and the Ministry of Health, Jordan, which directs Al-Basheer Hospital, Princess Basma Hospital, and Al-Karak Hospital. A consent form was obtained from all subjects who participated in this study. The study was registered with the Research Registry (researchregistry6271) in accordance with the declaration of Helsinki (<https://www.researchregistry.com/browse-the-registry#home/> Browse the Registry - Research Registry). The study was conducted according to the guidelines of Strengthening the reporting of cohort studies in surgery (STROCSS) 2019 [24].

2.2. Study design and data collection

This is a national retrospective cross-sectional study to determine HTN prevalence and its associated factors among diabetic outpatients in Jordan. Patients (N = 1485) with T2DM and on medication who are ≥ 18 years old were enrolled from five key university-affiliated and public hospitals in Jordan were assessed. These hospitals are King Abdullah University Hospital (KAUH, a teaching hospital affiliated with the Jordan University of Science and Technology in northern Jordan), Jordan University Hospital (a teaching hospital affiliated with the University of Jordan in the central area of Jordan), Al-Basheer Hospital (a public hospital in the central area of Jordan), Princess Basma Hospital (a public hospital in northern Jordan), and Al-Karak Hospital (a public hospital in southern Jordan). All patients enrolled in the study had a confirmed diagnosis of T2DM and were actively treated for their disease at the time of recruitment. A short interview with the patient was conducted by a clinical research coordinator. During the interview, the coordinator briefly explained the objectives of the study and collected demographic and clinical data. Patients who are younger than 18 years old, have mental diseases, or did not speak Arabic or English languages were excluded from the study. Consent forms were obtained from all patients.

2.3. Statistical analysis

Statistical packages Minitab version 17.0 was used to analyze the survey data. Descriptive analysis was used in describing the characteristics of the participated patients. A fit bivariate logistic regression model was used to identify the significant associated factors for HTN in patients with DM.

3. Results

This study included a total of 1485 T2DM patients; 598 males and 887 females (Table 1) and their age ranged from 18 to 96 years with a mean (SD) of 58.57 (10.82) (Fig. 1).

HTN was found to be highly associated with T2DM in Jordan with an approximate prevalence of 80% of the participated T2DM patients (Table 1). Therefore, we sought to determine the factors that might be associated with the concurrence of HTN and T2DM. These include sociodemographic factors (age, gender, body mass index), medical history (allergy, ischemic heart diseases (IHD), dyslipidemia, hypothyroidism, hyperthyroidism, renal impairment, liver impairment, asthma, chronic obstructive pulmonary diseases (COPD), gout, rheumatoid arthritis (RA), and depression), family history of other diseases (HTN, diabetes, hypothyroidism, hyperthyroidism, IHD, and asthma), and the

Table 1
General characteristics of participants.

Variable	Count	Percent
Gender		
Male	598	40.27%
Female	887	59.73%
Current smoking		
Not smoker	1272	85.6
Cigarettes	169	11.38
Shisha	35	2.36
Both	9	0.61
Marital status		
Single	48	3.23
Married	1252	84.43
Widow	180	12.12
Divorced	5	0.34
Hypertension		
Yes	1187	79.93%
No	298	20.07%

current smoking status.

A bivariate logistic regression fit model was used to determine the effect of these factors on the risk of getting HTN in diabetics.

Among all studied factors, patient age, IHD, dyslipidemia, and family history of HTN were the most significant factors to be related to the co-occurrence of HTN in T2DM patients ($P < 0.001$) (Table 2). Further, results showed that an increased risk of HTN is significantly correlated with the presence of gout disease, renal impairment, and family history of T2DM in diabetic patients ($P < 0.05$) (Table 2). Patient gender, BMI, or smoking were not significantly related to the increased risk of HTN development among T2DM patients. However, this does not exclude that these factors might play a role in developing HTN or T2DM in general population.

The logistic regression analysis showed that the model was highly significant with the seven significant factors $X^2 = 181.67, p < 0.001$. The Hosmer and Lemeshow Goodness-of-Fit Statistic was not significant $X^2 = 9.7, p > 0.05$ indicating the absence of evidence to conclude that the model does not provide a good fit for the data.

Besides, the Receiver Operator Characteristic (ROC) curve was plotted to check if the model can be used as a good classifier. The area under the curve was 0.78 (Fig. 2), indicating the accuracy of the model in predicting the associated factors of having HTN in T2DM patients.

Then, we analyzed the seven significant variables to our model and used the coefficient (Coef) value to estimate the extent to which a particular explanatory variable contributes to the possibility of having HTN in diabetic patients. For example, when the diabetic patient has gout disease, the logit transformation of having HTN increases by 1.469, and when she/he has IHD, the risk of HTN increases by 1.187. However, having a family history of diabetes is less likely to increase the risk of HTN development in T2DM patients since it has a coef value of (-0.363) (Table 3).

Further, to understand the effect of each factor in the model, we used the odd ratios for continuous and categorical predictors as illustrated in (Table 3). Age was the only continuous variable, and as it is shown in the results, an increased risk of HTN increases as the age increases. Increased patient age is common to be associated with many diseases and having T2DM will logically increase the risk of other comorbidities such as HTN in elderly people. Since other predictors in this study are categorical, the event (having HTN) is compared at two different levels for each predictor. Our predictors are coded as 1 when the patient has the diseases or the family history of a disease and 2 when she/he does not. When the odds ratio (OR) is higher than 1, that indicates the event is more likely to occur when the predictor being at level A and when it is less than 1 this indicates that the event is less likely to occur at level A. Table 3 shows that the OR values for all the significant variables were more than 1 except for the factor of having a family history of diabetes. As a result, we can conclude that it is more likely for the diabetic patient to have concurrent HTN if he/she has dyslipidemia, family history of HTN, IHD, renal impairment, or gout disease on ascending order, however it is less likely to have it if he/she has a family history of DM. Having a family history of DM might be strongly associated with developing DM in patient life, however, it might not be significantly related to increase the risk of developing HTN in patients who are already diagnosed with T2DM.

4. Discussion

T2DM and HTN are among the most common chronic diseases that predominate in elderly people. Both genetic and environmental factors have been shown to be associated with the development of both diseases [25]. HTN was reported as one of the most common diseases that can occur concurrently with DM. Prevalence was found to be associated with

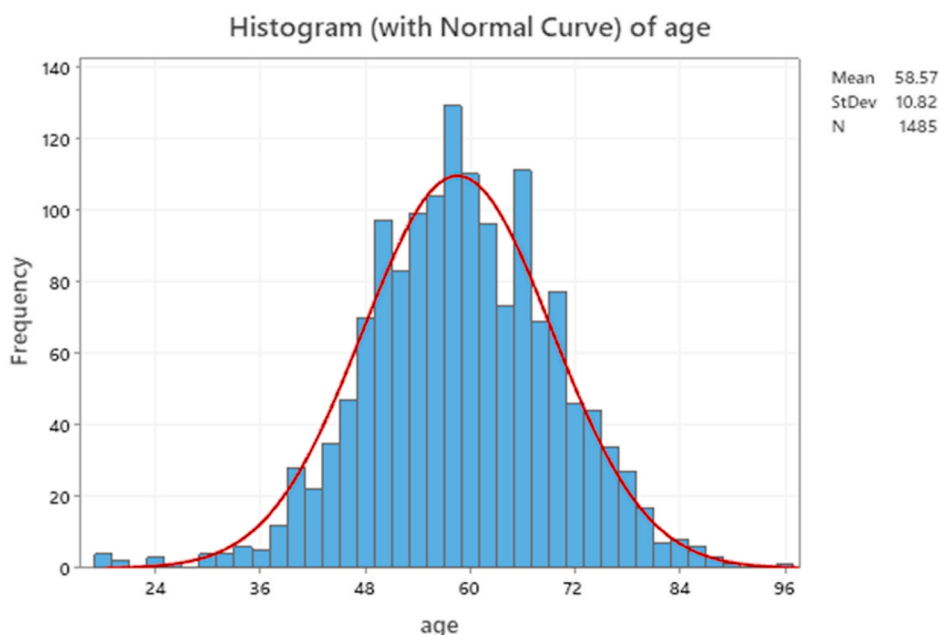


Fig. 1. Age distribution of the patients.

Table 2
Analysis of variance.

Wald Test			
Term	D.F	Chi-Square	P-Value
Age	1	60.52	0.000
Sex	1	1.58	0.209
BMI	1	0.00	0.992
Allergy	1	0.01	0.934
IHD	1	40.26	0.000
Dyslipidemia	1	22.80	0.000
Hyperthyroidism	1	0.00	0.979
Hypothyroidism	1	1.57	0.210
Renal impairment	1	6.14	0.013
Liver impairment	1	0.77	0.381
Asthma	1	2.82	0.093
COPD	1	0.93	0.336
Rheumatoid arthritis	1	0.25	0.618
Gout	1	5.81	0.016
Depression	1	0.36	0.550
Family history of hypertension	1	35.32	0.000
Family history of diabetes	1	4.30	0.038
Family history of hyperthyroidism	1	0.30	0.587
Family history of hypothyroidism	1	0.18	0.674
Family history of IHD	1	0.10	0.751
Family history of Asthma	1	0.55	0.457
Smoking	3	4.32	0.229

patients’ age, sex, race/ethnicity, BMI, history of glycemic control, and the presence of renal impairment [9]. Previous studies which were conducted among DM patients reported that approximately half of Thai [26] and three-quarters of Northern California [27] patients with DM also have HTN.

HTN and DM are among the most prevalent chronic diseases in Jordan. Recent studies by Ajlouni, K, group have revealed that among Jordanian population, 23.7% had DM [21] and almost one-third had HTN [23]. However, best to our knowledge, limited evidence is available regarding the co-occurrence of HTN in DM patients and risk factors for such occurrence.

Herein, we found that HTN is very common in T2DM patients with an approximate prevalence of 80%. Previous studies also reported that T2DM and HTN are more prevalent to occur concurrently than if it would occur as a single disease alone [28]. This suggests the presence of

certain common factors and/or pathways that predispose to the occurrence of both diseases concurrently. These might include common factors related to genetic or environment and/or biochemical pathways related to adipokines, insulin resistance, and oxidative stress pathways [28].

Age and family history of DM are well known as major risk factors for T2DM [29]. In addition, a family history of HTN is significantly associated with HTN prevalence [30]. In this study, we found that having HTN in T2DM patients is negatively correlated with a family history of DM, but positively correlated with a family history of HTN. However, a previous study by Shirakawa et al. showed that a family history of HTN did not increase the risk of diabetes, and vice versa [31].

Dyslipidemia is one of the most common conditions that predispose to T2DM and HTN [27], and our results confirm dyslipidemia as a commonly associated factor for being a patient with HTN and T2DM. A good approach for hypertensive diabetics is reducing their fat intake and improve their lipid profiles especially when antihypertensive therapies might affect insulin sensitivity and glucose level that might have a negative impact on patient health [32]. Special attention should also be directed to monitor the commonly prescribed medications for T2DM patients as they might affect the cholesterol and triglyceride levels. These medications include antihyperglycemic agents, antihypertensive

Table 3
Analysis of variance for significant factors.

Term	Coef	P-Value	Odds Ratio	95% CI
Age	0.05604	0.000	1.0576	(1.0431, 1.0724)
Dyslipidemia	0.684	0.000	1.9815	(1.4725, 2.6666)
Renal impairment	1.196	0.026	3.3057	(1.1576, 9.4399)
Gout	1.469	0.016	4.3450	(1.3195, 14.3080)
Family history of hypertension	1.032	0.000	2.8058	(2.0421, 3.8551)
Family history of diabetes	-0.363	0.038	0.6958	(0.4940, 0.9801)
IHD	1.187	0.000	3.2787	(2.2138, 4.8557)

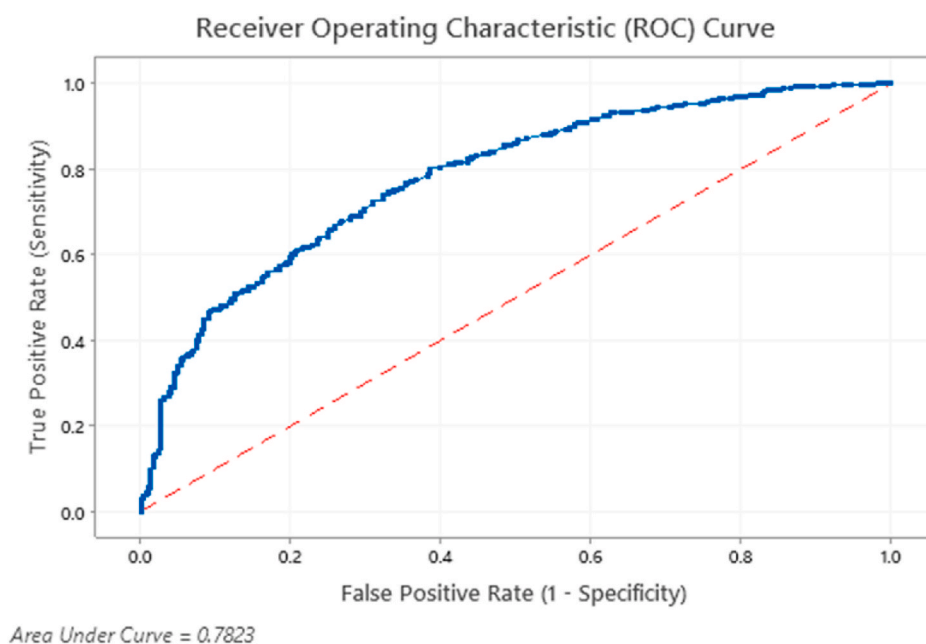


Fig. 2. Receiver Operator Characteristic (ROC) curve.

agents, weight loss medications, antibiotics, analgesics, oral contraceptives, and hormone replacement therapies [39].

DM is described to be strongly associated with chronic kidney failure and cardiovascular disease. In addition, HTN in DM increases the risk of vascular complications and might lead to chronic kidney diseases [33, 34]. In this study, we found that more than 80% of DM patients who have chronic kidney disease, also have a compounded burden of HTN. In line with that, IHD are also associated with getting HTN in Jordanian diabetics. Therefore, reaching a normal blood pressure measurement using proper antihypertensive agents is the target of HTN management in diabetic patients with kidney disease to prevent health deterioration [33].

Our results also showed a correlation between having gout disease with having concurrent HTN and T2DM. Gout is a disease that is biochemically characterized by elevated levels of uric acid [35]. Previous studies reported that having high levels of uric acid is an essential factor associated with metabolic syndromes [36]. Our findings are in agreement with other studies where serum uric acid levels were significantly increased in T2DM especially with those who have dyslipidemia and HTN [37].

Limitations of this study might include that it was conducted in a retrospective manner and therefore, observations need to be confirmed by studying a cohort of patients, ideally in prospective studies. Further, it was not recorded which disease is diagnosed before the other. In addition, patients' medications and serum levels of certain biomarkers that might give an explanation for the increased risk of HTN among T2DM were not investigated, however, it can be considered for future studies.

5. Conclusion

HTN is a chronic disease that has a high prevalence in Jordanian diabetics and its risk is increasing with age. The main risk factors that are associated with HTN in diabetics in Jordan are having dyslipidemia, gout disease, ischemic heart disease, renal impairment, or a family history of HTN. This highlights the possible role of controlling these factors using non-pharmacological and pharmacological approaches to prevent the incidence or better control of HTN in diabetics. Further studies among different populations are still needed and exploring the role of each factor in ameliorating HTN risk in diabetics will enhance the understanding of disease pathogenesis. In addition, prospective studies involving observation of healthy controls, prediabetic patients, and DM patients for the development of HTN and the associated factors might give a better understanding of the risk of HTN development in T2DM patients. Moreover, evaluation of patients' medications and serum levels of biochemical parameters might give a better explanation for the underlying mechanism of increased risk for HTN development in T2DM patients.

Findings from this study highlight the need for proper monitoring of DM patients to reduce the co-occurrence of HTN. Specific attention should be directed to control the patients' glycemic and lipid profiles as well as the cardiac and renal health, particularly in T2DM patients at old age and with a family history of HTN, to reduce patients' deterioration. This involves the inclusion of non-pharmacological and pharmacological measures. Results from this study will also be informative for the development of public health strategies to increase the awareness of the general population regarding T2DM and HTN since both diseases are very common among Jordanian population.

Ethical approval

Ethics approval was granted by the Institutional Review Boards of King Abdullah University Hospital, University of Jordan Hospital, and the Ministry of Health, Jordan which directs Al-Basheer Hospital, Princess Basma Hospital, and Al-Karak Hospital. Project number: 104/2012.

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Author contribution

N.A analysed and interpreted data and wrote the manuscript.
S.A collected data and wrote the manuscript.
L.E wrote and edited the manuscript.
R.K wrote and edited the manuscript.

Guarantor

Nosayba Al-Azzam.
Sayer Al-Azzam.

Trial registry number

1 Name of the registry: Research Registry
2 Unique Identifying number or registration ID: researchregistry6271
3 Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://www.researchregistry.com/browse-the-registry#home/registrationdetails/5fb957e4a4b6c4001bf02e97/>

Consent

Written informed consent was obtained from the patient for publication of this national cross-sectional study.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Declaration of competing interest

Authors declare no conflict or competing interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.amsu.2020.12.038>.

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