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Inter-Relation between Type 2 Diabetes Mellitus and Hypertension in Asia

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Abstract

Type 2 Diabetes Mellitus(T2DM) and hypertension (HTN) are most commonly inter-related. Diabetic patients are at a high risk of developing uncontrolled blood pressure leading to other complications like cardio vascular disease (CVD) and chronic kidney disease (CKD). The risk factors are ageing, obesity, dyslipidaemia, sedentary lifestyle, urbanization, and smoking. A keen comprehension of these interconnected factors will assist in prevention and management. The primary objective of the study is to evaluate the prevalence of HTN in diabetic patients in Asia to establish the inter-relationship to make the general public aware of the condition. The question that we aimed to answer was:" What is the relationship between T2DM and HTN and other variables causing morbidity?". A total of 27103 studies were retrieved from PubMed, Google Scholar and Embase in the period 2014 to 2024 out of which finally 12 studies were considered. HTN prevalence was found to be the highest among T2DM patients in Kuwait and China (87.16% each). Saudi (23%) reported the lowest prevalence followed by Iran (36.1%). The majority of studies reported higher prevalence in females in comparison to males. Factors such as obesity, dyslipidaemia, and low physical activity proved to be the key drivers in the development and progression of diabetes along with urbanization. HTN is a global burden and there has been a strong correlation between T2DM and HTN. Awareness, timely diagnosis and lifestyle modification can prove to be extremely beneficial in appropriate management of the condition and avert mortality.

Keywords: ***Hypertension, Diabetes Mellitus, Association, Asia.***

Introduction

Diabetes is progressively increasing so there is an increase in prevalence of hypertension(HTN). This is the ultimate cause of premature death in developing countries like India. The burden of hypertension and diabetes mellitus(DM) is escalating throughout the globe, especially in Asian countries. The prevalence of hypertension is higher in diabetic patients when compared to non-diabetic. The premature death among the diabetic hypertensive patients is due to cardiovascular disorders amounting to 17 million per year which is one-third of the total deaths in the world. It was estimated in a study that the global estimate for T2DM patients would be around 300 million by 2025 (Zimmet P,2003). Another study reported the global estimate to be around 366 million by 2030 (Wild S *et al,I* 2004). As such over half a million people are currently suffering from diabetes mellitus in Asia. The tragic story is that India is the diabetic capital.

The development of hypertension among diabetic patients includes multiple variables like age, gender, marital status, family history, lack of exercise, inadequate diet, smoking, and BMI. The renal disorders and cardiovascular complications occur in T2DM with HTN (Wang Z et, 2020). About 20-60% diabetic hypertensive patients are obese (Cheung B M, 2010). T2DM with HTN leads to microalbuminia, retinopathy and it is vital to understand the pathophysiology in detail (Parving H H *et al,I* 1988). Hypertension is a prevalent disease in elderly patients. International Diabetes Federation reports expenditure for diabetic population will reach 1.054 billion USD by 2045 bringing down the global economy (Sun H *et al,I* 2022). The T2DM prevalence is estimated to be higher in developing countries due to urbanization by 13.9% which may also be attributed to population ageing. The top ten countries who have Type 2 diabetes mellitus in 2045 were noted reporting that China and India will top the list among them reaching 174 million by 2045 due to urbanization (Cohen B, 2006). The slum residents will also show an increase in prevalence (Devi B N et, 2014). Hypertension prevalence in type 2 diabetes mellitus is mainly attributed to hyperinsulinemia resulting in retention of sodium and water which leads to sympathetic over activity and alteration in the cell membrane thereby altering the cation transport (Sechi LA, Bartoli E, 1997). In addition to this, there is increased angiotensin II and aldosterone activity. Above all oxidative stress is the cornerstone in etiopathology due to tumour necrosis factor and interleukin 6 and plasmin activator-inhibitor. Finally, these changes influence insulin resulting in insulin resistance which is a hallmark in prevalence of hypertension. In our study, we aimed to establish the interrelation between T2DM and HTN and other variables whose presence trigger morbidity.

Materials And Methods

A comprehensive literature review study was done for a period of 11 years from 2014 to 2024. The study was undertaken by two authors (S.S. and A.T.C.) using the keywords "Inter-relation", "Type 2 Diabetes", "Hypertension" and "Asia" from PubMed, Google Scholar and Embase. A total of 27103 studies were retrieved and 12 studies were considered finally for the systematic review and meta analyses (**Figure 1**) (Moher D *et al,I* 2009).

The inclusion criteria consisted of cases available with complete data, studies published only in English, studies that dealt with adults who were diabetic with essential hypertension and the studies that were cross-sectional in nature and those that were reviews and meta analyses conducted in Asia.

The exclusion criteria consisted of case reports, studies that included Non-Asian countries, paediatric and pregnant population, studies that included patients with secondary hypertension and those that were published in languages other than English. Studies that included insulin dependent diabetic patients were not taken and those that had a sample size less than 200 were also not considered.

No ethical approval was needed since we conducted a systematic review and meta-analyses.

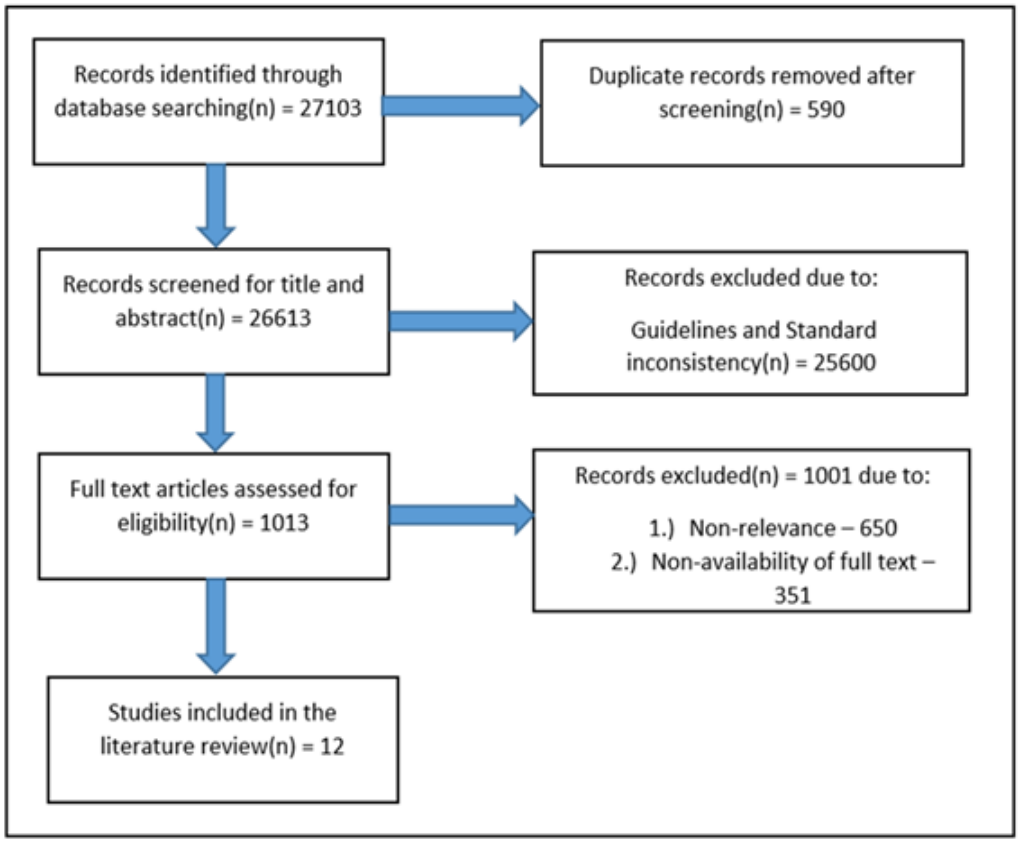

Figure 1: Flowchart for inclusion of studies in the systematic review and meta analyses

Statistical Analysis

Statistical analysis was performed with the SPSS version 28.0 and the data were presented using descriptive statistics such as number and percentage. R Studio was used for the preparation of graphs.

Results

Screening Flow

Usable data from eligible studies were independently extracted by two authors (S.S and A.T.C.). Any discrepancies in their decisions were resolved through consultation with a third author (J.K.S.). During the duplicate removal stage, 590 articles were removed. Out of a total of 26613 articles, 25600 articles were excluded during title and abstract screening. Finally, a total of 12 articles were considered for the systematic review and meta-analyses after excluding 1001 articles from the remaining 1013 articles during full text screening process.

Study Characteristics

This systematic review and meta-analyses included a total of 12 studies.

The studies were analysed by using Microsoft Excel 2016 and R Studio was used for graphical preparations. The two authors (S.S and A.T.C.) assessed the methodology and quality by using the New Castle Ottawa Scale (Wells GA *et al,I* 2000). Finally, a total of 12 studies met the quality of assessment. Our review included studies from 12 Asian countries namely India, Thailand, Kuwait, Lebanon, Egypt, Sri Lanka, Iran, Bangladesh, Jordan, China, Pakistan and Saudi. The author names, country, type of study, period of study, sample size and prevalence of hypertension in diabetic patients were tabulated (**Table 1 and Figure 2**). The studies selected were from various countries of Asia to evaluate the prevalence of hypertension in the diabetic population. Forest plot was prepared for prevalence of hypertension in diabetics in Asia stated by various authors (**Figure 2**). The pooled prevalence was 0.60(95 CI – 0.49 to 0.70). In this study, the heterogeneity was tested with I2 = 99.841% and P value <0.001 indicating the presence of heterogeneity.

Funnel test and Egger's test

Funnel plot was found out to be roughly symmetrical indicating minor publication bias (**Figure 3**). Egger's test was also used to rule out the bias (Egger M *et al,I* 1997). The results showed that P value is 0.341 that is >0.05 suggesting that there was publication bias.

Kuwait and China reported relatively high prevalence of hypertension in diabetic patients followed by Sri Lanka, Lebanon and Jordan. Saudi reported the lowest hypertension prevalence in diabetic patients followed by Iran (**Table 1 and Figure 4**).

Table 1: Study characteristics and HTN prevalence in T2DM patients across countries in Asia

Sl No	Author	Country	Type of Study	Period of Study	Prevalence (%)	Sample Size
1	Dhananjay Yadav *et al,I* 2014	India	Cross-sectional	3 years	49%	700
2	Cameron Hurst et al. 2015	Thailand	Cross-sectional	3 years	55.35%	55797
3	Arshad Mohamed Channanath *et al,I* 2015	Kuwait	Cross-sectional, retrospective	12 years	87.16%	3904
4	Lama Soubra *et al,I* 2018	Lebanon	Cross-sectional, retrospective	1 year	75%	700
5	Eman H Waly *et al,I* 2018	Egypt	Cross-sectional	3 months	68%	300
6	Maulee Hiromi Arambewela *et al,I* 2018	Sri Lanka	Cross-sectional	7 months	77.6%	3000
7	Soghra Rabizadeh *et al,I* 2021	Iran	Cross-sectional	1 year	36.1%	2612
8	Hiba Alsaadon *et al,I* 2022	Bangladesh	Cross-sectional, retrospective	1 year	67.2%	1252
9	Ahlam Bani Salameh *et al,I* 2022	Jordan	Cross-sectional	2 years	74.6%	1382
10	Xin Zhang *et al,I* 2024	China	Systematic review and meta-analyses	19 years	87.16%	7517
11	Mehwish Javeed *et al,I* 2024	Pakistan	Review	--	47.06%	2327
12	Abdulhameed A Alharbi *et al,I* 2024	Saudi	Retrospective. Cohort	5 years	23%	274

Table 2: Triggering factors

Sl No	Authors	Others
1	Dhananjay Yadav et al, 2014	Dyslipidemia Males- 56.3%, Females- 72% Metablic syndrome 6-10 years 39.4% SBP: 60.5% DBP: 80%
2	Arshad Mohamed Channanath *et al,I* 2015	Obesity 29.6%
3	Lama Soubra *et al,I* 2018	Dyslipidemia 75.6%
4	Eman H Waly *et al,I* 2018	Physical inactivity 97% Obesity 76.4% Cholestrol 62.1% Family history 65%
5	Maulee Hiromi Arambewela *et al,I* 2018	Vascular complication 84.4% Dyslipidemia 76.7% Obesity 75.7%
6	Soghra Rabizadeh *et al,I* 2021	Obesity 39.3% Metabolic Syndrome 88.8%
7	Hiba Alsaadon *et al,I* 2022	Physically inactive 69.6% Obesity 75.1% High waist hip ratio 63.3%
8	Ahlam Bani Salameh *et al,I* 2022	Hip waist circumference ratio 89.9%

**SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure*

Table 3: Correlation of hypertensive diabetes with gender

Sl No	Authors	Gender	
		Male	**Female**
1	Dhananjay Yadav *et al,I* 2014	55.2%	42.9%
2	Arshad Mohamed Channanath *et al,I* 2015	41%	59%
3	Lama Soubra *et al,I* 2018	55.2%	44.8%
4	Eman H Waly *et al,I* 2018	42.4%	57.6%
5	Soghra Rabizadeh *et al,I* 2021	34.3%	65.7%
6	Hiba Alsaadon *et al,I* 2022	63.1%	64.9%
7	Ahlam Bani Salameh *et al,I* 2022	48.05%	51.95%
8	Xin Zhang *et al,I* 2024	59.8%	40.2%

Table 4: Correlation of hypertensive diabetes with urbanization

Sl No	Authors	Urbanization	
		Urban	**Rural**
1	Hiba Alsaadon *et al,I* 2022	68.2%	54.2%
2	Ahlam Bani Salameh *et al,I* 2022	63.65%	36.35%

Table 5: T2DM prevalence in smokers

Sl No	Authors	Smoking
1	Lama Soubra *et al,I* 2018	56%
2	Maulee Hiromi Arambewela *et al,I* 2018	11%
3	Soghra Rabizadeh *et al,I* 2021	10.30%
4	Hiba Alsaadon *et al,I* 2022	66.10%

Table 6: Merits and gaps

Sl No	Authors	Merits	Gaps
1	Dhananjay Yadav et al	Robust dataset	Short period of study (3 years)
2	Cameron Hurst et al	First nationwide multicentre study in South East Asia with large sample	Absence of lifestyle and dietary data may have led to potential information bias.
3	Arshad Mohamed Channanath et al	First report to assess age and BMI correlation in T2DM hypertensive patients	Family history, lifestyle factors and dietary patterns were missing contributing to significant bias
4	Lama Soubra et al	one of the few studies that addressed hypertension in diabetes in Middle East	BP was recorded once adding to potential bias. Factors contributing to low controlled BP levels like medications and less stringent goals were not included.
5	Eman H Waly et al	Robust dataset	Cross-sectional nature leading to non-establishment of cause-effect relationship.
6	Maulee Hiromi Arambewela et al	Large scale descriptive study conducted in National Hospital of Sri Lanka which is the largest tertiary care hospital in the country allowing diverse representative sample of 3000 contributing to the reliability of the findings	Prevalence might have been over reported.
7	Soghra Rabizadeh et al	multivariate logistic regression modelling was used to recognize the independent factors of uncontrolled hypertension that strengthened the findings of the study. metabolic syndrome impacting hypertension in diabetic patients was depicted.	Cross-sectional nature
8	Hiba Alasaadon et al	Robust sample data from over 6 diabetes hospitals providing primary, secondary and tertiary care covering urban and rural settings utilized.	Cross-sectional nature
9	Ahlam Bani Salameh et al	Use of standardized automated sphygmomanometers ensured accurate data collection. Sociodemographic factors, anthropometric measurements, HbA1c levels and lipid profiles, contributed to thorough analysis of factors associated with HTN	Data missed out important factors such as medication adherence and patient behaviour.
10	Xin Zhang et al	Reported as first systematic review to investigate hypertension in T2DM Chinese patients.	High heterogeneity was noted and small number of studies were included.

11	Mehwish Javeed et al	Risk factors such as dyslipidaemia, obesity and poor lifestyle choices, high sodium intake and sedentary life were identified.	Generazibility limited due to varying health outcomes on basis of demographics and regions.
12	Abdulhameed A Alharbi et al	Thorough data collection was done using customized checklists using various demographic factors and health indicators.	Retrospective might have relied on existing health records only that might not always be very accurate.

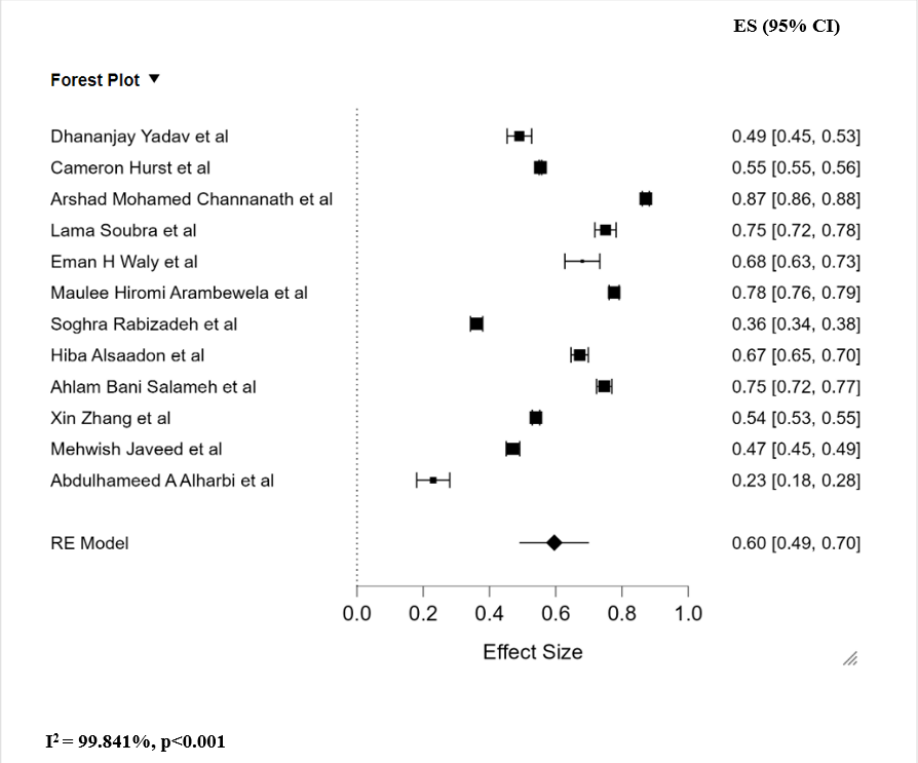

Figure 2: Forest plot for prevalence of HTN in diabetic Asians author wise

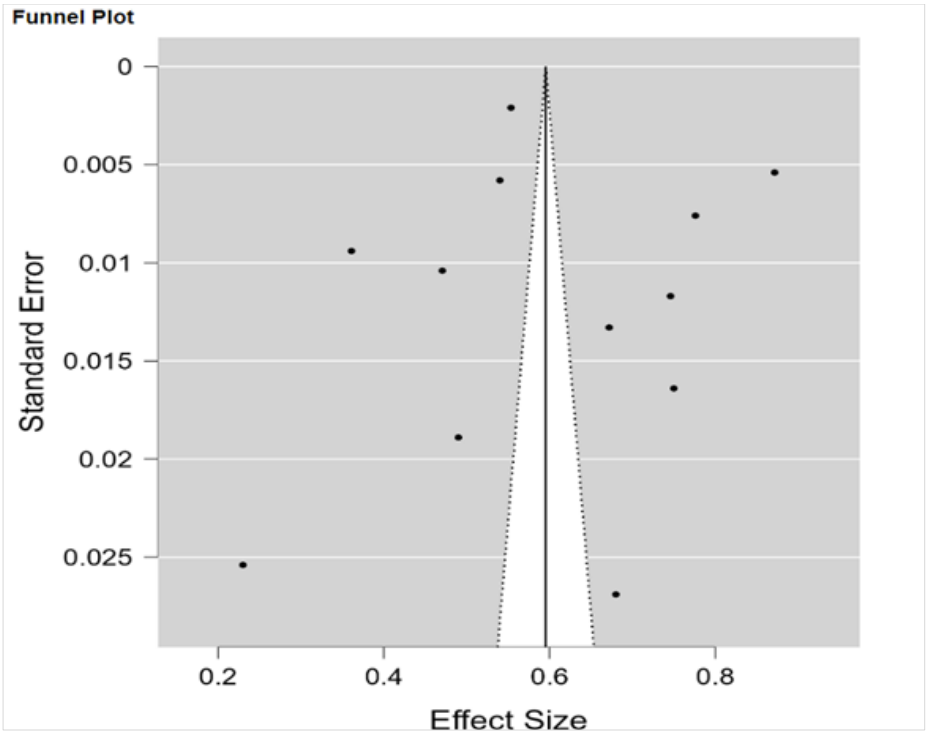

Figure 3. Funnel plot for HTN prevalence in Diabetic Asians

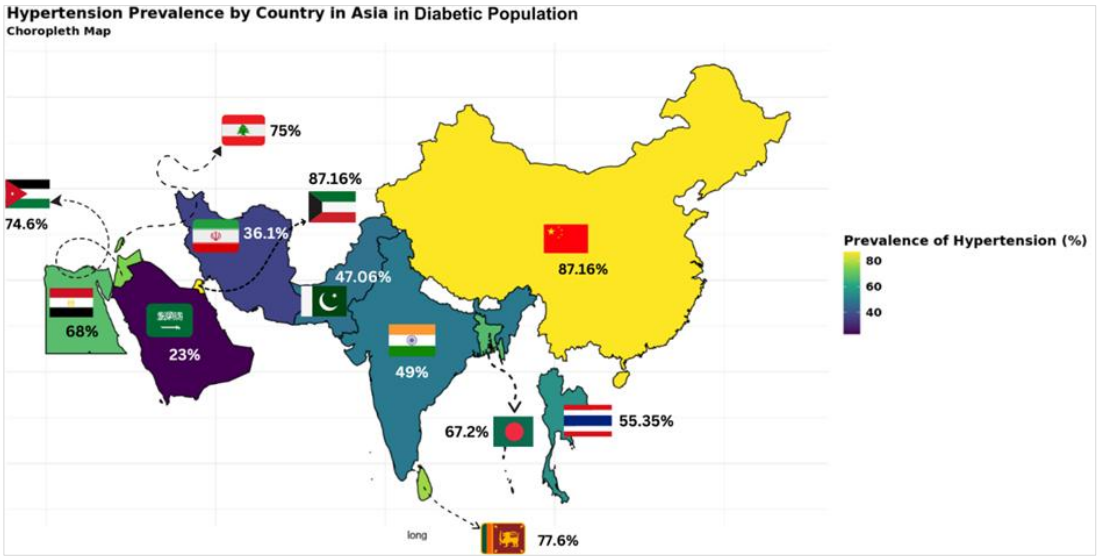

Figure 4: Chloropleth map depicting HTN prevalence in Diabetic Asians

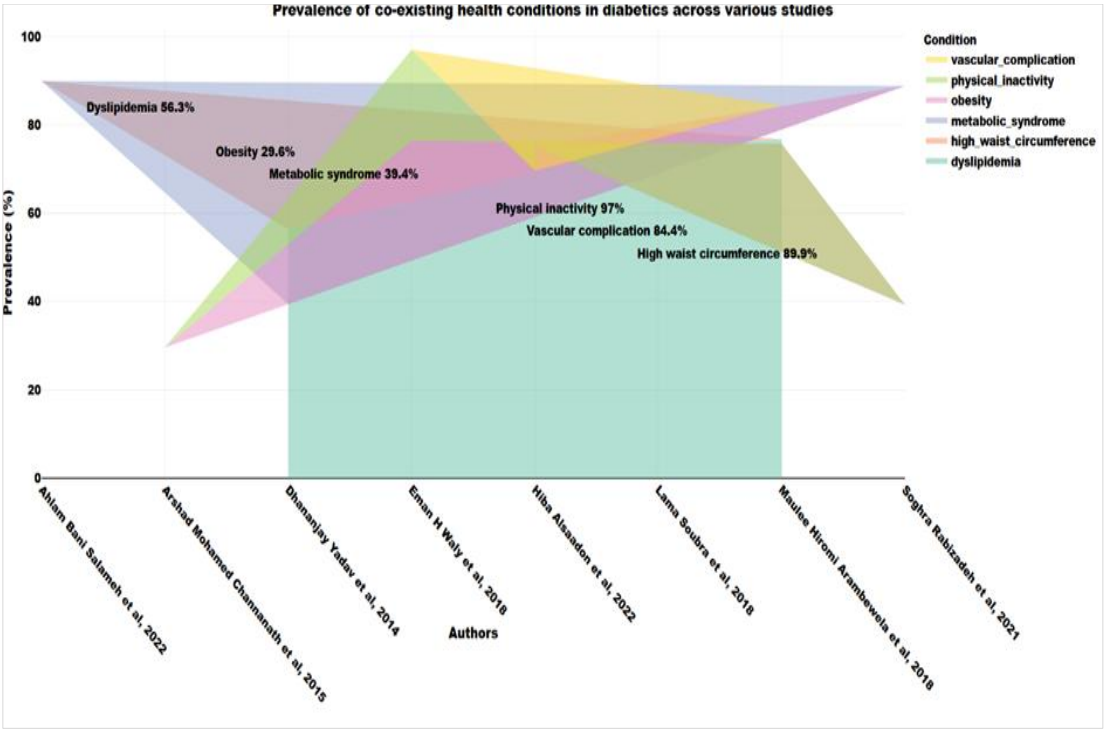

Figure 5: Stacked area chart depicting various triggering factors of diabetes author wise

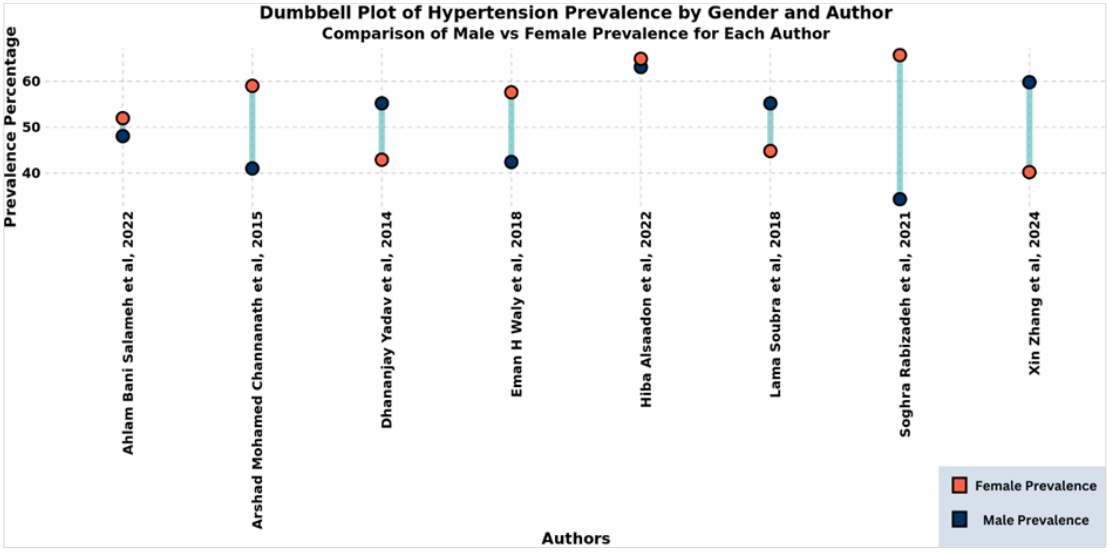

Figure 6: Dumbbell plot depicting male vs female HTN prevalence in diabetic Asians

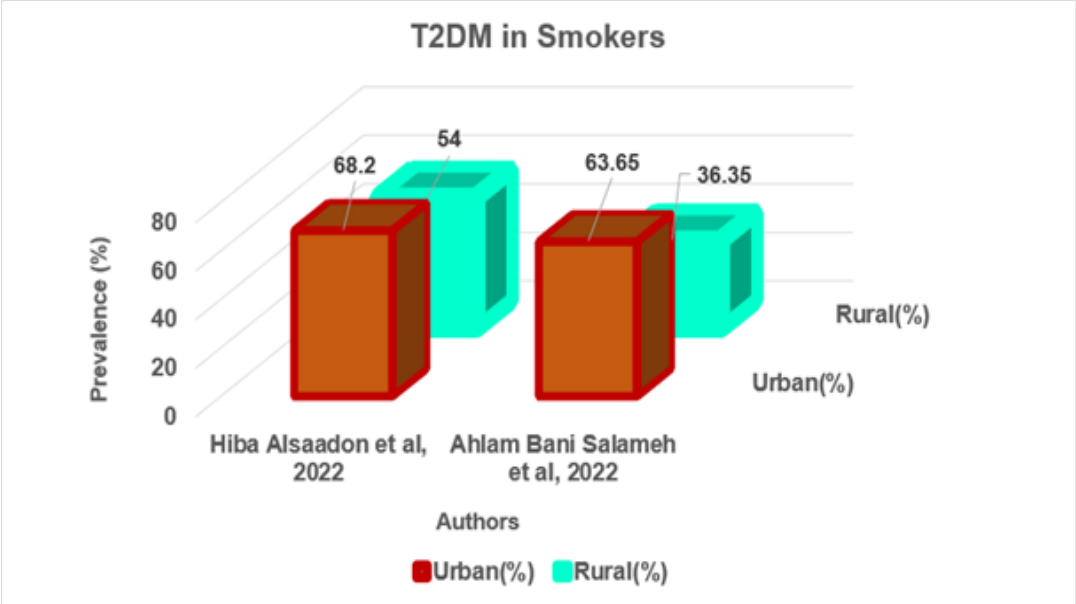

Figure 7: Association of urbanization and T2DM

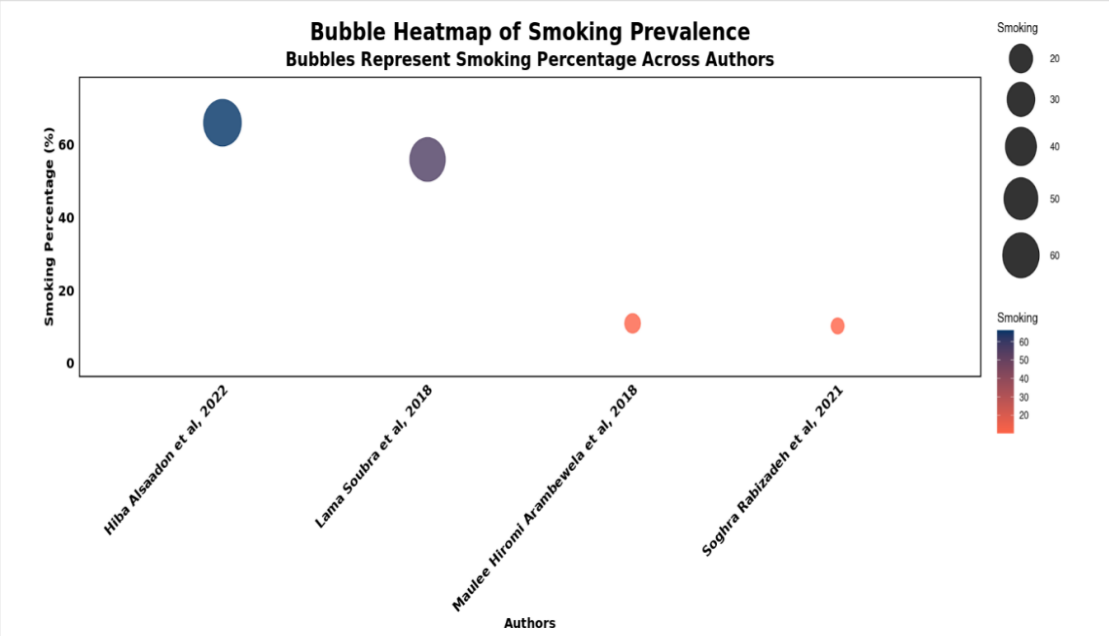

Figure 8: Bubble heat map representing smoking and T2DM association author wise

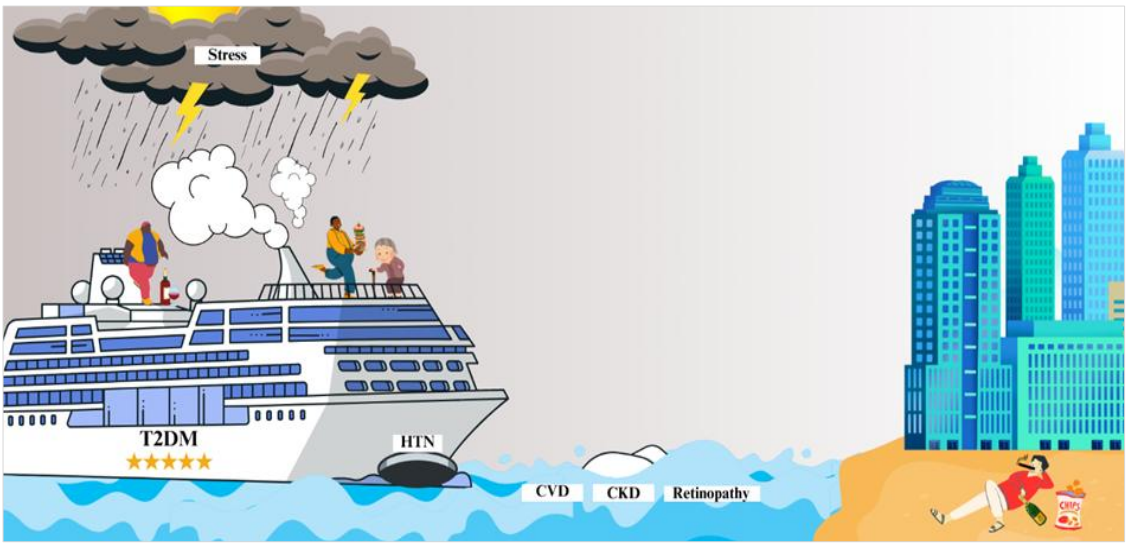

Figure 9: Inter-relation between T2DM, HTN and various triggering factors causing morbidity

Discussion

A critical area of research is the interrelationship between type 2 diabetes mellitus and hypertension, and this is evident in the findings of different authors of our study.

The correlation between hypertensive diabetes and various triggering factors was tabulated (**Table 2, 3, 4 & 5; Figure 5,6,7 & 8**).

The significant role of dyslipidaemia and metabolic syndrome in the prevalence of hypertension among diabetic patients was underlined by an author pointing out that these factors are the causes of the increased cardiovascular risk associated with diabetes (Dhananjay Yadav *et al,I* 2014). This was supported by another study (Suanrueang P, 2024). Another author of our study who further reported that hypertension is associated with microvascular complications in diabetic patients, found the notion that the presence of hypertension further complicates such problems as retinopathy and nephropathy (Cameron Hurst *et al,I* 2015). This was further corroborated on by another author (Joshi BS *et al,I* 2024). Another author of our study added to this argument by identifying obesity as the key factor leading to hypertension in diabetic patients and hence stated that the increasing rates of obesity in the region are directly linked to the simultaneous increase in the incidence of both conditions (Arshad Mohamed Channanath *et al,I* 2015). This was further elucidated upon by another author (Pasdar Y *et al,I* 2024). According to an author in our study the impact of physical inactivity, dyslipidaemia and smoking are the major contributors to hypertension in Lebanon, which supports the notion that lifestyle factors are the key to the management of both diseases (Lama Soubra *et al,I* 2016). This was further showed in another study (Yang X *et al,I* 2024). Another author of our study agreed with these findings, saying that in addition to physical inactivity, obesity is one of the major risk factors in Egypt, all of which complicate the proper management of hypertension among diabetic patients (Eman Waly *et al,I* 2018).

Yet another author of our study mentioned the prevalence of the alarming vascular complications among diabetic patients with hypertension in Sri Lanka, and stressed upon the fact that there was a link of acute health consequences with the two conditions dropping down the patients to irreversible stage (Maulee Hiromi Arambewela *et al,I* 2018). One more author of our study created awareness of the importance of metabolic syndrome which is a common factor in diabetic patients who had hypertension in Iran (Soghra Rabizadeh *et al,I* 2021). This was depicted in another study (Vareldzis R *et al,I* 2024). Two authors of our study stressed on urbanization, lifestyle changes and hip waist circumference ratio in Bangladesh by depicting their impact on increasing hypertension among diabetic patients (Hiba Alsaadon *et al,I* 2022; Ahlam Bani Salameh *et al,I* 2022). This was further noted in another study (Talukder A *et al,I* 2024). Yet another author demonstrated hyperinsulinemia as a biochemical pathway for the cause of hypertension in diabetic people (Xin Zhang *et al,I* 2024). This was reported by another author (Fazio S *et al,I* 2024). Yet another author of our study emphasized on the poor lifestyle choices and dyslipidemia as the important factors existing in Pakistan stressing on the need to adopt comprehensive lifestyle interventions to tackle both diabetes and high blood pressure (Mehwish Javeed *et al,I* 2024). Finally, another author of our study observed the regional differences in the prevalence of hypertension among diabetic patients in Saudi Arabia by recommending the authorities to respond with proper localized strategies to control and eliminate these interconnected conditions (Abdulhameed A Alharbi *et al,I* 2024). Together, these researches reveal the multifactorial nature regarding the relationship between T2DM and HTN by supporting the fact that lifestyle adjustments, metabolic syndrome and urbanization are the triggering factors. The merits and gaps of each study by various authors of our study were tabulated (**Table 6**).

Conclusion

The drivers of hypertension in a diabetic patient leads to dreadful catastrophe, hence awareness should be created among the common man. There should be facilities available to the public for cheap availability of digital BP monitor supply through ration shops. No smoking sign boards must be placed in areas in malls and public areas. All means to increase the awareness of this deadly duo namely HTN and T2DM to the public is made available through social media, advertisements on TV, and movies. NGO, and other organisations can arrange free camps and health check -up for the public. Our study aimed to evaluate the relationship between T2DM and HTN across various countries in Asia and showed positive correlation between the two conditions. The various triggering factors like obesity, dyslipidaemia, sedentary lifestyle, smoking and high sodium intake are the tip of the iceberg (**Figure 9**).

Declarations

Ethical Approval

Not Required

Source of Funding

This research was not supported by any specific grants from public, commercial, or non-profit funding agencies.

Data Availability

Available upon responsible request by corresponding author.

Conflicts of Interests

The authors report no conflict of interest.

Author Contributions

Conceptualization and methodology, S.S., A.T.C, and J.K.S; Formal analysis, A.T.C, S.S., J.K.S.; Visualization and writing – original draft S.S., A.T.C., J.K.S., H.A.; Writing – review and editing, S.S.,A.T.C., J.K.S.,H.A. and J.H. All authors have read and agreed to the final version of the manuscript.

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