Prevalence of epidemiological influence, risk factors of type-2 Diabetes Mellitus and analysis of hypertension as a complication among the relatively newly diagnosed patients from BIRDEM hospital

A DISERTATION SUBMITTED TO BRAC UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN BIOTECHNOLOGY

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DECLARATION

I hereby declare that the thesis entitled **"Prevalence of epidemiological influence, risk factors of type-2 Diabetes Mellitus and analysis of hypertension as a complication among the relatively newly diagnosed patients from BIRDEM hospital"** is entirely a product of my personal creative process, meticulous research and rigorous endeavor. I also declare that, it contains no material previously published or written by any other person and has neither been submitted nor accepted for an award of any kind or degrees from any university or an institute of higher education.

This research work was carried out with data from the BIRDEM hospital, Shahbag, Dhaka under the supervision of Dr. Mohammad Rafiqul Islam, Associate Professor, Department of Mathematics and Natural Sciences, BRAC University. The research work was also co-supervised by Dr. Parvin Akhter Khanam, Associate Professor, BIRDEM, Dhaka.

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Sincerely,

Ishtiak Ahmed Chowdhury

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1. Introduction

The most common disorder in the history of life threatening medical conditions is Diabetes and perhaps, it is one of the most deleterious and insidious form of clinical atrocity available worldwide. According to a statistical study conducted by the International Diabetes Federation in 2015, 7.4% of the population in Bangladesh, had been diagnosed with diabetes. Nearly half of the population with the disorder, 51.2%, do not even know that they possess the silent killer within them and thus they do not even receive any treatment (IDF Diabetes Atlas, 2015).

Bangladesh is home to a humongous 165 million population, according to a recent census report (Worldometers.info, 2017). During the 1990s, the country had a relatively lower diabetes affected population, in comparison. In 1995, it was only about 4%, which grew to 5% in 2000 and 9% within the years from 2006 to 2010. According to the International Diabetes Federation, the prevalence would come to be around 13% by 2030 (Diabetesatlas.org, 2015).

The main reason why diabetes has such a detrimental impact on the body is because of the complications it springs along. There are many associated complications which make life very difficult for a diabetic patient. They have been discussed in the later sections of this research work. There are also other medical conditions that can worsen the effect of diabetes in the body. Hypertension is one such condition. Hypertension is defined by an abnormal rise in blood pressure which is brought about by the heart, when it has to pump blood at a much higher force; while the walls of blood vessel too are constantly experiencing a higher pressure all along. It can happen due to the presence of certain obstructions within the blood vessels and also due to the presence of several other external and internal factors that cause the pressure to rise within the body. Besides the epidemiological framework, this research work also aims to understand the effect of hypertension and several other risk factors and their connection with diabetes and vice versa.

The organ that plays the major role of glucose metabolism in the body, is the pancreas. It is located right behind the stomach in the upper left abdomen. While the liver acts as the storage center for extra glucose in the form of glucagon, the pancreas provide the enzymatic support that is required to utilize and process the glucose obtained from food, efficiently, within the body. The pancreas has two functions. One of them is endocrine and another is exocrine in nature. The exocrine function enhances digestion procedures and the endocrine function is responsible for

the regulation of blood sugar. It's when the pancreas fails in its endocrine function and is unable to synthesize enough insulin or the body is somehow unable to use the insulin it produces, to process glucose efficiently, the level of glucose rises in the blood. This has very serious consequences and hence begins the miserable state of diabetes.

The beta cells present in the islets of Langerhans of the pancreas are responsible for the production of insulin. The figure below demonstrates the structure and the function of the pancreas.

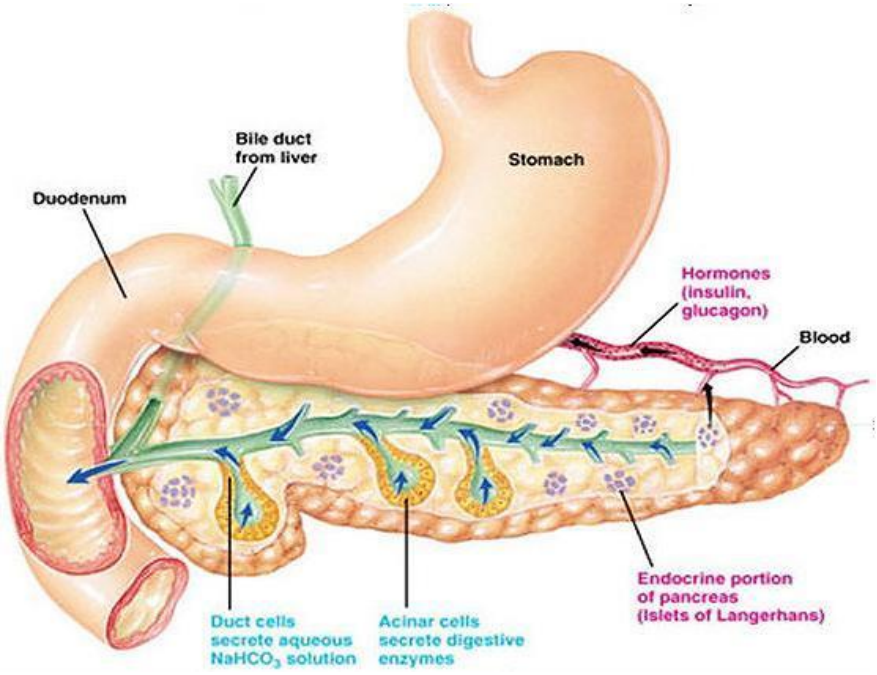

Figure 1.1 : Structure, location and functions of Pancreas

There are many risk factors that play a role in causing hypertension and diabetes. Most of the times people who are suffering from diabetes also tend to have hypertension and vice versa. In this research work, the prime risk factors have been taken into consideration that could cause hypertension in newly diagnosed type 2 diabetes patients. Many of the times, people are ignorant of their conditions and hence may develop far extreme complications, which have also been taken into consideration. All in all, the research work has been undertaken in such a manner that provides a holistic approach to understanding the prevalence of hypertension among the newly diagnosed diabetes type 2 patients while also analyzing the risk factors that are causing such problems among the individuals, concerned in the study.

1.1 What is Diabetes Mellitus?

Generally speaking, Diabetes Mellitus is a condition in which the body is unable to produce enough insulin or it is unable to efficiently use the insulin produced, to regulate the level of glucose within the body, resulting in insulin resistance. Failure to do so, results in the excess blood glucose to be strayed in to the blood.

Diabetes Mellitus can be characterized in to two types. According to the website of World Health Organization, **type 1 diabetes** (previously known as insulin-dependent, juvenile or childhood-onset) is characterized by deficient insulin production and requires daily administration of insulin. The cause of type 1 diabetes is not known and it is not preventable with current knowledge. Symptoms include excessive excretion of urine (polyuria), thirst (polydipsia), constant hunger, weight loss, vision changes, and fatigue. These symptoms may occur suddenly.(Who.int, 2017 **)**

The dictionary definition as of type 1 diabetes is stated as :

" a form of diabetes mellitus that usually develops during childhood or adolescence and is characterized by a severe deficiency in insulin secretion resulting from atrophy of the islets of Langerhans and causing hyperglycemia and a marked tendency toward ketoacidosis." (Merriam-webster.com/dictionary, 2017)

Similarly, the type 2 diabetes mellitus would be defined as :

" a common form of diabetes mellitus that develops especially in adults and most often in obese individuals and that is characterized by hyperglycemia resulting from impaired insulin utilization coupled with the body's inability to compensate with increased insulin production. " (Merriam-webster.com/dictionary, 2017)

Type 2 diabetes (formerly called non-insulin-dependent, or adult-onset) results from the body's ineffective use of insulin. Type 2 diabetes comprises the majority of people with diabetes around the world, and is largely the result of excess body weight and physical inactivity.

Symptoms may be similar to those of type 1 diabetes, but are often less marked. As a result, the disease may be diagnosed several years after onset, once complications have already arisen.

Until recently, this type of diabetes was seen only in adults but it is now also occurring increasingly frequently in children.(Who.int, 2017**)**

Therefore, it becomes quite clear that, inefficient production or utilization of insulin in the body is the ultimate reason for Diabetes Mellitus. In the type one, it is caused due to a deficiency in insulin production, failing to metabolize glucose within the body while in type 2, the body fails to respond to the secretion of insulin within the body and hence results in high blood sugar in the bloodstream. Either way, diabetes has fatal consequences.

The research work as entitled, focuses only upon diabetes type 2 patients ranging from the age of 18 to 70 years old. However, according to the website of World Health Organization, the definition of diabetes (both type 1 and type 2) is for a single raised glucose reading with symptoms, otherwise raised values on two occasions, of either fasting plasma glucose≥ 7.0 mmol/l (126 mg/dl) or with a glucose tolerance test, two hours after the oral dose a plasma glucose ≥ 11.1 mmol/l (200 mg/dl).

A random blood sugar of greater than 11.1 mmol/l (200 mg/dL) in association with typical symptomsora glycated hemoglobin (HbA1c) of ≥ 48 mmol/mol (≥ 6.5 DCCT %) is another method of diagnosing diabetes (WHO.int).

In 2009, an International Expert Committee that included representatives of the American Diabetes Association (ADA), the International Diabetes Federation (IDF), and the European Association for the Study of Diabetes (EASD) recommended that a threshold of ≥ 48 mmol/mol (≥ 6.5 DCCT %) should be used to diagnose diabetes. This recommendation was adopted by the American Diabetes Association in 2010 (Diabetes.org, 2017).

1.2 Causes and General Symptoms

Diabetes Mellitus is an extremely variegated form of medical condition, resulting from a huge spectrum of pre-existing factors and conditions. Some cases of diabetes are caused by the body's tissue receptors not responding to insulin (even when insulin levels are normal, which is what separates it from type 2 diabetes); this form is very uncommon. Genetic mutations (autosomal or mitochondrial) can lead to deleterious beta cell functioning. Abnormal insulin action may also have been genetically pre-determined in some cases. Any disease that causes extensive damage to the pancreas may also lead to diabetes (for example, chronic pancreatitis and cystic fibrosis). Diseases associated with excessive secretion of insulin-antagonistic hormones can cause diabetes (which is typically resolved once the hormone excess is removed). Many drugs impair insulin secretion and some toxins damage pancreatic beta cells. The ICD-10 (1992) diagnostic entity,

malnutrition-related diabetes mellitus, was deprecated by the World Health Organization when the current taxonomy was introduced in 1999 (WHO, 1999).

Given below are a list of potential causes for Diabetes Mellitus (Kumar, Robbin's Basic Pathology, 2003).

Genetic defects

- Genetic defects of β-cell function in the islets of Langerhans, pancreas.
- Maturity onset diabetes of the young
- Mitochondrial DNA mutations
- Genetic defects in insulin processing or insulin action
- Defects during pro-insulin conversion
- Insulin gene mutations
- Insulin receptor mutations

Organ-based defects and various other disorders

- Exocrine pancreatic defects
- Chronic pancreatitis
- Pancreatectomy
- Pancreatic neoplasia
- Cystic fibrosis
- Hemochromatosis
- Fibrocalculouspancreatopathy
- Endocrinopathies
- Excess of Somatotropin production
- Cushing syndrome
- Hyperthyroidism
- Pheochromocytoma
- Glucagonoma

Infections

- Cytomegalovirus infection
- Coxsackievirus B

Drugs

- Glucocorticoids
- β-adrenergic agonists
- Statins

General Symptoms of Diabetes Mellitus (Type 1 and 2)

In type 1 diabetes, the signs and symptoms can develop very quickly, and can develop significantly over the course of weeks or even days - particularly in children or adolescents. In addition to the symptoms above, symptoms of type 1 diabetes can also include dry mouth. In children and younger adults, signs such as increased urination, increased thirst, tiredness and sudden weight loss tend to be the most noticeable symptoms.(Kumar, Robbin's Basic Pathology, 2003)

Primary symptoms:

- Excessive thirst
- Unusually high levels of urination
- Feeling tired all the time (Lethargy)
- Loss of muscular bulk and unexplained weight loss

The main symptoms of type 1 diabetes are often referred to as the 4Ts of type 1 diabetes.

Other symptoms which may accompany the above symptoms are:

- Itchiness around the penis or vagina
- Blurring of vision (caused by dryness of the eyes)
- Unexpected cramping
- Skin infections

The disorder has reached severe tipping point if a combination of these symptoms are observed as well:

- A serious loss of appetite
- Nausea and vomiting
- A temperature
- Pains in the stomach
- A fruity, chemical smell on the breath

At diagnosis, people who have type 2 diabetes may show little or no symptoms of the condition. Because the symptoms develop slowly, type 2 diabetes may commonly be diagnosed following routine medical examinations or screening tests for non-related conditions. General symptoms include:

- Feeling tired during the day, particularly after meals (fatigue)
- Often feeling hungry, particularly if you feel hungry shortly after eating (polyphagia)
- Urinating more often than normal, particular needing to do so during the night (polyuria)
- Feeling abnormally thirsty (polydipsia)
- Blurred vision
- Itching of the skin, particularly itchiness around the genitals (genital itchiness)
- Slow healing of cuts or wounds
- Having regular yeast infections (thrush)
- Having a skin disorder such as psoriasis
- Sudden weight loss or loss of muscle mass

1.3 Complications in Type 2 Diabetes

1.3.1 Foot Complications

1. Bunions : It is a localized enlargement contained in the inner portion of the joint at the base of the big toe. The enlargement also in some cases, results in additional bone formations as well. This causes *halluxabducto valgus* deformity. It is a deformation, which cause the outward toe to misalign itself and rotate towards smaller toes. The deformity is progressive and increases with time. It can also cause stationary inflammation, localized at the joints of the toe, redness, tenderness and can produce extreme pain. Bursa, a small fluid-filled sac adjacent to the joint can also be inflamed resulting in bursitis and cause additional swelling. Localized arthritis is thus caused which becomes extremely painful. (diabetes.org, 2017)

Figure 1.2 : Bunion in a diabetic patient

2. Athelete's foot : This is a condition which is caused by extreme fungal infection. Cracked skin, itching and redness are associated with this condition. Fungus penetrates cracks in the skin and produces toxins which cause localized irritation. Antifungal creams are required to treat such ailments. The fungal infections are capable of spreading to even the lower ends of the feet and may cause further complications. (medicinenet.com, 2017)

Figure 1.3 : Athlete's foot in a diabetic patient

3. Nail infection : A browning of the nails is often observed in the diabetic patients. This is accompanied by twisting of the nails and causes the nails to become brittle and opaque. This is either assisted by additional fungal infections or the infected area may crumble and seen to slowly move away from the corresponding nails. Most of the times, fungal infections are

responsible for such browning, twisting and crumbling of the toe nails. (www.medicinenet.com, 2017)

Figure 1.4 : Nail infection in a diabetic patient

Calluses and corns : Calluses are hardened form of skin. Normally, every individual has hardened skin at the bottom of the leg but in the case of diabetes, the hardened skin is irregular and the hardness is more extreme in comparison. Corns are button like structures that are formed in diabetic patients in toe joints. They are generally circular and swollen areas which may cause pain and extreme difficulty in walking.

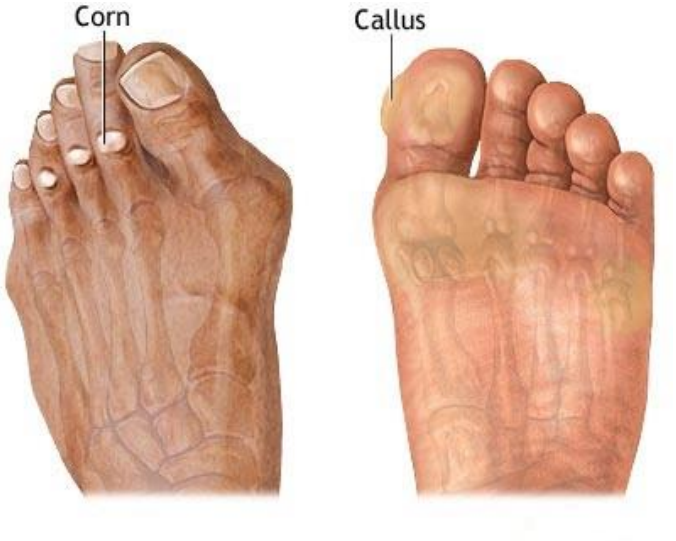

Figure 1.5 : Callus and Corn in diabetic patients

5. Foot ulcers : Extremely dangerous wounds that affect people with diabetes. In diabetic patients, even the minor cuts and sores tend to heal slowly. The lack of healthy blood flow to the ulcer area can cause a growth of ulcer in the area which might even require amputation. Most of the foot ulcers occur due to lack of oxygenated blood flow in the ulcer zone. Moreover, immuno-suppressed diabetic patients are at greater risks of significant foot ulcers. Such foot ulcers in diabetic patients are attributed to neuropathic and vascular complications. (www.webmd.com, 2017**)**

Figure 1.6 : Foot ulcers in a diabetic patient

Ingrown toenail: Often in diabetic patients, the toenails remain ingrown or start growing through the skin neighboring the toenail. This causes extreme discomfort and pain, while hampering movement and physical activities. They can also tend to result in neuropathic and vascular complications. If left untreated, it can cause serious injury to the bones or even the deeper tissues and non-healing ulcers as a consequence could also require the limb to be amputated. (diabetes.org, 2017)

Figure 1.7 : Ingrown toenail in a diabetic patient

Plantar warts: Plantar warts are rare viral infections which refuse to heal in diabetic patients. They are accompanied by painful blisters. Often without the presence of virus too, several wart like structures can grow and can cause infectious symptoms in diabetic patients, which may lead to non healing ulcers and thus foot amputations. (diabetes.org,2017)

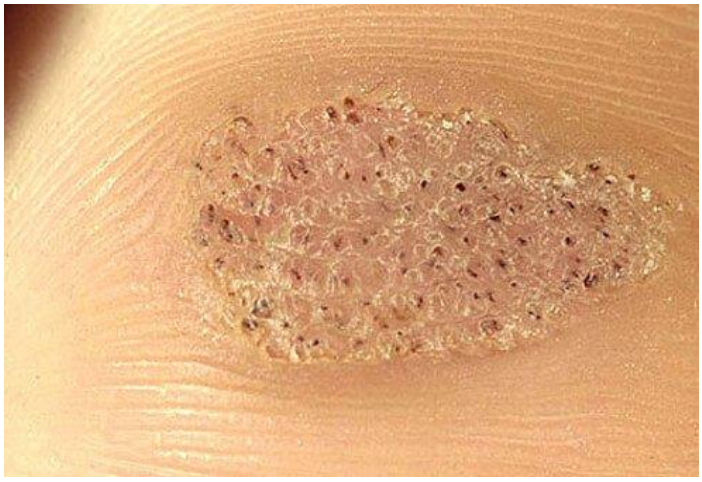

Figure 1.8 : Painful warts in a diabetic patient

1.3.2 Other severe life threatening complications in Diabetic patients

1.Diabetic Ketoacidosis(DKA)

When the body cells is starved of glucose due to the improper production of glucose in the body, the body starts to utilize or burn fat for energy production. This results in the production of chemical compounds called ketones in the body which pose a detrimental effect on the individual. Ketoacidosis may result in coma and even death. Thought relatively rare in type 2 DM patients, the chances of Ketoacidosis is still quite high. Ketoacidosis is very common with type 1 DM patients. The symptoms of Ketoacidosis may include: dry mouth, high blood sugar, burning sensation in mouth, lethargy, dry flushed skin, high content of ketones in urine. fruity odor in breath, breathing difficulties, wheezing, etc. The accumulation of acids in the body cells is extremely dangerous in the sense that normal cells stop functioning and metabolic pathways get hindered and therefore Ketoacidosis causes death in diabetic patients.

Biochemically, DKA is defined as an increase in the serum concentration of ketones greater than 5 mEq/L, a blood glucose level greater than 250 mg/dL (although it is usually much higher), and a blood (usually arterial) pH less than 7.3.(Fonseca V., Clinical Diabetes, 2006)

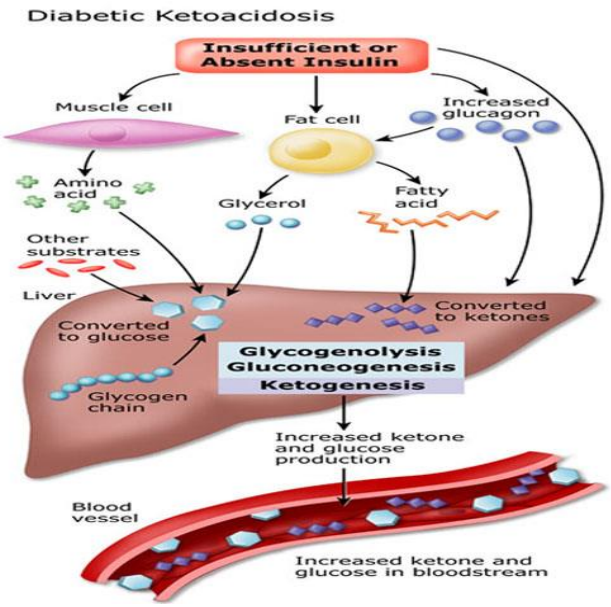

Figure 1.9 : Diabetic Ketoacidosis

1. Diabetic Nephropathy

Kidney complications are extremely common in diabetic patients. The typical Nephropathy which is accompanied by a decrease in the kidney activity is observed in both type 1 and type 2 diabetic patients.

Diabetic nephropathy is a clinical syndrome characterized by the following:

- Persistent albuminuria (>300 mg/d or >200 μg/min) that is confirmed on at least 2 occasions 3-6 months apart
- Progressive decline in the glomerular filtration rate (GFR)
- Elevated arterial blood pressure

Proteinuria was first recognized in diabetes mellitus in the late 18th century. In the 1930s, Kimmelstiel and Wilson described the classic lesions of nodular glomerulosclerosis in diabetes associated with proteinuria and hypertension. (Fonseca V., Clinical Diabetes, 2006)

By the 1950s, kidney disease was clearly recognized as a common complication of diabetes, with as many as 50% of patients with diabetes of more than 20 years having this complication. Currently, diabetic nephropathy is the leading cause of chronic kidney disease in the United States and other Western societies. Even in Bangladesh, it is one of the most significant long-term complications in terms of morbidity and mortality for individual patients with diabetes. Diabetes alone, is responsible for 30-40% of all end-stage renal diseases currently in the United States.

Generally, diabetic nephropathy is considered after a routine urinalysis and screening for microalbuminuria in the setting of diabetes. Patients may have physical findings associated with long-standing diabetes mellitus. Good evidences suggest that early treatment delays or prevents the onset of diabetic nephropathy or diabetic kidney disease. This has consistently been shown in both type 1 and type 2 diabetes mellitus.

Recently, attention has been called to atypical presentations of diabetic nephropathy with dissociation of proteinuria from reduced kidney function. Also noted is that microalbuminuria is not always predictive of diabetic nephropathy. Nevertheless, a majority of the cases of diabetic nephropathy presents with proteinuria, which progressively gets worse as the disease progresses, and is almost uniformly associated with hypertension (Batuman V., Diabetic Nephropathy, 2017**).** Most types of nephropathy are also accompanied by widening of glomerular basement

membrane within the kidneys and causes the patients to experience extreme kinds of symptoms like seizures, movement disability, a lack of urination, fluid retention in body and pain in the lower back area.

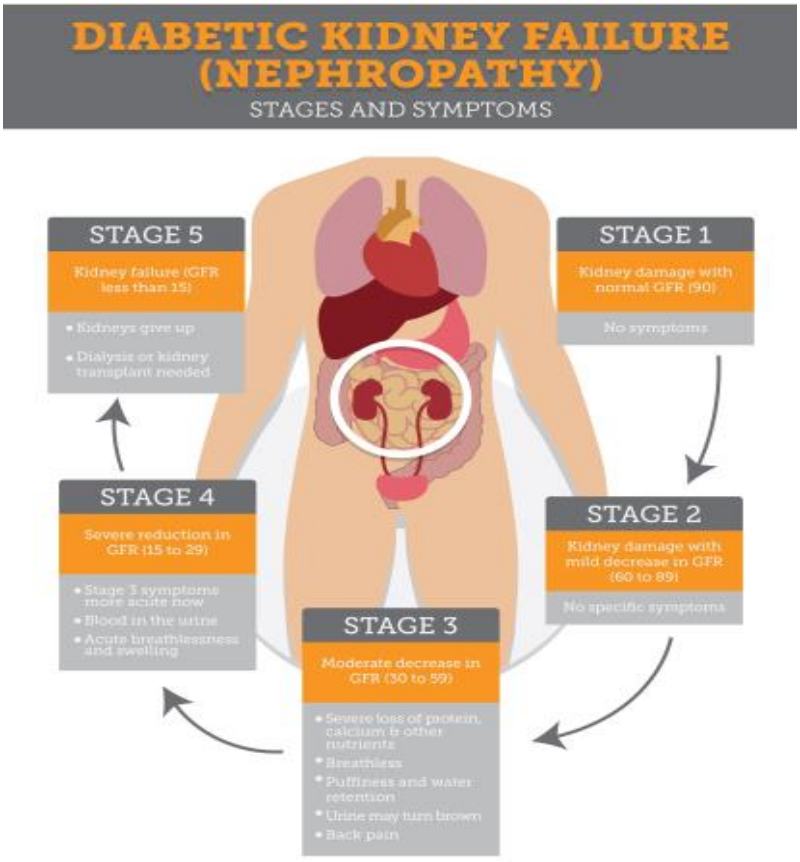

Figure 1.10 : Diabetic Nephropathy (www.epharmapedia.com,2017)

2. **High Blood Pressure (HTN)**

Hypertension (HTN), can be defined as a condition in which, the blood vessels have a consistent high pressure directed towards its walls. According to the website of World Health Organization,

"Hypertension, also known as high or raised blood pressure, is a condition in which the blood vessels have persistently raised pressure. Blood is carried from the heart to all parts of the body in the vessels. Each time the heart beats, it pumps blood into the vessels. Blood pressure is

created by the force of blood pushing against the walls of blood vessels (arteries) as it is pumped by the heart. The higher the pressure the harder the heart has to pump." (WHO.int, 2017)

People who have a stringent lifestyle and those who also have to undergo through a lot of psychological or emotional stress in their daily endeavors, generally tend to have a higher blood pressure than the normal. Since the heart has to struggle more to pump blood in to the blood vessels, there is an increased risk that the heart will give up thus resulting in heart failure. Hypertension could also arise from several medical conditions like atherosclerosis; lifestyle choices like drug habits, improper nutrition and also absolute lack or extreme levels of physical activity. Higher blood pressures or hypertension enhances the risk of cardiovascular diseases, kidney diseases, strokes, cerebro-vascular disorders, eye problems, etc.

Systolic blood pressure is the maximum pressure during a heartbeat, when the heart is sending blood throughout the body. Diastolic blood pressure is the lowest pressure between heartbeats, when the heart is filling with blood. The normal systolic/diastolic pressure is considered to be 120/80 mm Hg, for people below the age limit of 60 years old and over the age of 18. People who are hypertensive, are diagnosed to have a blood pressure above 140/90 mm Hg, generally. For people over 60, the hypertensive systolic and diastolic blood pressure is considered above 150/90. Pre-hypertension is a condition that could predict future hypertension, which is demonstrated at a systolic blood pressure of 120 to 139 over a diastolic blood pressure of 80 to 89.**(**WHO.int, 2017**)**

According to a research work (Chowdhury et al,2015) conducted in 2015, the overall prevalence of hypertension was determined to be 26.4% and the prevalence among women was seen to be higher. For men, it was 20.3%, whereas for women the prevalence rate was 32.4%. The study also found that, higher social status attributed to higher hypertension rates. This could be attributed to a deterioration of mental health along with detrimental physiological impact that could be established via further research. Hypertension is also presumed to be linked with cerebral-vascular disorders, renal disorders and many other complications that have serious adverse effects on the body. Understanding how hypertension is related to newly diagnosed diabetes patients in context to the Bangladeshi perspective, thus provides grounds for research and development of proper medication and therapy approach, aimed at proper management of both these disorders at one go.

3. **Neuropathy and Peripheral Neuropathy**

The term Neuropathy is associated with the meaning that the neurons and nerves tend to lose their functionality. People with diabetes, especially type 2 diabetic patients, can slowly and steadily develop nerve damages throughout the body. While some patients remain symptomless; others develop symptoms like tingling sensations in hand and feet, numbness in hand and feet, loss of feelings in hands, arms, feet, fingers and toes completely. Nerve damages can occur in every organs and organ systems as for example, the digestive tract or system, reproductive organs and system, etc.

About 65 to 70 percent of the diabetic patients have some form of neuropathy. The risk proliferates with the increasing age and duration of diabetes mellitus. People who have had diabetes for 20 or more years are more seen to be victims of diabetic neuropathy.

Symptoms of nerve damage may include :

- numbness, tingling, or pain in the toes, feet, legs, hands, arms, and fingers
- wasting of the muscles of the feet or hands
- indigestion, nausea, or vomiting
- diarrhea or constipation
- dizziness or faintness due to a drop in blood pressure after standing or sitting up
- problems with urination
- erectile dysfunction in men or vaginal dryness in women
- weakness

  Symptoms that are not due to neuropathy, but often accompany it, include weight loss and depression. (Fonseca V., Clinical Diabetes, 2006)

The types of diabetic nephropathy are as follows :

Peripheral neuropathy, the most common type of diabetic neuropathy, causes pain or loss of feeling in the toes, feet, legs, hands, and arms.

Autonomic neuropathy, results in changes in digestion, bowel and bladder function, sexual response, and perspiration. It can also affect the nerves that serve the heart and control blood pressure, as well as nerves in the lungs and eyes. Autonomic neuropathy can also cause

hypoglycemia unawareness, a condition in which people no longer experience the warning symptoms of low blood glucose levels.

Proximal neuropathy, leads to pain in the thighs, hips, or buttocks and leads to weakness in the legs.

Focal neuropathy, results in the sudden weakness of one nerve or a group of nerves, causing muscle weakness or pain. Any nerve in the body can be affected.

Peripheral neuropathy is also called as sensory neuropathy. The symptoms often worsen during the night. The diabetic patients with peripheral neuropathy tend to lose their reflexes. Injuries go unnoticed and hence, the injuries form into sores or blisters and if not treated on time, they may spread in to bones or deeper tissues. **(**Fonseca V., Clinical Diabetes, 2006 **)**

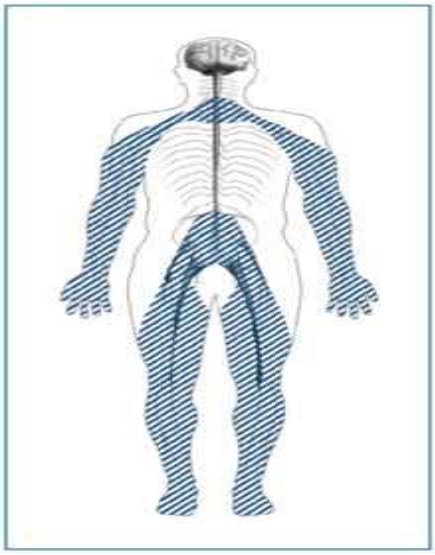

Figure 1.11 : Nerve regions affected by peripheral neuropathy

4. Arthritis

Arthritis is a medical condition which is the most common among diabetic patients. It is the medical condition which is recognized by the inflammation of joints. Though there are more than 100 different forms of arthritis, the type 2 diabetic patients tend to exhibit clinical symptoms of rheumatoid arthritis, gout and osteoarthritis. All of these are primarily associated with extreme joint pain and results in the disability of physical movements.

Osteoarthritis, is the most common form of arthritis in DM-2 patients. The majority of patients suffering from this form of arthritis are elderly people. The damage to the joints can be brought about by a number of factors including age, injury, joint injury, various other forms of arthritis and excess pressure on the joints due to being overweight and having obesity.

Gout, is generally characterized by the buildup of uric acid and causes extreme pain in the joints.

Rheumatoid arthritis, is a form of autoimmune arthritis which is characterized by the body's own defense mechanism attacking the bones and the joints.

5. **Diabetic Retinopathy**

It is a complication in diabetic patients which is characteristic of bringing damage to the eyes. It causes damage to the blood vessels of light sensitive tissue in eyes. High blood glucose is generally responsible for such damages of the retina. There are generally two stages of diabetic retinopathy. (Fonseca V., Clinical Diabetes, 2006)

Non Proliferative Diabetic Retinopathy : This type of retinopathy is the beginning stage of diabetic retinopathy and is also called as background retinopathy. This occurs when tiny blood vessels leak and there is a swell in the retina. NPDR also tends to cause damages to the nerve endings of the retina, in the eyes. When there is a swelling in the macular region of the eye, it is called macular edema. This is one of the primary causes why people tend to lose their eyesight while suffering from diabetic mellitus.

Vision loss may be mild to severe, but even in the worst cases, peripheral (side) vision continues to function. Laser treatment can be used to help control vision loss from macular edema.

Macular ischemia occurs when small blood vessels (capillaries) close. Vision blurs because the macula no longer receives sufficient blood supply to work properly. Unfortunately, there are no effective treatments for macular ischemia.

Macular ischemia cannot be cured. While there has been the presence of macular edema, efforts are made via laser operations to enforce the blockages to go away. In extreme cases, when

macular degeneration has already occurred; the laser procedures do not bring fruitful results at all.

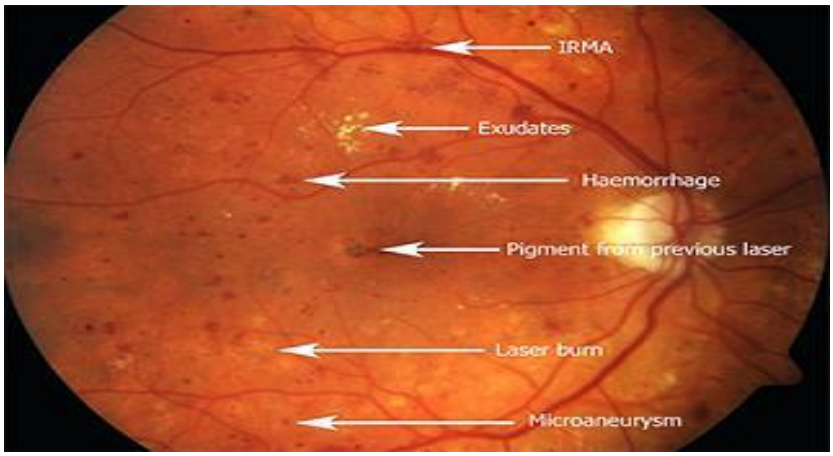

Figure 1.12: Non Proliferative Diabetic Retinopathy

As it can be clearly seen in the above figure that, patients with NPDR tend to develop microaneurysms or breakage of the blood vessels in the eye. There can also be seen significant amount of hemorrhages in the macular region, which can make a diabetic type 2 patient complete lose his/her eyesight.

Proliferative Retinopathy :

Proliferative Diabetic Retinopathy is the most dangerous form of complication of the eyes, in diabetic patients. In this type of advanced diabetic eye disease, the retina starts growing new blood vessels. This is termed as neovascularization. The fragile yet new blood vessels often tend to bleed into the vitreous humor. A little bleeding tends to cause increased amount of floaters in the vision but a larger proportion of hemorrhage may result in the complete loss of eyesight, as it could block the total vision.

The newly formed blood vessels are also capable of forming scar tissues. The scar tissues can interfere with the proper functioning of the macula and may even result to the complete detachment of the retina. Proliferative retinopathy has a greater risk of macular degeneration.

Vascular Endothelial Cell Growth Factor(VECGF) is the major growth hormone that tends to enforce a humongous amount re-growth of capillaries in the retina, when excess blood sugar has caused enough damage in the blood vessels, over the years. This is a complete exaggeration of body's normal response. This is what happens when the retina becomes exhausted of nutrients due to damage done by the excess blood sugar over the years and thus tries to make new blood vessels, that would perhaps deliver extra nutrient to the retina, itself. The new blood vessels fail to reach the expectations and in turn they tend to burst and this results in the gradual loss of vision. Though laser burns via laser treatment may result in temporary relief, the gradual stress on the retina gradually decreases eyesight. (Fonseca V., Clinical Diabetes, 2006)

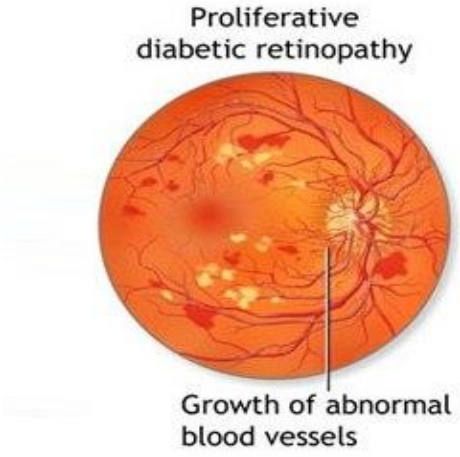

Figure 1.13 : Proliferative Retinopathy in Diabetic (type 2) patients

6. Hyperosmolar Hyperglycemic Nonketoic Syndrome(HHNS)

HHNS is exclusively a type 2 diabetic complication that is seen mostly among elderly people. This is a very serious complication that might implicate detrimental consequences. In HHNS, when the blood sugar rises, the body tries to get rid of the excess sugar via excretion through urine. The point to be noted is that, the blood sugar remains extremely high in these cases. At times, it can induce diabetic coma if left untreated. With extreme levels of blood sugar, when the body tries to get rid of it, it at times may cause complete dehydration thus leaving the patient hanging in the verge of death. Most of the times the patients experience dry mouth and thirst,

even if they do not feel thirsty. The body also tries to enforce frequent urination in large volumes, which becomes the tipping point. The general symptoms for HHNS are as follows :

- Blood sugar level over 600 mg/dl
- Dry, parched mouth
- Extreme thirst (although this may gradually disappear)
- Warm, dry skin that does not sweat
- High fever (over 101 degrees Fahrenheit, for example)
- Sleepiness or confusion
- Loss of vision
- Hallucinations (seeing or hearing things that are not there)
- Weakness on one side of the body

Though HHNS can occur due to various reasons, there are two primary reasons that are stressed on, as its primary cause.

- DM-2 patients stopping their drug doses for diabetes
- An infection or illness that has stressed the body

These can trigger immediate HHNS within a type 2 diabetic patient. (Fonseca V., Clinical Diabetes, 2006)

7. Glaucoma and Cataracts

Pressure builds inside the eyes when the fluids cannot be drained like they normally do. This occurs due to high blood glucose in type 2 diabetes patients. This condition is called as glaucoma. It can severely damage the blood vessels in the eyes and can also damage the retina.

There are basically two types of glaucoma. One is called open- angled glaucoma and the other is termed as narrow- angled glaucoma. Open angled glaucoma is much less severe in comparison. There is no pain involved in such condition. There is a constant pressure felt in the eyes, as the fluids are not drained properly as they need to. This constant pressure of the eyes, in open angled glaucoma can damage the optic nerve over the years and cause deterioration of normal vision. Normal medications can lower this excess pressure and can provide pressure relief.

The narrow angled glaucoma on the other hand, is a matter of grave concern. It is also termed as an acute attack. In this type, the drainage angle gets completely blocked and eye pressure rises

very quickly. This is a true medical emergency in patients and symptoms may include extreme eye pressure, severe eye pain, nausea, severe headache and visual color hallucinations**.** (Fonseca V., Clinical Diabetes, 2006)

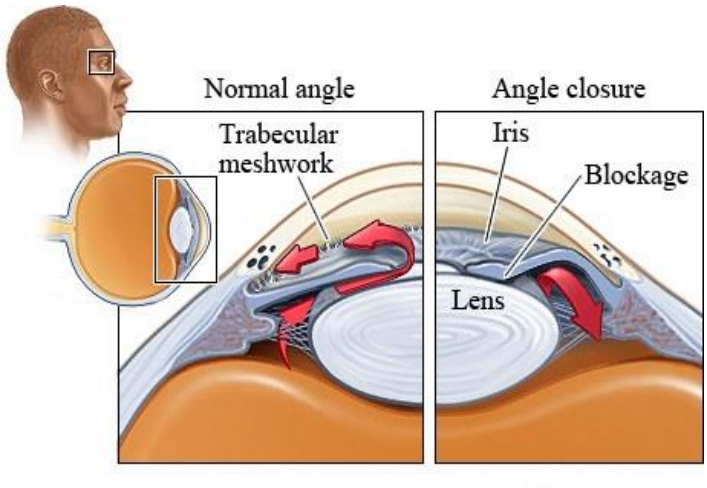

Figure 1.14 : Open angled and Closed angled glaucoma in diabetic patients

Cataracts pose a larger threat in type 2 diabetic patients who have a higher level of HbA1C. It is the clouding of the eye lens with sorbitol, a sugar formed from excess glucose, that develops gradually over the years on the eye lenses. Cataracts cause blurry vision and could enforce complete loss of eyesight. It is the primary cause of loss of eyesight among type 2 diabetic patients, aged 20-74 years (diabetes.co.uk, 2017).

People with consistent high blood sugars are at greatest risks of cataracts. Though easily removable, cataracts thus must require minor operations to be completely removed. At present times, laser operations are extremely efficient to remove cataract from the eyes, in case of diabetic patients (diabetes.co.uk, 2017).

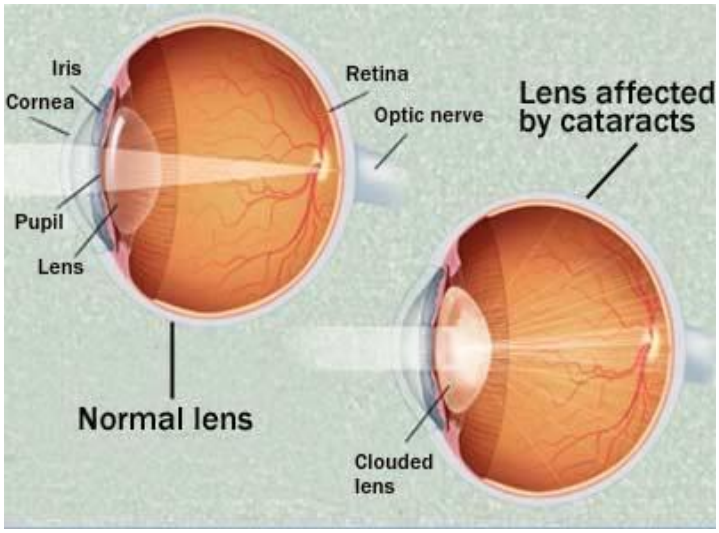

Figure 1.15: Cataracts causing a lesser amount of light to pass through the lenses

8. Gastroparesis

Gastroparesis is extremely common with diabetic patients and even more common among type 2 diabetes mellitus patients. It is also termed as delayed gastric emptying, that slows or hinders the movement of food from the stomach to the small intestine. Gastroparesis is also relatively common in people who have had a higher amount of blood sugar over a longer period of time.

The symptoms include:

- heartburn
- nausea
- vomiting of undigested food
- early fullness after a small meal
- weight loss
- bloating
- loss of appetite
- blood glucose levels that are hard to stabilize
- stomach spasms
- acid reflux

Gastroparesis is almost always a result of the damage to the vagus nerve. As type 2 diabetes causes peripheral nerve damage, thus a damage is also caused to the vagus nerve that results in gastroparesis among diabetic patients. There are also several other variety of factors that may result in the damage of the vagus nerve (Fonseca V., Clinical Diabetes, 2006).

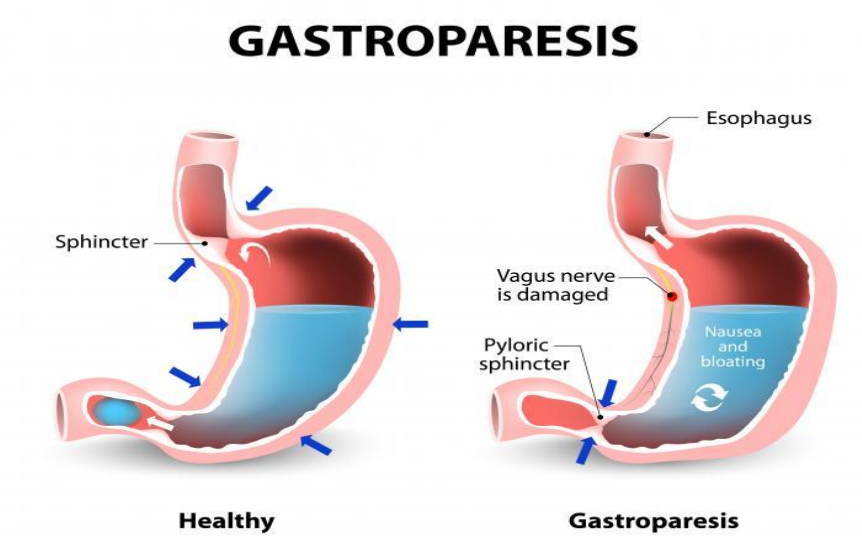

Figure 1.16: Representation of the stomach with Gastroparesis in type 2 diabetic patients

Diabetes mellitus has many detrimental impacts. From losing vision to multiple organ failures and gangrenes, diabetes offers a tremulously wide range of physiological conditions which only bring misery to the quality of life of an affected individual. It requires a rigorous management and utmost dedication to have a proper lifestyle, once somebody has been diagnosed with diabetes. When combined with hypertension, diabetes becomes an extremely difficult medical condition to manage.

1.4 Epidemiology at a glance and diagnosis of Diabetes Mellitus

Diabetes is the most common and complex medical condition that can lead to other more serious and sometimes life-threatening illnesses and complications. It's a great health problem globally and most importantly, in the developing countries. It is one of the most common non-communicable diseases and is the fourth or fifth leading cause of death in the most developed

countries. There is substantial evidence that, it is epidemic in many developing and newly industrialized nations. According to a WHO report, there are 366 million people living with diabetes worldwide, the number of affected people is predicted to reach 552 million by 2030. Diabetes is more prevalent in developing countries and may be related to the increasing urbanization, worldwide. The global prevalence of diabetes is 8.3% and 80% of people with diabetes live in low and middle-income countries. In Bangladesh, the diabetes prevalence is still very high.

Table 1.4.1 : Statistics on Diabetes in Bangladesh by IDF DIABETES ATLAS in 2015 (Source : IDF Diabetes Atlas, 2015)

Total Adult Population (1000s) (20-79 years)	95947
Prevalence of Diabetes in Adults (20-79 years)	7.4 %
Total case of Diabetes (1000s) Adults (20-79 years)	7138.9
Cost per person with Diabetes(USD)	41
No. of cases of Diabetes in adults that are undiagnosed (1000s)	3689.80

Because of the rapid increase in diabetes prevalence, the number of diabetes complications is rising quickly. Long time diabetes is a contributory factor in the development of diabetic complications such as macro-vascular and micro vascular complications. The macro vascular complications are related to atherosclerosis and include mainly coronary artery disease, peripheral vascular disease and cerebro-vascular diseases. Nephropathy, neuropathy and retinopathy are related to the micro vascular complications.

Diabetic retinopathy refers to the progressive pathologic alterations in the retinal microvasculature, leading to areas of retinal non-perfusion, increased vascular permeability and the pathologic proliferation of retinal vessels. Duration of diabetes (both type 1 and 2) is closely associated with the onset and severity of diabetic retinopathy. About 20% with T2DM patients develop retinopathy at the time of diagnosis of diabetes mellitus and most of them have some degrees of retinopathy over subsequent decades. Diabetic retinopathy is the primary cause of blindness among adults aged 18 to 70 years.

The clinical diagnosis of diabetes is often prompted by symptoms such as increased thirst and urine volume, unexplained weight loss and in severe cases, drowsiness and coma; high levels of glycosuria are usually present. The clinical features are encountered mostly in advanced stages of disease. However, for early detection, the proposed blood glucose values are given in a tabulated form as recommended by WHO Expert Committee are given as follows.

Table 1.4.2 : Clinical diagnosis of Diabetes Mellitus

Diabetes Mellitus	**Whole Blood**	**Plasma**
Fasting	Greater than or equal to 6.1 for venous and capillary	Greater than or equal to 7 for venous and capillary
2 hours after glucose load	Greater than or equal to 10 for venous and greater than or equal to 11.1 for capillary	Greater than or equal to 11.1 for venous and greater than or equal to 12.2 for capillary

Table 1.4.3 : Glucose concentration in mmol/L

Impaired-Glucose Tolerance	**Whole Blood**	**Plasma**
Fasting	Less than 6.1 for venous and capillary	Less than 7 for venous and capillary
2 hours after glucose load	From 6.7 to 10 for venous and from 7.8 to 11.1 for capillary	From 7.8 to 11.1 for venous and from 7.8 to 12.2 for capillary

The above classification proposed by WHO in 1985, is the one most widely accepted all over the world. Since Diabetes can lead to a variegated list of complications in its run, it is important to undergo treatment options and get checked out as soon as possible.

1.5 Objectives of The Research Work

1.5.1 General :

To assess and analyze the clinical and unrecognized effect and prevalence of epidemiological factors, risk factors and understand their association and impact, along with the assessment of hypertension as a complication, in relatively newly diagnosed type 2 diabetes mellitus patients at BIRDEM general hospital.

1.5.2 Specific :

- To evaluate the blood glucose level, cholesterol level, blood pressure, Serum ALT, Serum Creatinine, etc. and several other factors from the biochemical tests of the collected data, to assess hypertension and the presence of diabetes type 2 along with their impact and complications.

- To determine the relationship between hypertension and socio-demographic characteristics like social class, education, physical activity, marital status, etc. and also understand the role of these factors in relation with type 2 diabetes mellitus, thus establishing a complete epidemiological study.

- To determine the associations between diabetes, hypertension and several other risk factors like age, BMI, glycemic status and several of the other physiological co-variants involved.

- To determine hereditary connection of hypertension and diabetes, following the family tree data available from the collected data.

- To determine hypertension with other associated diseases like cardiovascular disease, kidney disease and other complications of diabetes and determine a statistical analysis of the treatments given to such patients.

1.5.3 Scope and Justification of the Research

The research work is aimed at recently diagnosed type 2 diabetes patients ranging from the age of 18 to 70 years old.

The value of this research work is of great importance to our country. We at present, have no study about undiagnosed prevalence of hypertension in newly diagnosed diabetic patients, in perspective of the individuals registered at BIRDEM general hospital. Moreover, there have been no studies in the local context, that link hypertension with type 2 diabetes considering such broad spectrum of co-variants. Clinical research has shown that hypertension is a growing health problem and the prevalence of hypertension is in the rise worldwide with or without the association of diabetes. So, this not only benefits to identify the prevalence of hypertension with newly diagnosed type 2 diabetic patients along with a detailed study of their risk factors, but also tries to find the genetic linkage of such disorders within the family tree of the diagnosed patients. It also conducts a detailed epidemiological study that would result in the proper understanding of the actual spread, management and control of such disorders and as a result, this research work will help to determine more appropriately designed therapeutic methods that could perhaps,

efficiently work to resolve the issues and complications of hypertension in context to type 2 diabetes along with the proper management of the patients' risk factors in consideration. It could also serve as a reference material for other ground breaking research works on hypertension and diabetes, in the future.

The non-communicable diseases or disorders like diabetes, Hypertension and Coronary Heart disorders are emerging as a major health problem in Bangladesh. The government of Bangladesh has given high research priorities on non-communicable diseases. Some small surveys on diabetes at community level showed higher prevalence of glucose intolerance and hypertension. BIRDEM is a unique referral center for diabetes health care. It has been working as a WHO collaborating center for diabetes care in South East region since 1982. This is the first referral model, not only in Asia but also in the entire third world, to undertake the comprehensive care of such a disorder like diabetes. More than three thousand diabetic subjects visit BIRDEM everyday either for registration or for the follow up. The objective of follow up is to control glycemia, triglyceride and hypertension and to maintain body weight.

Considering the increasing trend of diabetes mellitus and also the future need of diabetes health care in the country, it seems imperative to determine the diabetic complications among the patients undergoing follow up care. Thus, the outcome of the study will help in finding out the types of complications most prevalent in our community. Statisticians have developed varieties of methods which would not only cater to the normal mass but also would be helpful in the field of biotechnology to develop suitable therapy and medical procedures regarding hypertension and diabetes. The methods for analyzing longitudinal data will also allow for estimating the survival function, identifying the important risk factors with relation to complications over a period of time, which will help to undertake important intervention measures. All these possibilities will eventually lead to prevention of diabetic complications associated with the prevalence of hypertension and eventually lead to prevent diabetes, which is also a genetically inherited disorder, and thus assist in future planning and health policy implementation among our very own population in Bangladesh.

2. Literature Review

Hypertension results from a rise in the blood pressure. Though blood pressure is a highly variable physical trait depending upon the rate of physical activity and external environmental stimuli, the variation is an extremely complex phenomenon that depends on the day-night cycle and seasonal variations as well. Variations of blood pressure in the day and night was shown to be a risk factor for cardiovascular diseases a long time ago. The findings demonstrated that, the severity of hypertension was more closely related to the overall mean blood pressure during day and night ; not just the blood pressure at any given point of the day. Thus, this increases the chances for specific organ related catastrophes (Parati et al, 1987).

The determinants of such variation in patients was further elaborated by some researchers, while also analyzing a previous work by (Li et al, 2006 **).** According to these works; age, sex, adiposity, low socioeconomic status, ethnicity, etc. played a huge role in the development of hypertension among young individuals. The authors analyzed data using a multilevel growth curve model, an empirical model that is particularly suitable to analyze longitudinal datasets containing multiple observations for each of several participants, in which there is not an equal number of observations recorded on each participant. The model allows to fit a growth curve that represents the evolution of BP variability over time for each individual and to analyze the effect of individual variables on between-patient differences in such curves (Schillaci et al, 2010**).**

The study by (Li et al, 2006 **)** also provides an additional contribution to the research by reporting for the first time an association between father's low education levels and increased BP variability. These findings complement those which were obtained by (Chaix et al, 2006 **)** who reported, in 5941 French adults, that systolic BP increases with both decreasing individual education levels and decreasing education in the neighborhood of residence. In that study, body weight (expressed as body mass index or waist circumference) and heart rate modifications appeared to mediate the effects of both individual education and neighborhood education on BP. Taken together, these data may in part explain why people at low education and/or at low income are at increased cardiovascular risk, a finding that is not adequately predicted by current risk equations. Indeed, when assessing the atherosclerosis risk in communities, standard Framingham risk score underestimated coronary risk in people at low socioeconomic status (defined as <12 years of education or low income), and adding socioeconomic status to coronary risk assessment reduced this bias.

Such studies paved the way for an understanding that, rise in the hypertension is not merely dependent upon lifestyle factors but are also dependent on much elaborated sense of external and several other internal factors. Another study by researchers concluded that, "Compared with hypertensive people, total life expectancy was 5.1 and 4.9 years longer for normo-tensive men and women respectively." This is to state that, hypertension could thus be a cause of lesser life expectancy in adults. (Franco et al, 2005 **)**

Five years loss of life expectancy due to HTN seems extremely large if the total gain for all preventive and curative measures is 5years.according to a few researchers. Moreover, the 5-year loss is an average for all hypertensive patients in consideration. This means that it would be more than twice that for people at high risk like heavy smokers, those with high cholesterol, those engaging in no exercise, the obese and individuals with an SBP of 190 or more. Such an estimate is too high even for people at especially high risk. Finally, estimates of huge losses in life expectancy due to HBP cannot be supported at a much lower population level (Bunker et al, 1995).

In the 50 years since the introduction of the thiazide diuretics, many classes of antihypertensive drugs have been approved for use, for hypertension.

Five of these — diuretics, beta-receptor blockers, angiotensin-converting–enzyme (ACE) inhibitors, calcium-channel blockers, and angiotensin-receptor blockers — now represent the primary treatment options. In addition, several clinical trials were conducted that showed clear-cut benefits of therapy, beginning with the treatment of malignant hypertension. Subsequently, a few studies showed impressive reductions in cardiovascular events among patients with a pretreatment diastolic blood pressure of 115 to 129 mm Hg and later among those with a diastolic pressure of 90 to 114 mm Hg. The benefits were so impressive in the former study that a highly significant effect (in comparison with placebo) was observed with an intervention group of only 73 patients who were treated for 18 months.

Subsequent placebo-controlled trials showed the importance of blood-pressure lowering in elderly patients with isolated systolic hypertension with therapies based on the use of either diuretics or calcium-channel blockers. Most recently, the studies were expanded to include patients over the age of 80 years, among whom treatment with a diuretic and an ACE inhibitor was associated with a substantial reduction in mortality and morbidity from cardiovascular diseases.

Such reductions that have been achieved with antihypertensive therapy have been truly impressive. In placebo-controlled trials, the incidence of stroke has been reduced by an average of 35 to 40%, the incidence of coronary events by 20 to 25%, and the incidence of congestive heart failure by more than 50%. Malignant hypertension has become a rare entity, and acute hypertensive heart failure and hemorrhagic stroke are now uncommon **(**www.diabetes.org, 2017).

In 2004, a few researchers studied the sedentary lifestyle, obesity and impaired glucose regulation as the risk factors for type 2 diabetes. To identify the risk variables for type 2 diabetes, they used the Cox proportional hazard models. Proportional hazard models establish the relationship of an occurrence with that of time. In a proportional hazards model, the unique effect of a unit increase if a covariate is multiplicative with respect to the hazard rate. For example, taking a drug may halve one's hazard rate for a stroke occurring, or, changing the material from which a manufactured component is constructed may double its hazard rate for failure. This study was conducted in Finland in 1992 and included subjects aged 45 to 64 years. In this study classification of impaired glucose regulation was made based on a fasting plasma glucose and 2-hour plasma glucose levels. This study revealed that, subjects with impaired glucose regulation were older, had a lower education level, higher BMI, increased blood pressure and high prevalence of obesity than compared with normal glucose levels. Their study also addressed the joint association of physical activity, BMI and glucose levels with regard to the risk of type 2 diabetes. Increased physical activity was associated with increased risk of type 2 diabetes compared with subjects who were physically active, non obese and had impaired glucose level. Physical activity and weight control are critical factors in diabetes prevention; both in subjects with normal and impaired blood glucose level (Hu et al, 2004 **).**

In 2009, a study used the proportional hazards model for glucose control and vascular complications in Veterans with type 2 diabetes. They had taken two groups; the intensive therapy group started on maximal doses and the standard therapy group started on half the level of diabetic medications. A total of 1791 patients were enrolled in the study. The study found out that. the mean year since the diagnosis of diabetes was 11.5 and people receiving medications at the upper start of the study responded better. This study also carried out proportional hazard model analysis for explaining diabetes related complications (Duckworth et al , 2009 **).**

In a study based in Thailand from April 2003 to December 2003, which consisted 15 years and older people with type 2 diabetes; used the demographic data, age at diagnosis of diabetes, blood pressure, BMI, fasting plasma glucose, HbA1c, serum creatinine and vascular complications, including diabetic retinopathy, diabetic nephropathy, coronary artery disease, stroke, peripheral artery disease, foot ulcers and amputations. The study revealed that the prevalence of diabetic complications were significantly higher in long DM patients than compared with short DM patients. In this study it was also found that the risk of all vascular complications having diabetes for longer than 20 years was about 2 folds higher than patients having diabetes for less than 5 years except DR. In this study, they had not taken factors like genetics, medications or lifestyle.

In 2009, a study discussed its application to micro-vascular complications and risk factors in patients with type 2 diabetes. This study was cross sectional clinic based study and followed them in urban areas of Thailand. It was also observed that, longer durations of diabetes and poor glycemic control led to further complications. HbA1c played a vital role in this study (Mayurasakorn et al, 2009**).**

In 2011, another study used the logistic regression methods and discussed its applications to micro-vascular complications and also demonstrated the effects of risk factors in type 2 diabetic patients. The study also made logical connections of each of the risk factors with the subsequent portions of their focus data sets and also clarified on the points that led to complications with diabetic mellitus. Hypertension was since to be a risk factor in such complications and worsening of conditions in diabetic patients (Gomez et al, 2011).

In 2008, another study discussed the ten years follow up study in type 2 diabetes and newly diagnosed type 2 patients had been taken here to assess the association between microvascular complications, myocardial infarction and blood glucose. This study concluded that the levels of blood pressure and plasma creatinine and the ratio of albumin to creatinine did not differ significantly between two groups at any given time. This study also found that for reducing risk of cardiovascular related disorders, lipid lowering therapy with statins must be used. This in turn, lowers blood pressure as well (Holman et al, 2008).

A study occurring from 1981 to 1991 by another study wanted to determine the effect of potential risk factors on the three aggregate end points, assessed by Cox proportional hazard models. In this study, the independent variables included fasting blood glucose, HbA1c, DBP, SBP, Hypertension, LDL, HDL, TG, insulin, exercise and smoking. They found that, LDL,

HbA1c, SBP, DBP and smoking were not risk factors for fatal myocardial infarction. In this study, they also try to find the Cox model estimated hazard ratios for age and sex and the step wise selected variables for all the three types of diseases. So this study concludes that the complications will be prevented or delayed if the patient controls their LDL, HbA1c and BP. The BP is directly related to hypertension. They did not consider social class or family history of hypertension in this study (Nathan et al , 1991).

In 2002, another study used the proportional hazard model for micro-vascular complication of type 2 diabetes. In this study they have considered two states, one transient state and one absorbing state namely the complications stage. The aim was to determine risk factors for the development of different types of complications with type 2 diabetes. In this study, Cox proportional hazards model was performed with development of complications. Several connections between the risk factors of diabetes like height ,weight, BP, etc. were established (Boguslawa et al, 2002).

3. Materials and Methods

3.1 Place of the study

The study was conducted in **Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM)**, situated in Shahbag, Dhaka-1000. The primary location of the data retrieval was the BIRDEM hospital, Department of Epidemiology and Biostatistics.

3.2 Duration of the study

The study commenced in the month of July, 2017 and lasted till November, 2017.

3.3 Population of the study

The population of the study was chosen to be the relatively newly diagnosed type 2 diabetes mellitus patients receiving treatments from BIRDEM hospital. They patients were registered and receiving treatments from the hospital, at the time of the study. A total number of **24,000** patient data was collected. After screening and proper data cleaning procedures, a total number of **17,401** patients were selected. They all had the fasting blood glucose of 7.0 and above on separate multiple cases of testing and were diagnosed with the type 2 diabetes mellitus by their respective attending physicians.

3.4 Methodology

The data collected from BIRRDEM hospital were initially screened for missing, repeated and malicious data. After the primary data cleaning procedures, all the data that were irrelevant were disregarded. Values that were too big for analysis were tabulated into groups for deeper sense of understanding and observation. All the data were then categorized in the format of frequency tabulation and cross tabulation in order to perform analysis on various aspects. Several statistical tests were run as well to determine the results and reach a conclusion. The software used for statistical analysis was SPSS, developed by the IBM.

4. Results

Table 4.1 : Demographic data

Table 4.1.1: Frequency distribution of type 2 diabetic patients based on sex (n= 17401)

Sex	Frequency	Percentage
Male	8612	(49.5 %)
Female	8789	(50.5 %)
Total	17401	100 %

From the data of 17401 patients it was seen that, among the type 2 patients considered in the study, the number of females prevailed in comparison to the opposite sex. While 8789 of them were females, 8612 of them were males.

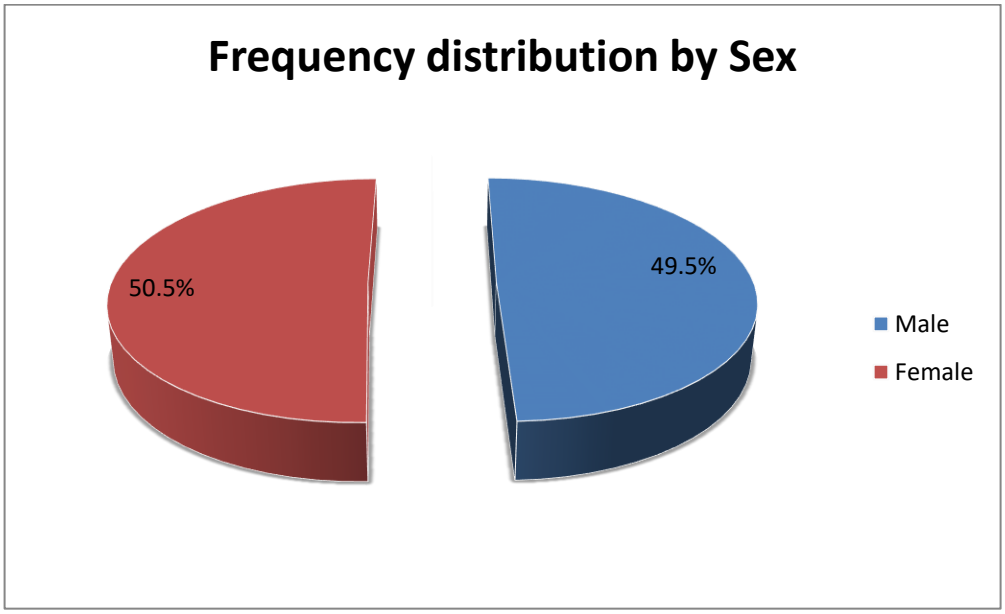

Figure 4.1: A pie chart demonstrating the percentage of males and females in the study

Table 4.1.2 : Frequency distribution of diabetes type 2 patients by age group (n=17401)

Age (years)	Frequency	Percentage
18-20	64	0.4%
21-30	1359	7.8 %
31-40	4361	25.1 %
41-50	5994	34.4 %
51-60	4101	23.6 %
61-70	1522	8.7 %
Total	17401	100 %

From the table above, it can be clearly seen that, among 17401 type 2 diabetes patients, the greatest number of patients belong in the range of 41-50 years of age. If a cumulative percentage is taken between 31-60 years of age, an astonishing 83.1% of the patients is seen to exist between that range. This further illustrates the finding that, type 2 diabetes occurs in people with comparatively older age. Also, patients from the range of 41 years to that of 50 years (34.4 %) are seen to be the dominant percentage, while the type 2 diabetes mellitus patients, by age group.

Table 4.1.3 : Frequency distribution of type 2 patients with their area of residence in childhood (n=17401)

Area of residence	Frequency	Percentage
Rural	14745	84.7 %
Urban	2254	13.0%
Suburban	385	2.2 %
Other	17	0.1 %
Total	17401	100 %

From the table listed above, it is clearly seen that most of the type 2 diabetic patients who had come for treatment at the BIRDEM hospital, had mostly spent their childhood in the rural areas. The percentage being at 84.7% thus denotes that most people grew up in the village zone. Whereas only 13.0% and 2.2 % of the population stayed in the urban or the suburban area. The remaining 0.1%, were born and brought up in abroad and later on came to Dhaka during their treatment.

Table 4.1.4 : Frequency distribution of type 2 patients with their area of residence in adulthood (n=17401)

Area of residence	Frequency	Percentage
Rural	9107	52.3 %
Urban	7421	42.7%

Suburban	838	4.8 %
Other	35	0.2 %
Total	17401	100 %

The table above illustrates the finding that, a greater percentage of people (52.3%) resided in the rural areas, during their adulthood as well. Furthermore, it also illustrates that BIRDEM receives relatively larger number of people from the rural zones who come for their treatment as compared to the people living in Dhaka. It is due to the free treatments and also the lack of good medical support in the rural zones, that drive them here.

Table 4.1.5 : Frequency distribution of marital status of type 2 diabetic patients (n=17401)

Marital Status	Frequency	Percentage
Married	17257	99.2 %
Unmarried	111	0.6 %
Other	3	0.2 %
Total	17401	100 %

The table of marital status signifies that, a very high number of diabetic 2 patients who come into BIRDEM hospital for treatment, are married. The percentage being a highly dominant 99.2%.Whereas for not being married, the percentage is merely a 0.6%. The "Other" section contains people who have been divorced, separated or one of the spouses have been recently deceased.

Table 4.1.6 : Frequency distribution of social class of type 2 diabetic patients (n= 17401)

Social Class	Frequency	Percentage
Rich	525	3.0 %
Upper middle	2761	15.8 %
Lower middle	10002	57.5 %
Poor	4065	23.4 %
Destitute	48	0.3 %
Total	17401	100 %

The social class of the patients is determined by the attending physician's impression about the patients. The physicians generally tend to ask the patients about their livelihood, family expenses, number of family members and their monthly income, which allows the physicians to reach a conclusion. The data demonstrates that, a dominant 57.5 % of the patients were from the lower middle class, which further illustrates that people with comparatively less amount of money are more inclined to visiting BIRDEM hospital. The data also shows that though it is a public hospital and the treatments are mostly free or cheaper; most of the patients who visit BIRDEM, are not poor or destitute. They rather have a steady income and belong from the zone of above the poverty level. A cumulative percentage of 76.3 % of the type 2 patients were from above the level of "Poor" zone, which indicates the upper middle class, lower middle class and the rich people. Though the rich and upper middle class constitute of merely 3 % and 15.8 % of the patients involved in the study, it still

supports the analysis that, majority of the patients with moderately lower but a steady income level are the ones who seek treatment at BIRDEM hospital.

Table 4.1.7 : Frequency distribution of education levels of type 2 diabetic patients (n= 17401)

Level of Education	Frequency	Percentage
Illiterate	4412	25.4 %
Can read only	1762	10.2 %
Can write a letter	4134	23.8 %
SSC or equivalent	2427	13.9 %
HSC or equivalent	1643	9.4 %
Graduate or higher	2720	15.6 %
Other	303	1.7 %
Total	17401	100 %

Shockingly, the above table illustrates that, a high number of patients concerned in the study were illiterate; the percentage being 25.4%. In today's world if 1/4th of a given population is illiterate, it is a matter of grave concern. It could mostly be due to the reason that, a high percentage (52.3%) of the people as seen before, belong from the rural areas. Since this study previously found that an alarming number of 23.4% of the patients were poor and 0.3 % destitute, it could also explain the illiteracy rate, as they could not afford an education in rural/urban areas. The "other" section

represents people who possess technical skills and or also have very little grasp on words and sentences.

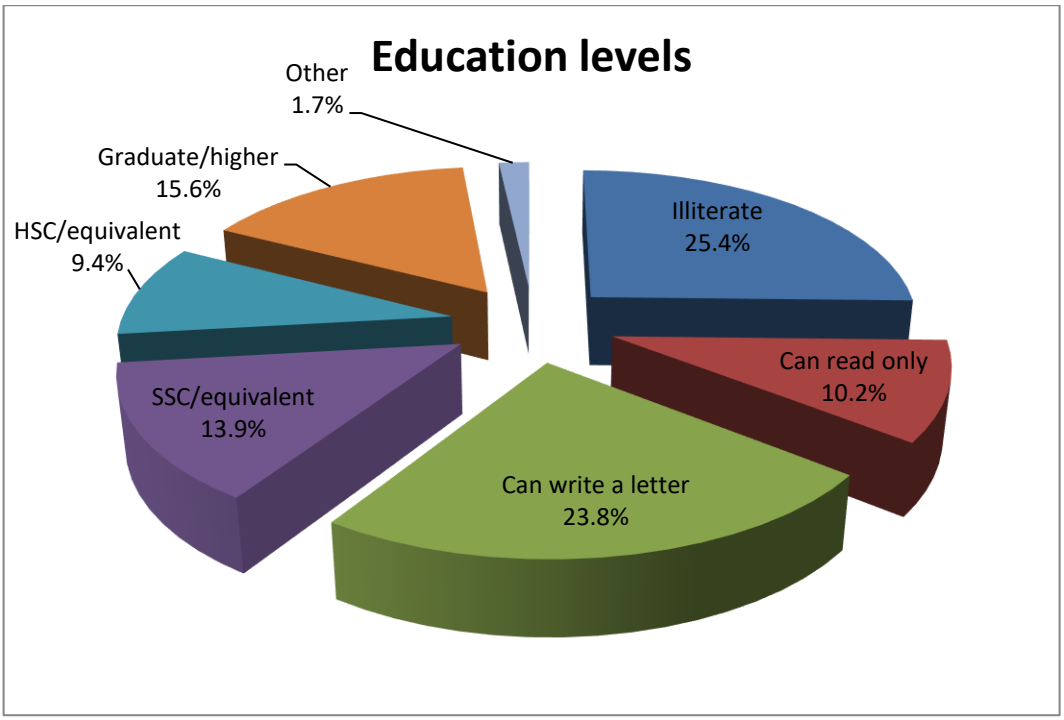

Figure 4.2: A pie chart demonstrating the education levels of DM-2 patients in the study

Table 4.1.8: Frequency distribution of the number of family members in type 2 diabetic patients (n =17401)

Family members	Frequency	Percentage
1 member	341	2.0 %
2-5 members	12858	73.9 %
6-10 members	3983	22.9 %

More than 10 members	219	1.2 %
Total	17401	100 %

The table above illustrates that, 73.9 % of the patients in the study had 2-5 members in their family. From the perspective that a high percentage of the patients belong from the rural areas, the data illustrates that 2-5 family members were common in such patients, within the given study. It also shows that 22.9% of the type 2 DM patients had more than 5 members in the family and another 1.2 % had more than 10 members. This perhaps could be associated with the overpopulated conditions in Dhaka and also Bangladesh, in a broader perspective

Table 4.1.9: Frequency distribution of occupations of type 2 diabetic patients (n = 17401)

Occupation	Frequency	Percentage
Professional/ Managerial/Business	3343	19.2 %
Clerical	431	2.5 %
Technical	386	2.2 %
Skilled worker	643	3.7 %
Partially skilled worker	765	4.4 %
Unskilled worker	714	4.1 %

Unemployed/ Pensioner	1022	5.9 %
Housewife	7745	44.5 %
Others	2352	13.5 %
Total	17401	100 %

The above data clearly states that, the highest percentage of the diabetic population in the study are from the housewife category, which is 44.50 %. This is consistent with the total data, as 50.5 % of the total population in the study, are women. Moreover, a pattern is observed here. 19.2 % of the population work at desk jobs with a good income source. This implies that, a dominant percentage of type 2 diabetic patients in this study, were sedentary in nature. This will be further elaborated while analyzing the data on physical exercises section, in this research work. The "others" section above, concerns people who are at several different types of other profession like, men of the mosque, monks, non-profit workers, etc. and a total of 13.50 % of the total patients are in such category.

Table 4.1.10 : Frequency distribution of family expenses in type 2 diabetic patients (n=17401)

Family Expense (Tk)	Frequency	Percentage
300 - 5999	2556	14.7 %
6000 - 15999	6577	37.8 %

16000 - 25000	3783	21.7 %
25001 - 40000	2869	16.5 %
40001 - 59999	898	5.2 %
60000 - 99999	459	2.6 %
100000 and above	259	1.5 %
Total	17401	100 %

From the table above it is clearly seen that, the highest percentage of diabetic patients in this study, had a monthly family expense ranging from 6000 - 15999 TK. The percentage is 37.8 %. This is consistent with the previously analyzed data of social class that, the majority of the patients were from the lower middle class. Another 16.5 % are seen to be spending 25001-40000 TK monthly and as the amount of monthly expenditure increases, the percentage of population keeps on going down. Moreover, it is also observed that, 14.7 % of the population spends 300- 5999 TK monthly as family expenses.

Table 4.2 : Lifestyle data

Table 4.2.1 : Frequency distribution of physical exercise in type 2 diabetic patients (n=17401)

Physical Exercise Level	Frequency	Percentage
Sedentary	8338	47.9 %
Light	7305	42.0 %

Moderate	1631	9.4 %
Heavy	127	0.7 %
Total	17401	100 %

The data above illustrates that, most of the type 2 diabetic patients remained sedentary that is, restrained to very minimal physical exercise. The percentage for that is 47.9 %. The other 42.0 % were involved in jobs that required a minimum of 1 hours of walking everyday and thus, involved very light exercise. The moderate section (9.4 %) represents slightly heavier workload in comparison like sweeping floors, workshop, etc. while, the last category enlists patients who are laborers, rickshaw pullers, etc and are involved in heavy physical workloads on a daily basis (0.7 %). This would indicate that, type 2 diabetes patients in this study, went through a low daily level of physical exercise.

Table 4.2.2 :Frequency distribution of smoking habits in type 2 diabetic patients (n= 17401)

Smoking habit	Frequency	Percentage
Never	14666	84.4 %
Ex- smoker	1332	7.6 %
Current smoker	1403	8.0 %
Total	17401	100 %

The table of smoking habit represents that a high number of the patients in the study, 84.4 %, have never smoked a cigarette in their lifetime. This can also be established by the fact that, more than 50% of the participants were females, a huge number of whom belonged from the rural areas. Moreover, 7.6 percent were ex smokers and an 8.0% of the population in the study are current smokers.

Table 4.2.3 :Frequency distribution of Tobacco/ Jarda/ Betel leaf habits in type 2 diabetic patients (n= 17401)

Tobacco/Jarda/Betel leaf	Frequency	Percentage
Yes	2829	16.3 %
No	14572	83.7 %
Total	17401	100 %

The table above illustrates that, 83.7% of the patients in the study had denied of ever consuming tobacco, jarda or betel leaf whereas 16.3% agreed to the consumption of either of the tobacco-chewing based products. This demonstrates that, majority of the patients in the study were disinclined to the concept of consumption of tobacco in personal life.

Table 4.3: Clinical and Biophysical Data

Table 4.3.1: **Frequency distribution of Body Mass Index (BMI) in type 2 diabetic patients (n=17401)**

BMI	Frequency	Percentage
Underweight	731	4.2 %

Normal	8439	48.5 %
Overweight	6304	36.2 %
Obese	1927	11.1 %
Total	17401	100 %

BMI was calculated by the formula {Weight/ (Height*Height) }. The height and the weight of the patients were grouped in BMI format for the purpose of detailed analysis regarding their physical well being. The Underweight section (BMI 0- 18.4) demonstrates that, only 4.2% of the population were below the optimum body mass index and thus are termed as underweight. Next, 48.5 % of the type-2 diabetic patients were observed to have normal (BMI 18.5 - 24.9) body mass index. 36.2 % of the population had a BMI which is in the overweight range (BMI 25 - 29.9) and hence grouped as overweight. Finally, 11.1 % of the population had a BMI in the range of obese (BMI 30 and above) and thus, were grouped as obese. The data demonstrated that, a significant percentage (48.5 %) of the diabetic population in the study, had a normal body mass index.

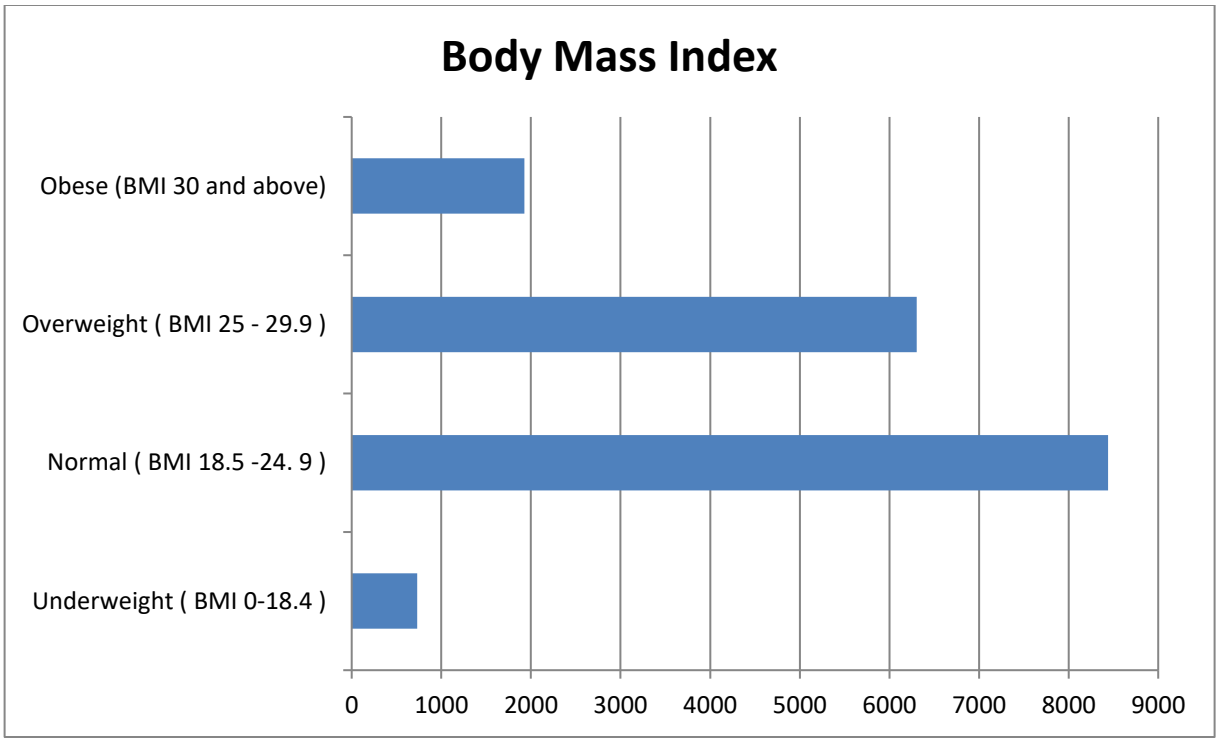

Figure 4.3: A bar graph representation of Body Mass index in the total population of type 2 diabetic patients in the study

Table 4.3.2 :Frequency distribution of resting heart rate in type 2 diabetic patients (n=17401)

Pulse / min	Frequency	Percentage
59 and below	26	0.1 %
60- 100	17171	98.7 %
101- 120	195	1.1 %
121 and above	9	0.1 %

Total	17401	100 %

The normal resting heart rate of an individual is defined to be in the range of 60 - 100 beats per minute. People who are highly athletic or have mild structural irregularities in the heart, have a resting heart rate, which is much lower than that. The table in the last page, has such low rate individuals as a very minor percentage of 0.1 %. The table above also shows that, majority of the population in the study, 98.7 % , had a normal resting heart rate in the range of 60 -100 beats per minute. While 1.1 % of the patients had a heart rate above 100 but below 121. They are at a high risk of cardio-vascular diseases. Moreover, the type 2 diabetic patients (9 of them) who are above 121 beats per minute, 0.1 % , are at the highest risk or have had cardio-vascular problems as one their complications.

Table 4.3.3 :Frequency distribution of systolic blood pressure in type 2 diabetic patients (n=17401)

Systolic BP	Frequency	Percentage
109 and below	1299	7.5 %
110 - 119	2637	15.2 %
120	6410	36.8 %
121 -140	5868	33.7 %
141 and above	1187	6.8 %

A systolic blood pressure of exactly 120 is the normal value. Generally, the numbers 109-119 are considered safe as well but much way below 109 (below 80) would be a sign of acute low blood pressure, which could be fatal (www.diabetes.org, 2017). The data contains 7.5 % of the type 2 diabetic patients in values below 109. The patients considered in the study did not have a systolic BP of less than 80. However, only 15.2 % had a systolic BP ranging from 110 to 119. The highest percentage of the population had a normal systolic BP which was 120. The range of 121-140 is considered as pre-hypertensive state which is a good predictor of future complications regarding heart diseases or stroke. An alarming 33.7% of the population were in that range and thus are termed to be pre-hypertensive. A systolic BP above 140 is considered as hypertensive and thus proves the presence of hypertension. Only 6.8 % of the population were thus seen to be hypertensive from the grouped data.

Table 4.3.4 : Frequency distribution of diastolic blood pressure in type 2 diabetic patients(n=17401)

Diastolic BP	Frequency	Percentage
70 and below	507	2.9 %
71 - 79	2190	12.6 %
80	11568	66.5 %
81 - 90	2086	12.0 %
91 and above	1050	6.0 %

Total	17401	100 %

A diastolic BP of 80 is considered to be normal. Though the range from 70 to 79 is considered harmless as well, a diastolic BP much lower than 70 could be fatal. The table above demonstrates that, majority of the population in the study, 66.5 % , had a diastolic BP of exactly 80. This is in the normal range. 12.6% were in the range of 71 to 79 which is considered harmless as well and 2.9 % of the total patients were below 70. However, another 12.0 % of the total population was seen to be pre-hypertensive as they had a diastolic BP of 81 to 90 (www.diabetes.org, 2017). Being pre-hypertensive means that they could have serious complications of heart related disorder and stroke in the upcoming future. Once again, only 6.0 % of the type 2 diabetic population in the study was seen to be hypertensive, as they had a diastolic BP of 91 and above. This table indicates that, among the total pre-hypertensive population, there are more people who have erroneous systolic BP than an irregular diastolic BP, responsible for the pre-hypertensive stage.

Table 4.3.5 :Frequency distribution of fasting blood glucose in type 2 diabetic patients (n =17401)

Fasting blood Glucose(mmol/L)	Frequency	Percentage
Below 7	0	0 %
7 and above	17401	100 %

The table above clearly shows that, all the patients in the study have a fasting blood glucose level of 7 and above. The fasting blood glucose results were obtained after multiple tests on individual patients, over a certain period of time. For diabetes mellitus type 2, the fasting blood glucose must be 7 and above and thus it shows that, all the patients taken into account have type 2 diabetes.

Table 4.3.6 :Frequency distribution of total cholesterol levels in type 2 diabetic patients (n= 17401)

Cholesterol level (mg/dl)	Frequency	Percentage
Desirable (0 -199)	11172	64.2 %
Borderline high (200-239)	4184	24.0 %
High (240 and above)	2045	11.8 %
Total	17401	100 %

From the table, it is demonstrated that, 64.2 % of the patients in the study had a desirable amount of total cholesterol. 24.0 % had a borderline high amount with risk of cardiovascular disorders and about 11.8 % had high to very high cholesterol levels. This is consistent with the BMI data in the sense of obesity, as 11.1 % of the patients were seen to be obese. Similarly, 11.8 % of the diabetic patients have high cholesterol levels.

Table 4.3.7 :Frequency distribution of serum Alanine Transferase levels in type 2 diabetic patients (n= 17401)

ALT level (units/liter)	Frequency	Percentage
0 - 6.9	39	0.2 %
7- 56	15730	90.4 %

57- 167	1544	8.9 %
168 - 200	65	0.4 %
201 and above	23	0.1 %
Total	17401	100 %

The table shows that, 90.4 % of the type 2 diabetes patients had normal range of ALT levels which is 7 to 56 units per liter. This means they had proper liver function. 0.2% had below 7, which is a sign of excellent liver functioning. Only when there is a damage in the liver, ALT enzyme escapes in to the blood and thus can be examined. 8.9 % of them had a mild elevation up to 3 times the normal level, which can be due to conditions like fatty liver. the values above 167 is explained by progressive stages of fatty deposits in liver and hence 0.4 % are seen to have such conditions. Finally, above 200 units per liter is a sign of extensive liver damage which can be caused due to final stage of fatty acid, commencement of cirrhosis, severe impairment in liver functioning or alcoholic hepatitis. only 0.1 % of the patients exhibited such state.

Table 4.3.8 :Frequency distribution of hypertension in type 2 diabetic patients (n= 17401)

Hypertension	Frequency	Percentage
Yes	3825	22 %
No	13576	78 %
Total	17401	100 %

The data from the complications section was taken into account and people with hypertension were grouped separately. It was seen from the data set that 22 % of the patients with type 2 diabetes were suffering from hypertension.

Table 4.4 : Family history data

Table 4.4.1 : Frequency distribution of history of diabetes in the family of type 2 diabetic patients (n = 17401)

Family History	Grandparents	Father	Mother	Brother/ Sister
No	14082 (80.9%)	13156 (75.6%)	12524 (72.0%)	12189 (70.0%)
Yes	270 (1.6%)	2368 (13.6%)	3177 (18.2%)	4019 (23.1%)
Unknowr	3049 (17.5%)	1877 (10.8%)	1700 (9.8%)	1193 (6.9%)
Total	17401	17401	17401	17401

From the table above it can be observed that, a strong majority of the type 2 diabetic patients denied of having any family history of diabetes. Only a minor 1.6 % had a history of their grandparents with the disease, 13.6% stated their father to be affected, 18.2% agreed of their mother being affected, while 23.1% of the patients reported that their siblings have had a history of diabetes.

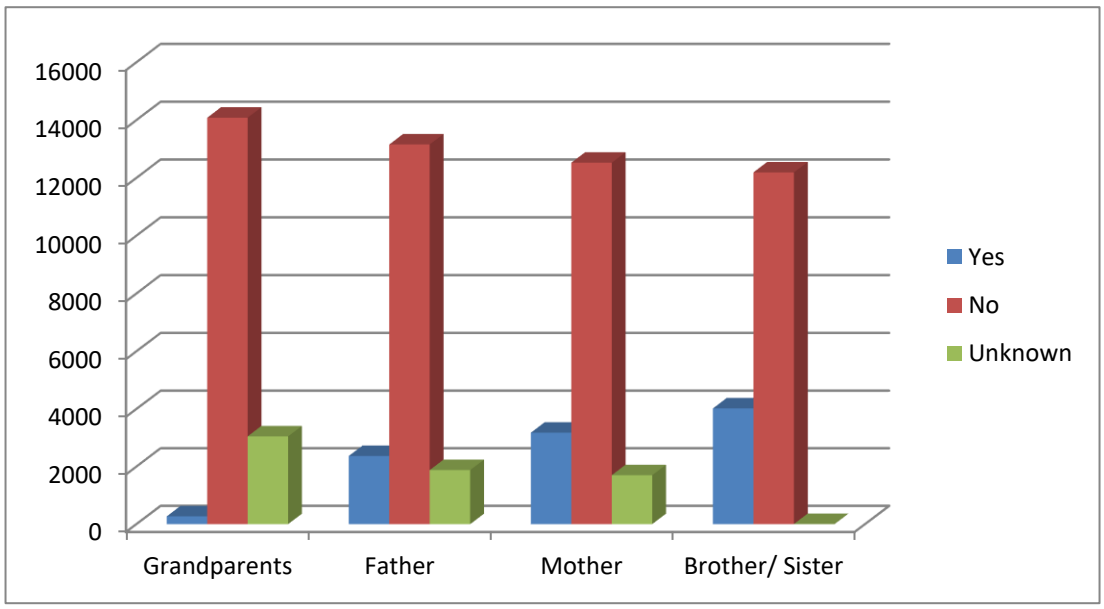

Fig 4.4: A bar graph representation of the family history of diabetes in type 2 patients

Table 4.4.2 : Frequency distribution of history of hypertension in the family of type 2 diabetic patients (n = 17401)

Family History	Grandparents	Father	Mother	Brother/ Sister
No	14163 (81.4%)	14275 (82.0%)	13881 (79.8%)	14558 (83.7%)
Yes	127 (0.7%)	1239 (7.1 %)	1755 (10.1%)	1438 (8.3%)
Unknown	3111 (17.9%)	1887 (10.8%)	1765 (10.1%)	1405 (8.1%)

Total	17401	17401	17401	17401

The table above demonstrates that, a strong majority of the patients did not agree to have any family history of hypertension as well. Only a minor 0.7% agreed that their grandparents had hypertension, 7.1% agreed their father to have been affected, 10.1% reported their mother to have had hypertension and another 8.3% agreed that their siblings have been victims of hypertension.

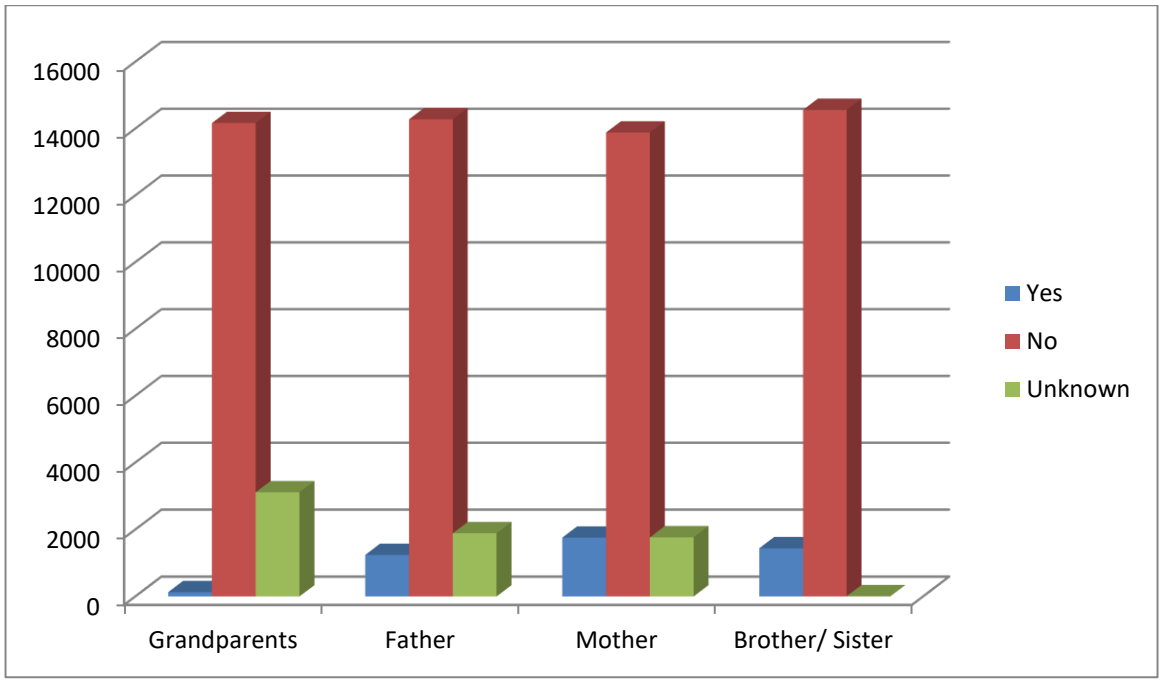

Fig 4.5 : A bar graph representation of the family history of hypertension in type 2 diabetes patients

Table 4.5: Cross-tabulation

Table 4.5.1: Cross Table Analysis between the sex and the prevalence of hypertension among type 2 diabetes mellitus patients (n = 3825)

Sex	Hypertension	Percentage	Total
Male	1728	45.2 %	1728
Female	2097	54.8 %	2097
Total	3825	100 %	3825

From the analysis in the given table, it can be observed that, among the type 2 diabetes mellitus patients, 3825 (22%) of them had hypertension, and the majority among them was female. According to the table above, 54.8 % of the patients with hypertension were of the female sex and 45.2 % were males. Thus, it can be concluded that, among the type 2 patients in the study group, hypertension is more prevalent among women than compared to men.

Table 4.5.2: Cross Table Analysis between Sex and Body Mass Index among the type 2 Diabetes Mellitus patients (n = 17401)

Sex	Body Mass Index (BMI)								Total	
	Underweight		Normal		Overweight		Obese		Freq.	%
	Freq.	%	Freq.	%	Freq.	%	Freq.	%		
Male	428	2.5%	4816	27.7%	2870	16.5%	498	2.9%	8612	49.5%
Female	303	1.7%	3623	20.8%	3434	19.7%	1429	8.2%	8789	50.5%
Total	731	4.2%	8439	48.5%	6304	36.2 %	1927	11.1%	17401	100%

The table above vividly illustrates that, among the 4.2% of the patients that are below the normal BMI range; a greater percentage of males, 2.5% are underweight. The data also shows that, 27.7% of the males have a normal BMI as in comparison to the females in the study. The study also found that, a greater percentage of the female patients were overweight and obese. 19.7% and 8.2% respectively, are the percentages for females who were overweight and obese. Whereas in comparison, 16.5 % and only 2.9% of the males were overweight and obese, respectively.

Table 4.5.3 : Cross Table Analysis between hypertension and physical exercise in type 2 diabetic patients (n = 3825)

	Physical Exercise									
	Sedentary		Light		Moderate		Heavy		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Hypertension	1814	47.4%	1630	42.6%	355	9.3%	26	0.7%	3825	100%
Total	1814	47.4%	1630	42.6%	355	9.3%	26	0.7%	3825	100%

The table above clearly demonstrates that, among the type 2 diabetic patients those who were hypertensive, 47.4 % were sedentary or had very little to no physical movement at all. People with light workload made up of 42.6 % of the hypertensive population, 9.3 % were in the moderate zone and only 0.7 % had heavy workout. The pattern clearly demonstrates that, people with lower levels of physical activity are present in a higher percentage, to have been suffering from hypertension. With increasing physical activity, there is a decreasing trend in the population of hyper-tensives, among type 2 diabetes mellitus patients.

Table 4.5.4 :Cross Table Analysis between serum creatinine and sex types among the type 2 diabetic patients (n = 17401)

Sex	Creatinine (mg/dl)							
	0 - 0.5		0.6 - 1.1		1.2 and above		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Male	19	0.1 %	7339	42.2 %	1254	7.2 %	8612	49.5 %
Female	19	0.1 %	8185	47.0 %	585	3.4 %	8789	50.5 %
Total	38	0.2 %	15524	89.2 %	1839	10.6 %	17401	100 %

The table above shows that, the majority of the patients, 89.2 %, had a creatinine level below 1.2 mg/dl. Normal level of creatinine in blood are 0.6 - 1.1 or 1.2 mg/dl for adult males and 0.6 - 1.1 mg/dl for adult females. This indicates that, the majority of the type 2 diabetic patients in the study, had normal kidney functioning.

Table 4.5.5 : Cross table analysis between hypertension and social class of type 2 diabetic patients (n = 3825)

	Social Class										Total
	Rich		Upper middle		Lower middle		Poor		Destitute		
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Hypertension	129	3.4%	682	17.8%	2346	61.4%	658	17.1%	10	0.3%	3825 100 %

Total	129	3.4%	682	682	2346	61.4%	658	17.1%	10	0.3%	3825 100 %

The table demonstrates that among the type 2 diabetic patients who have hypertension, the majority of them; 61.4 %, belong from the lower middle class. 17.8 % are from the upper middle class, 17.1 % are poor and 3.4 % belong from the rich society. Only 0.3 % of the hypertensive diabetic patients are destitute.

Table 4.5.6 : Cross table analysis between hypertension and cholesterol levels in type 2 diabetic patients (n = 3825)

Cholesterol	**Hypertension**		**Total**	
	Frequency	**%**	**Frequency**	**%**
Desirable (0-199)	2578	67.4 %	2578	67.4 %
Borderline high (200-239)	836	21.9 %	836	21.9 %
High (240 and above)	411	10.7 %	411	10.7 %
Total	3825	100 %	3825	100 %

The table above illustrates that among the 3825 patients who had hypertension, a strong majority of 67.4 % had a desirable cholesterol level. A moderate amount of 21.9 % had a borderline high cholesterol and the remaining 10.7 % had a high cholesterol level. However, a large number of

the patients who exhibited borderline high BP, also exhibited or complained of typical symptoms or had a history of hypertension in recent past. Thus the attending doctors were determined to add hypertension as a " complication " in the patient data sheet.

Table 4.5.7 : Cross table analysis between hypertension and smoking habits in type 2 diabetic patients (n = 3825)

Smoking	Hypertension		Total	
	Frequency	%	Frequency	%
Never	3230	84.5 %	3230	84.5 %
Ex - Smoker (6+months)	331	8.6 %	331	8.6 %
Current smoker	264	6.9 %	264	6.9 %
Total	3825	100 %	3825	100 %

The above table further demonstrates that, a strong majority of the hypertensive diabetic patients, 84.5 %, denied of smoking completely. 8.6 % of the hypertensive patients agreed on being ex smokers and 6.9 % of the patients only agreed on being a current smoker. The data thus suggests that, smoking is not related to hypertension in the given type 2 diabetic patients.

Table 4.5.8 : Cross table analysis between hypertension and tobacco/ jarda/ betel leaf habits in type 2 diabetic patients (n = 3825)

Tobacco/Betel leaf/Jarda	Hypertension		Total	
	Frequency	%	Frequency	%
Yes	599	15.7 %	3230	84.5 %
No	3226	84.3 %	331	8.6 %
Total	3825	100 %	3825	100 %

The table suggests that, the majority of the patients, 84.3 % denied of ever consuming tobacco based products. Thus, it could suggest that perhaps, tobacco products may not be cardinal to the cause of hypertension in type 2 diabetic patients since a dominant percentage shows a refusal of usage.

Table 4.5.9 : Cross table analysis between hypertension and area of residency (adulthood) in type 2 diabetic patients (n = 3825)

Area of residency (adulthood)	Hypertension		Total	
	Frequency	%	Frequency	%
Rural	1913	50.0 %	1913	50.0 %
Urban	1689	44.2 %	1689	44.2 %
Suburban	216	5.6 %	216	5.6 %

Other	7	0.2 %	7	0.2 %
Total	3825	100 %	3825	100 %

The table demonstrates that, majority of the diabetic patients who had a complication of hypertension, belonged from the rural areas of residency during their adulthood. 50.0 % of the hypertensive population spent a 3/4th of their lifetime in the rural parts of the country. However, another 44.2 % and 5.6 % respectively, resided in the urban and the suburban setting. This vividly demonstrates the clear distribution of hypertensive diabetic patients across the country, for the given data set and also states that, type 2 diabetic patients from the rural setting are higher in percentage for complications regarding hypertension.

Table 4.5.10 : Cross table analysis between hypertension and family expense in type 2 diabetic patients (n = 3825)

Family expense (Taka)	**Hypertension**		**Total**	
	Frequency	**%**	**Frequency**	**%**
300 - 5999	423	11.1 %	423	11.1 %
6000 - 15999	1343	35.1 %	1343	35.1 %
16000 - 25000	886	23.2 %	886	23.2 %
25001 - 40000	734	19.2 %	734	19.2 %

40001 - 59999	249	6.4 %	249	6.4 %
60000 - 99999	121	3.2 %	121	3.2 %
100000 and above	69	1.8 %	69	1.8 %
Total	3825	100 %	3825	100 %

The table above suggests that, a higher percentage, 35.1 % of the hypertensive diabetic patients had a family expense between 6000 - 15999 taka per month. Also, the table thus, suggests that, the trend in hypertension gradually tends to decline with increase in the social class among the type 2 diabetic patients.

Table 4.5.11 : Cross table analysis between hypertension (HTN) and age group in type 2 diabetic patients (n = 3825)

	Age Group													
	F	%	I	%	F	%	F	%	F	%	F	%	F	%
	18 - 20		21-30		31-40		41-50		51-60		61-70		Total	
HTN	5	0.1%	97	2.5%	618	16.2%	1404	36.7%	1197	31.3%	504	13.2%	3825	100%
Total	5	0.1%	97	2.5%	618	16.2%	1404	36.7%	1197	31.3%	504	13.2%	3825	100%

The table shows that, among type 2 diabetic hypertensive patients, the age group 41-50 (36.7%) is at the highest risk for hypertension. The age group 51-60 is at the second highest risk of hypertension, the percentage being 31.3%.

5. Discussion and Limitations of the study

As it can be seen from the tables that, a dominant percentage of the type 2 diabetic patients belong from the middle class family of rural areas and have a family expense that corresponds to their social status. A strong majority of the diabetic patients, were sedentary and to be precise, belonged from the lower middle class and 22 % among these patients also had hypertension. Majority of them denied of any smoking or tobacco habits and also completely denounced the notion of family history of diabetes and hypertension in context. However, a higher percentage of them also had tolerable BMI, tolerable cholesterol levels and a proper resting heart rate. They also exhibited proper kidney functioning and normal ALT levels.

It was found, that 50.5 % of the population were female and 49.5 % were male, thus the number of females being slightly greater in number. The study also found that, age group 41-50 had the highest number of diabetic patients. 34.4 % of the patients belonged in that age group. This shows that, type 2 diabetes occurs among elderly people; specifically, people who are 41-50 are at the highest risk. Majority of the patients, 84.7 % , grew up in rural zones and 52.3 % of these total patients spent 3/4th of their life in the urban areas. 99.2 % of the diabetic patients were also married. It was also found that, type 2 diabetes was predominant among the lower middle class, 57.5 %, and a larger portion of the patients were also illiterate, 25.4 %. Most of the type 2 diabetic patients, 73.9 % had 2- 5 members in the family. A moderate number of the patients also had overpopulated families; 22.9 % having 6- 10 members and 1.2 % had above 10 family members. The study also found that, the highest percentage of the patients, 44.5 %. were housewife by profession. Majority of the diabetic patients had a sedentary lifestyle, 47.9% or did work that involved light exercise, 42.0 %. Thus, it was concluded that, middle class people with lower exercise levels and a sedentary lifestyle were more prone to the risk of type 2 diabetes. The lower middle class statement was also supported by the data that, the majority of the patients, 37.8 %, had a family expense between 6000 -15999 taka. 21.7 % had a family expense between

16000 and 25000 taka. Majority of the patients 84.4% did not have a smoking habit. Also, 83.7 % never consumed tobacco based products in their life. This states that, type 2 diabetes has no relation with smoking or tobacco consumption. A higher number of patients also had normal BMI. 48.5 % had a normal BMI while 36.2% were overweight and 11.1 % were obese. This indicates that, only a slightly more number of people had normal BMI as in comparison to overweight or obese patients. Since the distribution is almost even, it is difficult to state whether BMI has an absolute impact on diabetes patients. However, majority of the patients had absolutely normal resting heart rate, the number being 98.7 %. Majority of the patients, 66.5 % also had a normal diastolic blood pressure. However, only 36.8% of the total patients had normal systolic pressure. A greater percentage, 33.7% and 6.8% had blood pressure above the normal range. However, 64.2%, a greater majority also had desirable levels of total cholesterol count. Only 24.0 % had a borderline high and 11.2 % were from the high count. The BMI for obese people corresponds to the high cholesterol levels, 11.1 % being obese and 11.8 % having high counts of cholesterol. Majority of the patients, 90.4 % also had normal levels of alanine transferase in the blood. 8.9 % of them had ALT levels above the normal level and 0.5 % had very high ALT levels. These could be due to fat deposition in the liver. It was also found that, 22 % of the patients were associated with complications of hypertension. These patients exhibited symptoms, complained about it, or had higher variable BP counts at different points of medical examination during the diagnosis and thus were labeled with hypertension. Surprisingly, the majority of the patients stated that they did not that have any family history of diabetes. From 70 to 80.9 % of the type 2 patients stated that, none of the family member in their family had diabetes. This implicates that, genetic factors thus, could as well not be a cardinal factor for type 2 diabetes. Majority of the patients also stated that, there family members did not have hypertension as well. The numbers ranging from 79.8 % to 83.7 % agreed that, neither their grandparents, parents or siblings had a history of hypertension. Thus, hypertension could as well not be related to genetic factors in type 2 diabetes patients. However, it was observed that, among the 22% of the total type 2 diabetic patients who had hypertension as a complication; the majority 54.8%, were of the female sex. Also, among the 17401 diabetic patients, a greater percentage were female, who were either overweight or obese; 19.7 % and 8.2% respectively. It was also found that, the 22% of the total patients who had hypertension or among 3825 of them, the percentage of hypertension decreased with the increasing levels of physical exercise. 47.4 %

of the 3825 hypertensive diabetic patients, had a sedentary lifestyle while, only 0.7 % of the patients who had a rigorously active lifestyle were hypertensive. This shows that, greater levels of physical activity reduces the risk of hypertension as a complication, in type 2 diabetic patients. Majority of the type 2 patients, 89.2 % also had optimum creatinine levels in blood, which demonstrated proper kidney functioning. Furthermore, it was again observed that, the highest percentage of people, 61.4 % of the 3825 (22%) diabetic patients who were hypertensives, belonged from the lower middle class. However, majority of these patients, 67.4 % , who were hypertensive had a desirable cholesterol level. While 21.9 % and 10.7 % of the hypertensive patients had borderline high and very high cholesterol levels, respectively. It was also observed that, these hypertensive type 2 diabetic patients in majority, belonged from rural areas. 50.0 % of the 3825 patients were from rural areas in adulthood, while 44.2 % stayed in the urban setting during adulthood. Also, majority of the patients who were hypertensives, never smoked or chewed tobacco products in their lifetime; 84.5 % and 84.3 % respectively, thus illustrating that, smoking or tobacco consumption might not be a prime reason for hypertension in type 2 diabetic patients. Also, a higher percentage of the patients had a family expense in the range of lower middle class social status. People who are diabetic, were also seen to develop hypertension mostly at the older ages of 41-50 and 51-60. 36.7% of the diabetic hypertensive patients were from the age range of 41-50 and 31.3% were from the age range of 51-60.

The findings are thus somewhat related with the results of studies conducted previously; (Li et al, 2006, Chaix et al, 2006, Gomez et al, 2011, Hu et al, 2004, and Holman et al, 2008) that state in general that, hypertension and diabetes have a relationship with several factors like age, lifestyle choices, BMI, cholesterol levels, etc. and the epidemiological influence too is a factor worth consideration. However, the overall accuracy of the data in this study and the statistical analysis through SPSS have been maintained with utmost efficiency.

Limitations of the study

Almost all of these patients had been diagnosed for type 2 diabetes very recently, within a period of maximum of 3 years. The data does not go back beyond 2014. Thus, they have not yet developed full blown catastrophes imposed by diabetes mellitus and as such all of them cannot be vividly predicted. Since a higher percentage is also illiterate or have low literacy levels belonging from the rural areas, there is often a chance that some people tend to exaggerate

medical conditions or falsify statements about lifestyle habits such as tobacco or smoking. Moreover, since a huge majority also grew up in rural areas, it is likely that their parents or grandparents did not ever get tested for diabetes or hypertension. Also, many of them were given hypertensive medications as well, that could have interfered with the BP levels. Proper data on cardiovascular diseases was unavailable which could have perhaps, strengthened the case on hypertension and elaborated the study on cardiovascular complications.

6. Conclusion

An active lifestyle is cardinal for avoiding disorders like diabetes and hypertension among the adults. The study shows the prevalence of females with a sedentary lifestyle in higher number for type 2 diabetes mellitus and developing hypertension as a complication. A higher percentage of the patients belonged from rural areas, had lower literacy levels and belonged from a lower middle class family with 2-5 members with a comparatively low monthly family expense.

Though smoking and tobacco habits have detrimental impacts on the lungs and cardiovascular systems; this study found that the majority of the patients with diabetes or hypertension did not have the habit of smoking or tobacco consumption. From the study it was also evident that, stress levels of residing in an urban setting like Dhaka could as well be as inconclusive for determination of diabetes and hypertension, as compared to residing in a rural setting. People from the rural settings demonstrated a higher percentage for being hypertensive, as compared to the people living in the urban areas. Thus, the prevalence was higher for rural areas.

Genetic inheritance has often been believed to be a major risk factor of diabetes mellitus and hypertension. In this study, a dominant majority of the patients claimed that neither of their grandparents, parents of siblings had diabetes or hypertension. Thus, the prevalence of family history of type 2 diabetes and hypertension, was very low among the patients in the study.

Majority of the patients also exhibited proper kidney and liver functioning. They also demonstrated normal BMI, normal resting heart rate and desirable total cholesterol levels. The diastolic blood pressure in majority was seen to be consistent within the nominal levels whereas, the systolic blood pressure was seen to be higher in a dominant percentage.

Research works like this, often tend to broaden the perspectives related to several factors that play a vital role during the designing of therapeutic procedures and development of medications. Thus, this particular research work will definitely prove to be fruitful in the field of biotechnology and other research works related to biomedical facilities, concerned with especially type 2 diabetes mellitus.

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Abstract

Diabetes is a major health concern all over the world with a huge number of people being freshly diagnosed each day. This research work evaluates the epidemiological influence, risk factors and hypertension as a complication associated with type 2 diabetes mellitus, through a bio-statistical perspective of analysis. The primary characteristic of type 2 diabetes mellitus is a constant fasting blood glucose on repeated testing, which remains at or above 7.0 mmol/L.

The patients concerned in this study had a constant fasting blood glucose of 7 and above upon repeated medical testing and hence they were diagnosed with type 2 diabetes mellitus. The study was based on the data of 17401 type 2 diabetic patients, ranging from 18 to 70 years old. Variants taken into consideration were: age, sex, educational background, marital status, number of family members, occupation, family expense, area of residency (childhood and adulthood), social class, levels of physical exercise, resting heart rate, BMI, smoking habits, tobacco habits, family history of diabetes, systolic blood pressure, diastolic blood pressure, fasting blood glucose level, serum alanine transferase levels, serum creatinine levels, total cholesterol levels and hypertension (complication). The data was collected from the department of Epidemiology and Biostatistics, from BIRDEM hospital. The data was then cleaned thoroughly for errors and erroneous data values. Then the data of 17401 type 2 diabetic patients was selected and prepared for further analysis.

The study found that a dominant percentage of the patients exhibited rural residency (52.3%), sedentary occupation (44.5%), low family expenditure (37.8%), lower middle socio-economic status (57.5%), lower levels of physical exercises (47.9%), among the relatively newly diagnosed type 2 diabetes patients. However, BMI, cholesterol levels, resting heart rate, serum creatinine and serum ALT levels was seen to be normal among the dominant percentage of diabetic patients in the study. The female diabetic patients were seen to be overweight and obese in a greater percentage (19.7% and 8.2%), as in comparison to the males. The analysis also exhibited that, the percentage (34.4%) of patients with type 2 diabetes was the highest in the age group of 41-50. The research work also found that, 22% (3825) of the diabetic patients had developed hypertension among which, the females in comparison to the males, were seen to be in a dominant percentage (54.8%), developing hypertension as a complication. A dominant percentage (84.4% and 83.7%) of the patients suffering from type 2 diabetes or hypertension as a complication, denied smoking or tobacco use. Physical exercise and an active occupation, was found to constitute a lower percentage among the hypertensive type 2 diabetic patients. Percentage of patients with hereditary association of hypertension or diabetes was found to be very low as well (below 20%). Lower middle class rural people, with much lower levels of literacy and lower family expenses having type 2 diabetes, were seen to be in a greater percentage for the development of hypertension, as compared to the urban people. The percentage (67.4%) of patients with normal cholesterol levels was very high among the hypertensive diabetic patients. Diastolic blood pressure was found to be in the normal range for the dominant percentage (66.5%) of the diabetic patients whereas, a greater percentage (40.5 %) among them had a higher systolic pressure above the normal level. The analysis also showed that

type 2 diabetic patients exhibited the highest percentage (36.7%) by population for developing hypertension as a complication, at the age range of 41-50. There is also a moderately high percentage (31.3%) of the patients who developed hypertension at 51-60 years of age in case of the type 2 diabetic patients, in the study.

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ACE	Angiotensin- converting- enzyme
BIRDEM	Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine Metabolic Disorders
BMI	Body Mass Index
BP	Blood Pressure
CVD	Cardiovascular diseases
DBP	Diastolic Blood Pressure
DM-2/ T2DM	Diabetes Mellitus (Type 2)
FBG	Fasting Blood Glucose
GFR	Glomerulation Filtration Rate
HBA1C	Hemoglobin A1C
HDL	High Density Lipoprotein
HTN	Hypertension
IDF	International Diabetes Federation
LDL	Low Density Lipoprotein
SBP	Systolic Blood Pressure
VECGF	Vascular Endothelial Cell Growth Factor
WHO	World Health Organization