Chapter-2

Review of Literature
The concept of prediabetes is new in India and very few number of prevalence studies were available, so we have considered the prevalence of diabetes studies along with prediabetes studies for our literature review as risk of conversion from prediabetes to diabetes is high if early identification of the individuals was not done.

**Historical Perspective**

The history of diabetes mellitus begins with the mention of polyuria in Ebers papyrus in 1550 BC. The earliest mention of honey urine (Madhumeha) was made by Sushrutha in 400 BC. Though Celsus (30 BC-50 BC) recognised the disease, Aretaeus or Cappadocia gave the name “Diabetes” (a siphon). He made a complete description of diabetes mellitus describing it as “melting down of the flesh and limbs into urine” (George F and Cahill JR, 2005). In the 3rd to 5th centuries AD scholars in China, Japan and India wrote of a condition with polyuria in which the urine was sweet and sticky.

**Diabetes Mellitus As Seen In the Ancient Ayurvedic Medicine**

The understanding of diabetes mellitus in Ayurvedic medicine dates back to the treatises of Sushrutha and Charaka (400 BC). The complete pathophysiology of the disease was discovered by Wagbhat during 800 BC. Ayurvedic physicians considered diabetes as a urinary disease and described it as “Madhumeha”. It was included under “vat prameh” considering it as incurable. Sushrutha also noted that sedentary persons, averse to exercise and who eat foods promoting obesity would develop Pramah (Diabetes).

Different precipitating causes of diabetes like hereditary nature and genetic predisposition were known to ancient Ayurvedic physicians like Charaka and
Sushrutha which is evident by the fact that Sushrutha classified diabetes into two groups. One is due to hereditary factor present from birth, and the other is due to violating the rules of healthy living (S. S. Ajagaonkar, 1972).

**PAST WORKS DONE**

**Prevalence Studies of Diabetes Mellitus and Prediabetes in India**

**National studies**

In 1966, Ajogaonkar A, examined diabetic prevalence rates in different metropolitan cities of India from 1936-1966. He found a continuous rise in the prevalence rates from 0.7% to 9%.

In 1966, Patel J. C, reviewed various studies carried out by the Indian Diabetic Association and found that diabetes prevalence in general population was 1%. They also observed diabetes prevalence was 7% in office going adults.

In 1970, Tripathi B. B et al., did a population based survey in one part of Cuttack, Orissa. A total 592 subjects of age 20 years and above were examined, they found a prevalence rate of 4.4%.

In 1985, Eswhege E P et al., stated that environmental factors unmask NIDDM in a genetically susceptible individual. They also stated that it appears to be a disease associated with a changing life style including increased longevity, dietary changes from traditional foods and increased food storage.

In 1988, Ramachandran A et al., screened 678 urban people. They found the prevalence of type 2 diabetes mellitus was 5% and that of impaired glucose tolerance was 2%.
In 1988, Rao PV *et al.*, conducted a survey in Eluru, a small town in South India, and in four adjoining villages. A total of 9563 subjects were surveyed of whom 5699 lived in Eluru and 3864 lived in the four villages. The overall crude prevalence rate was 1.6% (1.9% in males, 1.4% in females). The study also reported prevalence in Eluru (1.5%) was similar to that in the four villages (1.9%). The prevalence of known diabetes was 6.1% in all subjects aged 40 or over and rose to 13.3% in the age group 50-59 years.

In 1990, Ramaiah KL *et al.*, suggested that NIDDM was rare in population that maintained a traditional way of life. In an epidemiological study of diabetes in Asians of the Indian subcontinent, they concluded that with modernization of lifestyle, either by city itself or by migration of individual to an urban centre, the frequency of occurrence of NIDDM rose. They suggested that there is an ethnic susceptibility to diabetes among Indians. They concluded that prevalence of non-insulin dependent diabetes mellitus (NIDDM) in migrant Indians is higher than that in the population residing in the Indian subcontinent and is also usually higher than in the other racial groups in the host country.

In 1999, Dwivedi RN and Gopal Krishna, highlighted the importance of identification of diabetes and its risk factors. They analysed that diabetes is an iceberg disease and its prevalence rates have shown a gradual increase from 1.2% in 1971 to 11.6% in 1995 in urban areas and 1.3% to 2.5% in rural areas.

In 2000, Joseph *et al.*, carried out a study high risk for coronary heart disease: from serum lipids and other risk factors in 206 individuals at Thiruvananthapuram. They found the prevalence of type 2 diabetes mellitus was 16.3%.
In 2001, Misra et al., conducted a cross sectional epidemiological descriptive study in rural urban migrants settled in urban slums of Delhi to determine the prevalence of type 2 diabetes mellitus in 532 subjects and reported diabetes prevalence was 10.3% in both males and females above 30 years of age.

In 2001, Ramachandran A et al., conducted a National Urban Diabetes Study using a stratified random sampling method, 11215 subjects (5288 men and 5798 women) aged 20 years or above representing of all socio-economic status, were tested by OGTT. The prevalence of diabetes and impaired glucose tolerance were 12.1% and 14% with no gender difference. This national study showed that the prevalence of diabetes is high in urban India and large pool of subjects with IGT at a high risk of conversion for diabetes.

In 2002, Ramachandran A et al., have conducted a population based study in Chennai among subjects aged 20 years and above with an emphasis on identifying the risk factors responsible for diabetes in three urban diabetes surveys conducted in 1989, 1995 and 2000. Their observations during the period between 1989 and 1995 showed a 40% rise in the prevalence of diabetes and a further increase of 16.4% in the next 5 years. An increase in IGT was seen in year 2000, especially in subjects aged less than 40 years.

In 2003, Gupta et al., conducted an epidemiological study using stratified random sampling among urban subjects aging 20 or above in western India to determine prevalence of diabetes, Insulin resistance syndrome (IRS) and their risk factors. A total of 1091 subjects were evaluated, diabetes prevalence was found to be 12.3% (13.2% in men and 11.5% in woman), IFG 5.2%. Significant prevalence of diabetes and IRS was present in this urban Indian population.
In 2003, Mohan et al., conducted a study to assess the impact of family history of diabetes, obesity and lifestyle factors particularly physical activity on glucose intolerance in a selected south Indian population. This study found that type 2 diabetes mellitus and impaired glucose tolerance was 12% (7.2% of known diabetic subjects and 4.8% undiagnosed) and 5.9%.

In 2003, Ramachandran A, et al., done a prevalence study of impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) in urban Indians and their demographic and anthropometric characteristics in 10,025 subjects aged > or 20 years. Age standardized prevalence’s of IFG, IGT and newly detected diabetes were 8.7%, 8.1% and 13.9%, respectively. IFG was more prevalent in women (9.8%) than in men (7.4%) (\(\chi^2=13.62, P=0.0002\)), while the gender differences in IGT (men 8.4%, women 7.9%) and diabetes (men 13.3%, women 14.3%) were not significant. Body mass index and waist circumference were higher in glucose intolerant groups than in normal glucose tolerance (NGT).

In 2003, Snehalatha C et al., conducted a national survey of diabetes and impaired glucose tolerance (IGT) conducted in 2000 AD in six major cities of India showed a high prevalence of diabetes (12.1%) and IGT (14%). Prevalence of IGT was higher than that of diabetes in subjects with less than 40 years when compared with older subjects. This analysis was done to look for differences in the risk factors associated with IGT in the younger and older subjects.

In 2004, Gupta et al., conducted an ethnic group sample survey in Punjabi Bhatia community to determine the prevalence of cardiovascular risk factors. A total
of 458 subjects (men 226, women 232) were evaluated and prevalence of diabetes was found to be 16.8%.

In 2004, S.M. Sadikot et al., carried out a random multistage cross-sectional population survey to determine the prevalence of type 2 diabetes mellitus in subjects aged 25 years and above in India using both 1999 WHO criteria and 1997 ADA criteria. A total of 18363 (9008 males and 9355 females) subjects were screened and the standardized prevalence rates for diabetes mellitus in the total Indian, urban and rural populations using WHO criteria was 4.3%, 5.6% and 2.7% respectively.

In 2004, S. M. Sadikot et al., conducted a random multistage cross sectional population survey to determine the prevalence of diabetes mellitus (DM) and impaired fasting glycemia/glucose (IFG) in subjects aged 25 years in 41270 (20,534 males and 20736 females). 21516 (10865 males and 10651 females) were from urban areas and 19754 (9669 males and 10085 females) from rural areas. The age and gender standardized prevalence rate for DM and IFG in the total Indian population was 3.3% and 3.6% respectively.

In 2005, H Basavanagowdappa et al., estimated the prevalence of diabetes mellitus and impaired fasting glucose (IFG) in Suttur village of Karnataka state. They adopted ADA 1997 criteria for diagnosis of IFG and diabetes mellitus. They reported diabetes prevalence rate of 3.77% in persons above age of 25 years. The prevalence in males was 4.58% and in females it was 2.66%. Impaired fasting glucose was 2.82% in male and 2.78% in females.

In 2005, Prabhakaran et al., conducted a cross-sectional survey among all employees aged 20-59 years to evaluate the prevalence of CVD and its risk factors
among a large industrial population of northern India. A total of 2122 subjects with a mean age of 42 years were screened and the prevalence of diabetes was found to be 15.0%.

In 2006, Reddy et al., conducted a baseline cross-sectional survey as a part of CVD surveillance programme and estimated the risk factor burden using standardized tools in Indian industrial populations. A total of 10442 subjects were screened and diabetes prevalence was found to be 10.1%.

In 2007, Gupta et al., conducted a community-based epidemiological study that focussed on lifestyle determinants of obesity and its correlates in migrants from Punjab was performed at a single location in Jaipur and the prevalence of diabetes was found to be 20.1%.

In 2007, Kokiwar PR et al., conducted survey in rural area of Nagpur district to determine the prevalence and abnormal glucose tolerance and to study the association of various factors with abnormal glucose tolerance. This study found that there was high prevalence of diabetes (3.67%) as compared to that in the WHO report (2.4%) for rural India.

In 2007, Raghupathy P et al., have conducted a study in Vellore and nearby villages to report the prevalence of glucose intolerance and insulin profiles, and their relationship to lifestyle factors in 2218 young adults. This study found that type 2 diabetes mellitus and impaired glucose tolerance (IGT) was higher in urban than rural subjects (3.7% verses 2.1%), while prevalence of impaired fasting glycemia (IFG) was similar in urban and rural population (3.8% verses 3.4%, P=0.04).
In 2008, Zargar A H et al., carried out a study in Kashmir valley to assess the burden of type 2 diabetes mellitus and other abnormalities of glucose tolerance in young adult (20-40 years) men and non pregnant women. This study reported prevalence of diabetes, impaired glucose tolerance (IGT), and impaired fasting glucose (IFG) was 2.5%, 2.0% and 11.9% respectively.

In 2009, Purty A J et al., conducted a community based study in Pudicherry to estimate prevalence of diagnosed type 2 diabetes mellitus patients. The diagnosis of diabetes was retrospectively documented by reviewing all family folders of 2667 families. The prevalence of known diabetes was estimated to be 5.6% (5.31% in males and 6.1% in females).

In 2010, P. Ravikumar et al., conducted a cross-sectional survey to assess the prevalence and risk factors associated with diabetes in the north Indian city of Chandigarh. A total of 2227 subjects aged ≥ 20 years representing urban population using 1999 WHO criteria. The age standardized prevalence of diabetes and prediabetes was found to be 11.1% (95% CI: 9.7-12.4) and 13.2% (95% CI: 11.8-14.6).

In 2011, Anjana RM et al., conducted a national study to determine the prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in India. A total of 363 primary sampling units (188 urban, 175 rural), in three states (Tamilnadu, Maharashtra and Jharkhand) and one union territory (Chandigarh) of India were sampled using a stratified multistage sampling design to survey individuals aged ≥ 20 years. Of the 16607 individuals selected for the study, 14277 (86%) participated, of whom 13055 gave blood samples. The weighted prevalence of diabetes (both known and newly diagnosed) was 10.4% in Tamilnadu,
8.4% in Maharashtra, 5.3% in Jharkhand, and 13.6% in Chandigarh. The prevalence of prediabetes (impaired fasting glucose and/or impaired glucose tolerance) is 8.3%, 12.8%, 8.1% and 14.6% respectively. Projections for the whole of India would be 62.4 million people with diabetes and 77.2 million people with prediabetes.

In 2012, Rajeev Gupta et al., conducted a study using stratified random sampling to evaluate the cardiovascular risk factors in urban middle class in Jaipur in subjects aged 20-59 years and to determine secular trends with previous cross-sectional studies performed in same locations in years 2002-3 and 2004-5. The prevalence of diabetes was found to be 13.4%.

**International studies**

In 2003, Pearson TL et al., conducted a population based study in USA with an objective of the identification of individuals at risk for development of type 2 diabetes mellitus. In this study, questions associated with the risk of developing diabetes were incorporated into a health risk assessment (HRA). A total of 16,427 members completed the HRA with a follow up time of 4.8 years (mean 2.5 years). They observed that the incidence of new diabetes at the end of the study was 3.5% in high risk group and 0.7 % in the low risk group (P < 0.001).

In 2004, Sarah Wild et al., estimated the prevalence of diabetes and the number of people of all ages with diabetes for years 2000 and 2030. The prevalence of diabetes for all age groups worldwide was estimated to be 2.8% in 2000 and 4.4% in 2030. The total number of people with diabetes was projected to rise from 171 million in 2000 and 366 million in 2030.
In 2008, Abbas Ali Mansour et al., conducted a cross-sectional population based study to screen for diabetes in al-Madina a rural area located in the north of Basrah, Iraq. A total of 3176 subjects were screened and overall prevalence of undiagnosed diabetes was 2.14%, known diabetics constituted 5.29%, IFG was seen in 2.02%, subjects with abnormal glycemia (diabetes and IFG) constitute 9.45%. Previously undiagnosed diabetics constitute of 28.81% of all diabetics in this study.

In 2009, Shaoyan Zhang et al., have done a study to assess the prevalence of diabetes and IFG and to compare the risk factors between diabetes and IFG in the Mongolian population, China. A total of 2589 Mongolians aged 20 years or more were screened and the overall prevalence of diabetes and IFG was 3.7% (males 3.9%; females 3.5%) and 18.5% (males 17.7%; females 19.0%) respectively.

In 2010, Qiang Lu et al., conducted a cross-sectional study in 3937 Han adolescents aged 13-18 years, to evaluate the prevalence of impaired fasting glucose (IFG) and its relationship with cardiovascular risk factors. The prevalence of IFG was found to be 3.5% similar in both genders.

In 2011, Amina Khambalia et al., conducted a nationwide survey of people aged 15-64 years (n=1592) for the prevalence and risk factors of diabetes and impaired fasting glucose in Nauru. The sex standardized prevalence of diabetes and prediabetes was found to be 13.7% and 6.0%.

In 2012, Yan Feng et al., conducted a cross-sectional survey among Han, Manchu and Korean Chinese aged 20 years or more in Mudanjiang area of China. The prevalence of diabetes in Manchu (8.39%) and Korean Chinese (9.42%) was
significantly lower than that in Han (12.10%). The prevalence of prediabetes was 18.96%, 19.36% and 20.47% in Han, Manchu and Korean Chinese.

**Risk Factors Associated With Prediabetes**

**Body Mass Index**

In 2003, Vikram NK *et al.*, have evaluated body mass index (BMI) and body fat profiles of obese and non-obese subjects and correlated those values with cardiovascular risk factors. This cross-sectional study involved 639 subjects from low socioeconomic stratum residing in urban slums of New Delhi. Non-obese subjects were categorised into quartiles of percentage of body fat and waist circumference (WC). They concluded that Asian Indians have excess cardiovascular risk at BMI and waist circumference values considered “normal” and suggested that definition of “normal” ranges of BMI and WC need to be revised for Asian Indians.

In 2003, Snehalatha C *et al.*, conducted a study in Chennai, India, with an assumption that Asian Indians have a high risk of developing glucose intolerance even with small increments in their BMI. Therefore, this analysis was performed to find out the normal cut-off values for BMI and upper body adiposity (waist circumference) computing their risk association with diabetes. They observed that a normal cut-off value for BMI was 23 kg/m² for both genders. Cut-off values for WC was 85 and 80 cm for men and women, respectively. They also observed that cut-off value for WC was lower in women than in men.

**Waist Circumference**

In 2002, Foucan L *et al.*, revealed that hypertension, dyslipidemia and type 2 diabetes are strongly linked to obesity. Body mass index (BMI) and waist
circumference (WC) are measures of obesity that can be useful in identifying individuals with these risk factors. The study population included 5149 consecutive women aged 18 to 74 recruited in a health centre of Guadeloupe in 1999. They concluded that waist circumference, a practical tool that had higher discriminated ability than BMI in identifying presence or absence of risk factors and it appears as the best screening tool in this population.

In 2009, Massimo Motta et al., conducted a study in 2603 elderly subjects of 65–84 years of age to identify the subjects of risk of future diabetes on the basis of a combined measurement of glycemia, the glycosylated hemoglobin (HbA1c) and the waist circumference (WC). They concluded subjects who displayed at the baseline an impaired fasting glucose (IFG) accompanied by HbA1c and WC values above the normal cut-points proved to be diabetic after a 3-year follow up in 18.96%, while the subjects with normal fasting glucose (NFG) accompanied by normal HbA1c and WC values were found to be diabetic only in 1.34%.

In 2010, Soojin Lee et al., conducted a study to determine whether abdominal obesity is a risk factor for impaired fasting glucose (IFG) and hypertriglyceridemia and to verify whether moderate effect of abdominal obesity on the relationship between IFG and hypertriglyceridemia in 5938 subjects aged 20 year old drawn from non-diabetic participants in a health examination survey in Korea. Abdominal obesity was found to be positively moderated in the interaction between waist circumference and fasting blood sugar. They concluded that moderate effect between abdominal obesity and IFG contributes to the development of hypertriglyceridemia.
Family History

In 2000, Ramachandran A *et al.*, carried out a population based study in Chennai to analyse co-segregation of obesity with familial aggregation of type 2 diabetes mellitus. This study involved a total of 2463 subjects (M:F 1196:1267) with normal glucose tolerance (NGT). They observed that a positive family history of diabetes was present in 24.7% of the study subjects. Mean BMI and percentage of obesity were significantly higher in families with a positive family history (group 2) vs. families with no family history (group 1). They concluded that general and central obesity are associated with a family history of diabetes.

In 2007, Rodolfo Valdez *et al.*, conducted a study to test the association between stratified levels of familial risk of diabetes and the prevalence of the disease in 16,388 adult U.S. population. Familial risk of diabetes was classified as average, moderate, or high. Overall, 69.8% of the U.S. adults were in the average, 22.7% in the moderate, and 7.5% in the high familial risk for diabetes. The crude prevalence of diabetes for each risk class was 5.9, 14.8, and 30%, respectively. They concluded that in the U.S. population, family history of diabetes has a significant, independent, and graded association with the prevalence of diabetes.

In 2012, Mithun Das *et al.*, conducted a study to find the association between familial risk of type 2 diabetes mellitus (T2DM) and the prevalence of metabolic syndrome (MS) in 448 (>30 years) (257 males and 191 females) adult Asian Indians. Familial risk of T2DM was classified into three groups viz., 1=both parents affected; 2=parent and/or siblings affected and 3=none or no family history for T2DM. Family history of T2DM had significant effect on individuals with MS as compared to their counterparts (individuals having no family history of T2DM). It therefore seems
reasonable to argue that family history of T2DM could be useful as a predictive tool for early diagnosis and prevention of MS in Asian Indian population.

**Hypertension**

In 2003, Sheritha Hill Golden *et al.*, conducted a prospective cohort study in 1152 white male medical students to evaluate elevated Blood Pressure as a long term predictor of type 2 diabetes with a median follow up period of 38 years. After adjustment for BMI and other risk factors for diabetes, SBP and DBP at age 30 years remained significantly higher in individuals who developed diabetes than in their nondiabetic counterparts; however, the difference in the rate of increase in SBP was no longer significant following multivariate adjustment. They concluded that BP elevations precede the development of type 2 diabetes in middle age by 20–25 years. Higher BP in the prediabetic state might contribute to the presence of vascular disease at the time of diagnosis of type 2 diabetes.

In 2012, Delia B. Carba *et al.*, conducted a study in 1871 women aged 35-68 years to examine waist circumference as a risk factor for having hypertension only, impaired fasting glucose only, or both, and assess whether the associations vary according to overweight status. Each cm increase in waist circumference increased the odds of hypertension by 5% for non-overweight women and 3% for overweight women; impaired fasting glucose by 9 and 3% for non-overweight and overweight women, respectively; and hypertension and impaired fasting glucose by 17% among non-overweight versus 9% for overweight women. They concluded waist circumference was significantly associated with impaired fasting glucose and both hypertension and impaired fasting glucose, and the associations vary by overweight status.
Physical Activity

In 2002, Perry I J, observed the glucose intolerance representing a spectrum of abnormalities including impaired fasting glucose, impaired glucose tolerance and type 2 diabetes. This global epidemic of diabetes is largely driven by the globalisation of western culture and lifestyles. It is estimated that more than 90% cases of type 2 diabetes could be prevented with the adoption of a prudent diet (high in cereal fibre and polyunsaturated fatty acids and low in trans fatty acids and glycaemic load), avoidance of overweight and obesity (BMI<25 kg/m²), engagement in moderate to vigorous physical activity for at least 0.5 hour per day, non smoking and moderate alcohol consumption.

In 2003, Quinn L, stated that type 2 diabetes mellitus, characterized by insulin resistance and beta cell defect, and appears to result from a number of gene and environmental interactions. There are marked differences in phenotypic expression of type 2 diabetes mellitus with individuals exhibiting varying levels of insulin resistance and impairment in insulin secretion. Study results indicate that a number of healthy lifestyle behaviours such as increased physical activity and reduced intake of dietary fat are associated with decreased development of type 2 diabetes mellitus.

In 2005, M. Bacardi Gasco na et al., conducted a study to document physical activity (PA) of migrant Mexican women with type 2 diabetes who have participated in diabetes intervention programs at a primary care level. One hundred out of 133 women of seven diabetes education groups from different Mexican institutions located in the city of Tijuana were invited to participate in the study. A PA history questionnaire was completed weekly. Metabolic Equivalents (METs) were used to calculate physical activity level (PAL). Forty percent were classified as overweight
and thirty one percent as obese. Six percent of the women performed more than 150 min of moderate/vigorous weekly PA, while more than 80 min of weekly PA was reported by seventy three percent of the population. The majority of these migrant women who participated in the diabetes intervention program seem to engage in the minimum recommended levels of PA.

**Smoking**

In 2009, Lisa Rafalson et al., conducted a study during the years 2003 and 2004 to determine whether cigarette smoking is associated with the conversion from normoglycemia to impaired fasting glucose (IFG) in 1455 participants from the Western New York Health Study who were free of type 2 diabetes and known cardiovascular disease at baseline (1996–2001) were reexamined (68% response rate). Baseline smoking status was categorized as never, former, or current. Of the 1,455 participants, 924 were normoglycemic at baseline: 101/924 converted to IFG over 6 years. Compared with those who remained normoglycemic, converters to IFG were at baseline older, had a larger body mass index, more likely to be hypertensive, currently smoke, and have a family history of type 2 diabetes mellitus. They concluded that smoking was positively associated with incident IFG after accounting for several putative risk factors.

In 2010, Bernd Kowall et al., conducted a 7 year study in 1223 subjects aged 55-74 years at baseline in 1999-2001 to evaluate the effect of passive and active smoking. They found that among never smokers, subjects exposed to ETS (Environmental Tobacco Smoke) had an increased diabetes risk in the total sample and in a subgroup of subjects having prediabetes at baseline. Active smoking also had a statistically significant effect on diabetes incidence and in prediabetic subjects. This
study provides us evidence that both passive and active smoking is associated with T2DM.

**Education and Occupation**

In 2004, Mohan V *et al.*, designed a study to assess the influence of socioeconomic status on the prevalence of the metabolic syndrome in all individuals above 19 years of age involving two residential colonies in Chennai representing the middle and lower income groups, an urban south Indian population. They observed that there were significant differences in the socioeconomic status and lifestyle of the two areas. The dietary profile of the middle income group showed higher intake of calories, fat and sugar compared to low income group (P<0.001). The age standardised prevalence rates of the various components of the metabolic syndrome were significantly higher in the middle compared to the low income group diabetes (12.4 vs. 6.5%). They concluded that significant differences exist in the prevalence of various components of the metabolic syndrome even within the urban environment and this appears to be influenced by socioeconomic status.

In 2000, Mehrotra R *et al.*, conducted a population based study in Allahabad (UP) to assess the importance of education and occupation in relation to knowledge about good control of diabetes. In a total of 793 diabetic patients, 46.7% of the subjects were aware of the importance of blood glucose testing. A positive impact of education on overall knowledge levels was observed. However no definite relationship was found between knowledge and occupation. They have given impression of knowledge regarding self care of diabetes in all educational and occupational categories. This study serves as a guideline for developing an educational package for different subsections of the community.
In 2005, Maty et al., examined associations between several life-course socioeconomic position (SEP) measures (childhood SEP, education, income, and occupation) and diabetes incidence from 1965 to 1999 in a sample of 5422 diabetes-free Black and White participants in the Alameda County Study. Race specific Cox proportional hazard models estimated diabetes risk associated with each SEP measure. They concluded the important role of life course SEP measures in determining risk of diabetes, regardless of race and after adjustment for factors that may confound or mediate these associations.

**Alcohol**

In 2003, Lu W et al., conducted a longitudinal study in Washington to explore the relationship between alcohol intake and glycaemia and type 2 diabetes among American Indians aged 45-74 years and involving thirteen American Indian communities in three geographic areas in the United States. Alcohol consumption was determined by self reported alcohol intake history. They observed that fasting and 2 hour plasma glucose concentration showed an inverse j-shaped curve across categories of alcohol intake. Using never drinkers as reference group in cross sectional analysis, light drinkers had a significantly lower risk of having diabetes among drinkers; heavy drinkers had a higher, although not significant, prevalence of diabetes. Longitudinal analysis showed no significant worsening of glucose tolerance across levels of alcohol intake. They concluded that although plasma glucose concentration showed a shallow inverse j shaped association across levels of increasing alcohol intake in American Indians aged 45-74 years, alcohol intake did not appear to significantly increase the risk for worsening glucose tolerance. Thus alcohol intake does not appear to be a determinant of diabetes in this population.
In 2012, M. Cullmann et al., had done a study to investigate the influence of alcohol consumption and specific alcoholic beverages on the risk of developing prediabetes and type 2 diabetes. Subjects, who at baseline had normal glucose tolerance (2070 men and 3058 women) or prediabetes (70 men and 41 women), aged 35–56 years, were evaluated in this cohort study. Total alcohol consumption and binge drinking increased the risk of prediabetes and Type 2 diabetes in men, while low consumption decreased diabetes risk in women. Men showed higher risk of prediabetes with high beer consumption and of type 2 diabetes with high consumption of spirits. Women showed a reduced risk of prediabetes with high wine intake and of type 2 diabetes with medium intake of both wine and spirits whereas high consumption of spirits increased the prediabetes risk. They concluded that high alcohol consumption increases the risk of abnormal glucose regulation in men. In women the associations are more complex: decreased risk with low or medium intake and increased risk with high alcohol intake.

Nutritional Factors

In 2002, Ferreira SR et al., conducted a study with an objective of analysing the association between nutritional factors and body fat deposition in a representative sample of 530 subjects aged 40-79 years. They observed that groups of obese subjects and those with central adiposity consumed higher proportions of energy as fat as and lower as carbohydrate than those without obesity and central adiposity (P < 0.05). They concluded that a deleterious dietary pattern may contribute to weight gain and same was associated with abdominal fat deposition in particular a protein rich diet, and reflected by their waist circumference.
In 2005, LM Goff et al., conducted a Case–control study to test the hypothesis that dietary factors in the vegan diet lead to improved insulin sensitivity and lower intramyocellular lipid (IMCL) storage in London. A total of 24 vegans and 25 omnivores participated in this study. There was no difference between the groups in sex, age, BMI, waist measurement, percentage body fat, activity levels and energy intake. Vegans had a significantly lower systolic blood pressure and higher dietary intake of carbohydrate, non starch polysaccharides and polyunsaturated fat, with a significantly lower glycaemic index. Also, vegans had lower fasting plasma triacylglycerol and glucose concentrations. There was no significant difference in HOMA %S but there was with HOMA %B, while IMCL levels were significantly low in the soleus muscle They concluded that vegans have a food intake and a biochemical profile that will be expected to be cardioprotective, with lower IMCL accumulation and beta-cell protective.

Stress

In 2006, M. Norberg et al., conducted a case-referent study nested within a population-based health survey investigated the associations between psychosocial stress, and future development of type 2 diabetes among occupationally working middle aged men and women during 1989–2000 (n=33,336) in Umea in northern Sweden. Multivariate logistic regression analyses and interaction effects between variables showed in women, passive or tense working situations were associated with future type 2 diabetes with odds ratios 3.6 (95% confidence interval 1.1–11.7) and 3.6 (1.0–13.3), respectively, and also low emotional support 3.0 (1.3–7.0). These associations were not seen in men. They concluded, work stress and low emotional support may increase the risk of type 2 diabetes in women, but not in men.
In 2012, Emily Mendenhall *et al.*, conducted in-depth qualitative interviews and administered the Hopkins Symptoms Check List (HSCL-25) to evaluate depression among 59 people with diabetes in northeast Delhi between December 2011 and February 2012. Depression was most common among the poorest income group (55%) but was also reported among middle (38%) and high income (29%) participants. One quarter of respondents reported diabetes distress, but only those from the low income community reported co-occurring depression and these respondents often revealed poor access to diabetes care. These data suggest that lower income populations not only have higher rates of depression but also may be more likely to delay health care and therefore develop diabetes complications.

**Other Studies for Risk Factors**

In 2008, Anand *et al.*, carried out a study in urban population of Ballabgarh town in Faridabad district of Haryana to analyse risk factors in non-communicable diseases. A total of 1263 male and 1326 female respondents were selected using multistage systematic random sampling, in 5 age groups of 10 years (15-24, 25-34, 35-44, 45-54 and 55-64). The prevalence of current daily use of smoked tobacco was 22.2% for males and 1.4% for females. In males the prevalence of current alcohol consumption was 28.9%. Physical inactivity was reported by 23.2% of males and 52.4% of female respondents. Only 8.6% of males and 4.4% of females were consuming adequate portions of the fruits and vegetables. 23.1% males and 15.7% females were either in stage 1 or 2 of hypertension (JNC VII) or were taking antihypertensive drugs. The prevalence of tobacco and alcohol use among males and physical inactivity among females was high. Low consumption of fruits and vegetables, hypertension and overweight was equally common among both the sexes.
in the population studied. They concluded that there is an urgent need for initiating measures at the risk factor level to counter this modern day epidemic.

Different Biochemical Parameter Estimation

Liver enzymes

In 2006, Shin JY et al., performed a prospective study for 2 years (2002-2004) in a total of 4711 men to know whether serum GGT is a reliable predictor of the incident impaired fasting glucose, including diabetes. A total of 738 cases (15.7%) of incident IFG and 13 cases (0.3%) of diabetes occurred. The mean serum GGT concentration were quite different between the normal (38.0 IU) and incident IFG groups (50.3 IU) and the incident diabetes group (66.0 IU) (p<0.001). The risks significantly increased with increasing levels of GGT for 2 years when comparing the increased groups (< 10%, 10-20%, > 20%) versus the decreased over 20% group of GGT, the risks for IFG or diabetes were 1.334 (1.002–1.776), 1.613 (1.183–2.199) and 1.399 (1.092–1.794). They concluded that serum GGT concentration within its normal range may be an early predictor of the development of IFG and diabetes. As serum GGT is a relatively inexpensive and a reliable marker, it might have important implications in public health promotion.

In 2012, Gao Fei et al., investigated the relationship of liver enzymes with hyperglycemia in 3756 participants in Shanghai to find out the association between liver enzymes and insulin resistance. Liver enzyme concentrations were independently associated with i-IGT, IFG+IGT, and diabetes. With the increase of ALT and GGT concentrations, ORs for i-IGT, IFG+IGT, and diabetes increased gradually. By comparing patients in the highest quartile of GGT concentrations or
ALT concentrations with those in the lowest quartile (Q1), ORs for i-IGT, IFG+IGT, or diabetes was significant after adjustment. Both ALT and GGT concentrations were linearly correlated with HOMA-IR and independently associated with HOMA-IR [ALT OR (95% CI): 2.56 (1.51-4.34) \( P=0.00 \); GGT OR (95% CI): 2.66 (1.53-4.65) \( P=0.00 \)]. They concluded that serum ALT and GGT concentrations were closely related to prediabetes and diabetes in the Shanghai population and positively associated with insulin resistance.

**Lipid Profile**

In 2012, Kivity Shaye *et al.*, conducted a study in 10,913 men and women to assess whether normoglycemic fasting plasma glucose (FPG) is associated with increased risk of CVD outcomes in healthy patients. A total of 1119 incident cases of CVD occurred during a mean follow-up of 4.3 years. Subjects with fasting glucose levels in the high normal range (95-99 mg/dL) had an increased CVD risk when compared with levels <80 mg/dL. A multivariate model, adjusted for age, serum triglycerides, and high-density lipoprotein and low-density lipoprotein cholesterol levels, revealed an independent increased risk of CVD with rising FPG levels in the normal range. They concluded that elevated CVD risk is strongly and independently associated with glucose levels within the normoglycemic range. Fasting plasma glucose may help in identifying apparently healthy persons with early metabolic abnormalities who are at increased risk for CVD before progression to prediabetes and overt diabetes mellitus.

In 2012, Steffano Giannini *et al.*, conducted a study to evaluate the relationship of visceral adiposity and lipid profile with fasting (FPG) and post load glucose (2hPG) in subjects without known diabetes (DM2). A total of 3030 subjects
were divided in three groups: obese subjects (OB; n=490), nonobese subjects with an increased waist circumference (NOB/W1; n=500), and nonobese subjects without an increased waist circumference (NOB/W2; n=2040). This study suggests that triglycerides and HDL-C, together with non-HDL cholesterol, are associated with impaired fasting and 2hPG and that high total cholesterol levels are associated with abnormalities of fasting glucose metabolism only in patients with elevated waist circumference.

**Serum Uric Acid**

In 2008, Hairong Nan *et al.*, conducted a study to investigate the predictive value of serum uric acid (UA) for the development of diabetes in Asian Indians and Creoles living in Mauritius. A total of 1941 men aged 25–74 years and free of diabetes, cardiovascular disease and gout at baseline examinations in 1987 or 1992, were re-examined in 1992 and/or 1998. The relationship between baseline UA and the development of diabetes during the follow up was estimated using interval censored survival analysis. In this cohort 337 (17.4%) men and 379 (16.4%) women developed diabetes during the follow up. Individuals who developed diabetes during the follow up had a lower serum UA levels at follow up compared with their baseline UA levels, but this is not observed for postmenopausal women. Multivariate adjusted hazard ratios (HRs) (95% CIs) for the development of diabetes corresponding to one S.D. increase in UA concentration at baseline were 1.14 (1.01, 1.30) in Indian men and 1.37 (1.11, 1.68) in Creole men. They were 1.07 (0.95, 1.22) and 1.01 (0.84, 1.22) respectively, in Indians and Creole women. They concluded that elevated serum UA is an independent risk marker for future diabetes in Mauritian men, whereas the prediction is weak in women.
In 2010, Vidula Bhole et al., conducted a prospective study using Framingham Heart Study original (n=4883) and offspring (n=4292) to evaluate the impact of serum uric acid levels on the future risk of developing type 2 diabetes independent of other factors. They identified 641 incident cases of diabetes in the original cohort and 497 cases in the offspring cohort. The incidence rates of diabetes per 1000 person years for serum uric acid levels <5.0, 5.0-5.9, 6.0-6.9, 7.0-7.9 and ≥8.0 mg/dL were 3.3, 6.1, 8.7, 11.5, and 15.9, respectively, in the original cohort; and 2.9, 5.0, 6.6, 8.7, and 10.9, respectively, in the offspring cohort (P-values for trends < 001). The prospective data from 2 generations of the Framingham Heart Study provide evidence that individuals with higher serum uric acid; including younger adults, are at a higher future risk of type 2 diabetes independent of other known risk factors. These data expand on cross sectional associations between hyperuricemia and the metabolic syndrome, and extend the link to the future risk of type 2 diabetes.

**Serum Creatinine**

In 2011, B. Shivananda Nayak et al., conducted a study to know the association of low serum creatinine level, abnormal lipid profile and demographic variables with type 2 diabetic Trinidad subjects. Data was obtained from a cohort of 1122 diabetic and non diabetic patients from clinics in Trinidad. They concluded that abnormal lipid profile, gender, age and serum creatinine are associated with type 2 diabetes. While age and gender are non modifiable risk factors, steps should be taken to monitor and control the serum creatinine and lipid profile values of diabetics and nondiabetics.

In 2011, Nwose EU et al., conducted a study to identify whether low serum creatinine levels as a risk factor of diabetes mellitus. A 1017 glucose tolerance tests
performed and were sorted into normal (control), prediabetes and diabetes based on decisive interpretation. All cases with creatinine results in the control (n=48), diabetes (n=18) and prediabetes (n=36) groups were selected. Mean levels of serum creatinine levels in the controls (80+/-32 micromoles/L), diabetes (82+/-26 micromoles/L) and prediabetes (82+/-23 micromoles/L) were not statistically significantly different. The prevalence of low levels of serum creatinine is less in prediabetes (11%) than in the control (23%). They concluded that further studies using a larger number and adjusting for confounding factors is needed to ascertain the role of low serum creatinine level as a risk factor of diabetes.

**Electrolytes**

In 2010, Ranee Chatterjee *et al.*, conducted a study to know the association of Serum and Dietary Potassium and Risk of Incident Type 2 Diabetes, they analyzed data from 12209 participants from the Atherosclerosis Risk in Communities (ARIC) Study, an ongoing prospective cohort study beginning in 1986, with 9 years of in-person follow-up and 17 years of telephone follow-up. Using multivariate Cox proportional hazard models, they estimated the relative hazard (RH) of incident diabetes associated with baseline serum potassium levels. During 9 years of in-person follow up, 1475 participants developed incident diabetes. They concluded that dietary potassium intake was significantly associated with risk of incident diabetes in unadjusted models but not in multivariate models. Serum potassium is an independent predictor of incident diabetes in this cohort. Further study is needed to determine if modification of serum potassium could reduce the subsequent risk of diabetes.

In 2010, Ganda OP *et al.*, provide a current overview of the worldwide prevalence and pattern of cardiovascular disease and discuss the role of sodium intake
and salt sensitivity, with a focus on the Asian Indian population. They found evidence for a strong link between increased salt sensitivity and insulin resistance leading to metabolic syndrome and cardiovascular disease. This relationship may be particularly relevant to the escalating epidemic of cardiovascular disease in the southern Asian Indian population. A broad based community action to achieve at least a modest restriction of salt intake can yield important health benefits and is urgently needed.

RBC

In 2010, D. Simmons carried out a ‘‘Crossroads study’’ between June 2001 and March 2003 across seven Australian towns. The aim of this study was to test whether an increased red blood cell count (RBC) is present in prediabetes, obesity and the metabolic syndrome. The results demonstrate that these diabetes precursor states are associated with an increased RBC. This relationship can be explained, in part, by an increased HbA1c.

WBC

In 2008, Jing-Yan Tian et al., examined WBC count, a marker of inflammation among Chinese population aged 40 years and more. Based on the 75g OGTT, 1016 subjects aged from 40 to 88 years were classified into four groups: normoglycemic (n = 299), isolated IFG (n = 213), IGT (n = 213) and type 2 diabetes (n = 291). The IGT and type 2 diabetes groups had a significantly higher WBC count than the normoglycemic and isolated IFG groups. By stepwise regression analyses, they found that waist circumference, DBP, total cholesterol, HDL cholesterol and 2 h post glucose showed an independent association with the WBC counts. In the analysis stratified by sex and smoking status, WBC count was independently associated with
age and triglycerides in males, whereas it was associated with BMI, SBP, triglycerides and 2 hr post glucose in females. BMI, SBP, triglycerides and 2 h post glucose showed an independent association with WBC counts in subjects who never smoked.

From the cursory look of past literature it was found that the prevalence of type 2 diabetes mellitus is growing in epidemic proportions all over the world, particularly in India. It is now known that India has the highest number of diabetic subjects even higher than China and USA. India has the highest prevalence rates of diabetes i.e. about 20% of the total diabetic population in the world.

The diabetes epidemic is accelerating in the developing world, with an increasing proportion of affected people in younger age groups. Recent reports describe type 2 diabetes is being diagnosed in children and adolescents. This is likely to increase further the burden of chronic diabetic complications worldwide, there is increasing interest in identifying people without diabetes and who are at increased risk of the future development of the condition.

Even though many studies were done in urban areas and few in the rural areas to assess the diabetes prevalence and to study different factors influencing it, none of these studies had done a complete evaluation of prediabetes prevalence.

The present study was done by Stratified random sampling methodology which gives more accurate prevalence rates than any other methodologies like hospital level studies and identification of prediabetic subjects through health camps/diabetes screening camps.
In this study we had estimated only prediabetes prevalence rate and the influence of different factors. We also estimated different biochemical parameters in the subjects who were identified as prediabetics and evaluated different factors influencing them.
Bibliography


