

## Risk Factor for Diabetes in Different Populations of Manipur

Ahsana Shah and Mohammad Afzal\*

Human Genetics and Toxicology Laboratory, Section of Genetics, Department of Zoology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India

\*Corresponding author: Mohammad Afzal, Human Genetics and Toxicology Laboratory, Section of Genetics, Department of Zoology, Aligarh Muslim University, Aligarh, Uttar Pradesh, India, Tel: + 057-1 270-09; E-mail: [afzal1235@rediffmail.com](mailto:afzal1235@rediffmail.com)

Received date: January 28, 2015, Accepted date: March 28, 2015, Published date: April 4, 2015

Copyright: © 2015 Shah, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

### Abstract

#### Background

Type 2 diabetes mellitus (DM) is among the most common non-communicable chronic diseases in developed and developing countries around the world. The present study was conducted to find out associated risk factors, awareness of basic knowledge regarding risk factors, treatment and complications of diabetes among different populations of Manipur.

#### Methods

Individuals of both sexes belonging to three different populations were randomly selected and screened for diabetes from different districts of Manipur, which is a small hilly state, situated in the north eastern extreme corner of India sharing an international boundary with Myanmar (Burma). DM was defined according to the American Diabetes Association (ADA) recommendations as FBS > 126 mg/dl or oral glucose tolerance test OGTT<sub>2</sub> > 200 mg/dl.

#### Results

Majority of the present studied diabetic individuals were males i.e., 65.31%. About 30.27% had family history of diabetes. The prevalence of diabetes is more in meat eaters. Muslims shows highest percentage of overweight diabetic individuals i.e. 36.2%. Only 42.18% of diabetic individuals had basic knowledge regarding risk factors, treatment and complications of diabetes.

#### Conclusion

Large scale epidemiological studies for other populations need to be undertaken to ascertain the causes of rising DM epidemic, initiative for reducing or if possible, some serious efforts must be taken by the Government, health planners to promote physical activity, changing societal perceptions of health and improving knowledge about their associated risk factors by discussing it with the general public.

**Keywords:** Diabetes mellitus; Population; Risk factors; Manipur; India

### Introduction

Type 2 Diabetes mellitus (DM) is by far the most common metabolic disorder in many populations of the world. It is the third most common health disorder worldwide and fourth leading cause of death. The incidence and prevalence of DM are rapidly increasing worldwide in both developing and developed nations. According to recent analysis the number of adults with DM from 2010 to 2030 would increase 20% in developed countries and 69% in developing countries [1,2]. DM is a disease of insidious onset and the symptoms, when they eventually appear, do not warrant immediate attention and thus remain undiagnosed at onset and even when diagnosed is often ignored by persons afflicted by it [3]. When unmanaged, DM causes damage to many organs and tissues of the body leading to serious complications [4]. The aetiology of diabetes in India is multifactorial and includes genetic factors coupled with environmental influences

such as obesity associated with rising living standards, steady urban migration, and lifestyle changes [5]. DM has reached epidemic proportions worldwide, placing a substantial burden on healthcare services. Recent estimates suggest that the prevalence of DM is rising globally, particularly in developing countries [6]. The biggest increase in DM cases is expected in China and India. India currently, have around 40 million cases of DM and these numbers are projected to increase to 87 million by the year 2030 [7]. Anticipating an epidemic like increase in the number of diabetic patients India has been christened as the 'diabetic capital of the world as it is reported that 1 out of 4 individuals will be an Indian diabetic in the world [8,9]. Asian Indians are more prone to type 2 DM at a younger age and premature cardiovascular disease (CVD) remains speculative, there is a growing body of evidence to support the concept of the "Asian Indian Phenotype" [10,11]. A patient who suffers from type 2 DM has a 2–4 times greater risk of death from cardiovascular causes than the patient without DM. The most common cause of death in the diabetic patient is heart disease. In addition, peripheral vascular disease, end-stage renal disease, blindness and amputations are common co-morbidities

in diabetic patients [12]. Thour et al. [13] reported higher prevalence of depression in patients with type 2 diabetes. Kapoor et al. [14] reported that urban environment showed a changing lifestyle and high prevalence of DM among tribal migrating urban tribes as compared to traditional tribes. The aim of present study was to find out associated risk factors, awareness of basic knowledge regarding risk factors, treatment and complications of diabetes among different populations of Manipur.

## Subjects

Manipur is a small hilly state, situated in the north eastern extreme corner of India that connects the Indian subcontinent to East Asia and South East Asia as a unique narrow passageway and shares an international boundary with Myanmar (Burma). It is bound by Nagaland in the north, Mizoram in the south, Assam in the west and Burma lies in the east and also isolated from the rest of India, both geographically and economically [15]. The survey was conducted in the given districts of Manipur i.e. Imphal East, Imphal West, Thoubal, Ukhrul and Senapati taking three different populations viz. Manipur Muslims, Meitei (Hindu) and Naga.

Manipuri Muslims comprising 8.32% of the total population according to the 2001 census are mostly migrants who started coming to the state in the middle of the 16th century and they belong to Sheikh, Syed, Pathan or Mughal.

## Materials and Methods

A well designed, pre-tested questionnaire was used and a house to house survey was conducted of all the people above the age of 20 years who were interviewed and examined. Informed written consent was obtained. Data on age, sex, occupation, marital status and personal habits were also collected.

Plasma FBS concentration was measured by finger stick with a glucometer. Recent studies have shown that modern handheld glucose measuring devices have excellent technical characteristics and yield results that are similar to the reference laboratory methods. Furthermore, various studies have reported that capillary glucose measurements are as suitable as venous glucose measurements in the diagnosis and detection of type 2 DM in epidemiological studies and may be cost effective in the implementation of pre-screening procedures [16-22]. The American Diabetes Association (ADA) recommends screening for Type 2 DM by using a verbal or written questionnaire to select high-risk individuals to increase the cost-effectiveness of testing undiagnosed individuals [23]. Participants with levels >100 mg/dl subsequently underwent an OGTT2 to confirm the diagnosis of DM. DM was defined according to the ADA recommendations as FBS >126 mg/dl or oral glucose tolerance test OGTT2 >200 mg/dl [24]. Any resident who reported that he/she was a diabetic and on treatment was counted as a diabetic, irrespective of FBS values, and was not tested further.

## Results

Majority of the present studied diabetic individuals were males i.e., 65.31 % (192/294) and 34.69% (102/294) were females. The studied diabetic individuals include 147 Muslims, 43 Meitei and 30 Naga populations. The diabetic individuals were analyzed under the following subheadings:

### Family history of diabetes

About 31.25% of the males and 28.43% among females had family history of diabetes. Among Muslims 32.58% of the individuals had family history of diabetes while 67.42% had no family history of diabetes. In case of Meitei and Naga, 25.58 % and 20% respectively had family history of diabetes (Table 1).

### Diet and food intake pattern

Analysis of food intake patterns show that the prevalence of diabetes is more among meat eaters than the non-eaters.

Populations	Male		Female		Combined	
	P	A	P	A	P	A
Muslim	49	98	23	51	72	149
	-33.33	-66.67	-31.1	-68.92	-32.58	-67.42
Meitei	6	17	5	15	11	32
	-26.1	-73.91	-25	-75	-25.58	-74.42
Naga	5	17	1	7	6	24
	-22.73	-77.27	-12.5	-87.5	-20	-80
Total	60	132	29	73	89	205
	-31.25	-68.75	-28.43	-71.57	-30.27	-69.73

**Table 1:** Prevalence of diabetes among family with diabetes in different populations of Manipur. 'P' and 'A' represents presence and absence of diabetes. Percentage shown in parentheses.

Males of the present studied population shows higher intake of meat which includes both white and red meat. Among the different populations, studied Manipuri Muslims and Naga shows higher intake of meat. But the dietary pattern was more fatty and spicy among muslim in comparison to the Meitei and Naga population. Fish is a favorite meat for Meiteis though it was consumed by other two populations also, supplemented with pulses, besides roots and tubers, whereas meat or fish and rice is consumed by all the population taken in the present study.

### Overweight

In the present study 33.85% of overweight males had diabetes while among diabetic females 36.27% were overweight. Muslims show highest percentage of overweight diabetic individuals i.e. 36.2% while the least case of overweight diabetic individuals was found among Naga (26.67%) (Table 2).

### Marital status

Among diabetic individuals 90.1% of the males and 94.2% of females were married. Among Muslims only 9.04% of unmarried individuals were found to be diabetic, while 6.98% and 6.67% of unmarried Meitei and Naga respectively were found to be diabetic.

### Common complication

Diabetic individuals face many complications, some of the common problems as they discussed during the survey include feet (neuropathy

and peripheral vascular disease), kidneys (nephropathy), eyes (retinopathy), heart and blood vessels (cardiovascular disease) and gum disease (periodontal disease). The prevalence of cardiovascular and eye disease was found to be highest in comparison to the prevalence of other diseases.

### Diabetes awareness

Most of the participants had heard about diabetes but the basic knowledge regarding risk factors, treatment and complications of diabetes was poor. Awareness about risk factor, treatment and long term effects of diabetes was found to be highest among Meitei population (55.81%), followed by Muslim (40.27%) and Naga population (36.67%). Only about 40.82 % of the diabetic individuals reported regular monitoring of blood sugar level. Most of them were on sugar free diet, take insulin or tablets for controlling their blood glucose level.

Populations	Male		Female		Combined	
	P	A	P	A	P	A
Muslim	52	95	28	46	80	141
	-35.37	-64.63	-37.84	-62.16	-36.2	-63.8
Meitei	7	16	7	13	14	29
	-30.43	-69.57	-35	-65	-32.56	-67.44
Naga	6	16	2	6	8	22
	-27.27	-72.73	-25	-75	-26.67	-73.33
Total	65	127	37	65	102	192
	-33.85	-66.15	-36.27	-63.73	-34.69	-65.31

**Table 2:** Prevalence of diabetes among overweight individuals in different populations of Manipur. P' and 'A' represents presence and absence of diabetes. Percentage shown in parentheses

### Discussion

Diabetes mellitus is one of the major non communicable diseases which are growing very fast in this modern era. Diabetes and associated complications pose a major health care burden worldwide and present major challenge to patients, health care systems and national economies. Asia is the major site of a rapidly emerging diabetes epidemic [25]. India and China both are having highest number of diabetes patients in coming years. The smaller countries of the Indian subcontinent like Pakistan, Bangladesh and Srilanka were also witnessing a rapid increase in prevalence of type 2 diabetes [25]. Till date, very little information exists about the prevalence of DM from North-Eastern part of India which also includes Manipur. The present study was so conducted to find out associated risk factors, awareness of basic knowledge regarding risk factors, treatment and complications of diabetes among different populations of Manipur.

The development of type 2 diabetes results from a complex interaction of social, economic, environmental, behavioural, and genetic factors, impacting both genders with different effects for each [26]. Among 294 diabetic individuals taken in the present study, males shows higher incidence of diabetes. Similar findings were reported by various researchers in India regarding female preponderance in Indian

diabetics especially by Venkatesham et al. [27] and Ramachandran et al. [28] observed male excess amongst the diabetic person's. A study conducted in Turkey has found high prevalence of type-2 DM among women [29]. About 30.27% of individuals had family history of diabetes. Proper care needs to be taken by siblings of diabetic parents, since family history is one of the important genetic factors that results in the development of DM.

Diet is thought to play an important role in the aetiology of type 2 diabetes [30]. In the present study analysis of food intake patterns shows the prevalence of diabetes is more in meat eaters. Snowdon and Phillips [31] first reported an association between meat intake and diabetes in a study of Seventh Day Adventists, a population with a high proportion of vegetarians. Meat intake was associated with an increased prevalence of diabetes in men and women; and an increased diabetes-associated mortality in men, but not in women. Several subsequent publications have reported an increased risk of diabetes or type 2 diabetes with a high intake of processed meat [32-34], red meat [32-34] and total meat [32], but the results have not been consistent [35]. Meat is an important source of total and saturated fat and could increase the risk of type 2 diabetes through overweight/obesity [36,37], the metabolic syndrome [38,39] and hyperinsulinaemia and hyperglycaemia [35], although some studies found no association [40,41]. Another possible mechanism may be through the effects of haem-iron derived from meat [34]. Iron can promote oxidative stress by increasing the formation of hydroxyl radicals [42] which can cause damage to tissues, in particular the pancreatic beta cells [42]. Elevated iron status may interfere with glucose metabolism and may reduce pancreatic insulin synthesis and secretion [43] and one study suggested a detrimental effect of red meat intake on glucose metabolism. Higher meat intake is often associated with other unhealthy lifestyles including physical inactivity, overweight, smoking and unhealthy dietary patterns.

33.85% of overweight males had diabetes while in diabetic females 36.27% were overweight. Overweight and obesity are major risk factors for type 2 diabetes and a meta-analysis suggested an approximate 20% increase in type 2 diabetes risk for each unit increase in BMI [44,45]. According to American Diabetes Association, being overweight is a risk factor for developing this disease, but other risk factors such as family history, ethnicity and age also play a role. Unfortunately, too many people disregard the other risk factors for diabetes and think that weight is the only risk factor for type 2 diabetes. Most overweight people never develop type 2 diabetes, and many people with type 2 diabetes are at a normal weight or only moderately overweight.

In the present study overall only 42.18% of diabetic individuals have awareness of basic knowledge regarding risk factors, treatment and complications of diabetes. Deepa Mohan et al. in [46] Chennai observed that even among self-reported diabetic subjects, knowledge about diabetes including awareness of complications of diabetes was poor. This indicates that majority of the patients have not been taught about diabetes by their physicians. Therefore, there is a need to improve the knowledge and awareness about diabetes [47]. Many medical treatments are available to help when diabetes complications occur but self precautionary measures involving a program of healthy, low-fat eating, regular exercise and quitting smoking can help a lot in preventing diabetes complications. Peripheral vascular disease, end-stage renal disease, blindness and amputations are reported to be common co-morbidities in diabetic patients [48].

The development of type 2 DM is influenced by lifestyle factors such as poor diet and lack of exercise resulting in high blood glucose levels, blood pressure and obesity. The most effective way to prevent and delay the increasing incidence of type 2 DM is through primary prevention, preventing illness before it occurs. Lifestyle interventions such as dietary and physical activity changes improve health outcomes in people who are at high risk of developing type 2 DM. Type 2 DM can be controlled in its early stages through healthy eating and regular physical activity. However, as the disease progresses, medication such as insulin may be needed [48,49]. American Diabetes Association has also proposed the screening of all the patients aged over 45 years by measuring fasting blood glucose, every three years, in addition to screening patients from high-risk groups and younger patients with HT, obesity, the family history of DM in the first-degree relative, and a family history of gestational DM. Of interest is the prospect of introduction of presymptomatic diagnosis of susceptible individuals using genetic markers, where it is expected to play an essential role in the control and prevention of non-communicable diseases. If this becomes a practical approach, the prevention of the complications will be of appreciable benefit to those prone to DM [50]. The need of the hour, therefore is that large scale epidemiological studies for other populations be undertaken to ascertain the causes of the rising Type 2 DM epidemic in the state of Manipur, either for reducing or if possible, some serious efforts must be taken viz. like concerted preventive measures need to be taken by the Government, health planners by discussing it with the general public steps to promote physical activity, changing societal perceptions of health and improving knowledge about their associated risk factors like hyperlipidemia, microalbuminuria and central obesity.

### Conflict of Interest

The authors declare no conflict of interest.

### Acknowledgements

Thanks are due to the Department of Science & Technology (DST), New Delhi, for awarding INSPIRE Fellowship to the first author Ahsana Shah (SRF, IF10378) and to the Chairman Department of Zoology, A.M.U., Aligarh (U.P), India, for laboratory facilities. I am also thankful to Mr. Rahman, MsIqbal, MsIshrat, Mr. Bashit, Mr. Arshad, Ms Mohsina, Mr. Abdul Hye, Dr. Atiqur Rahman, Mr. Azad, Mr. Syed Rafi for their kind assistance. It was a noble experience working with the people of my State. I also gratefully acknowledge the cooperation of all the individuals who participated as subjects in this study.

### References:

1. King H, Rewers M (1993) Global estimates for prevalence of diabetes mellitus and impaired glucose tolerance in adults. WHO Ad Hoc Diabetes Reporting Group. *Diabetes Care* 16: 157-177.
2. Shaw JE, Sicree RA, Zimmet PZ (2010) Global estimates of the prevalence of diabetes for 2010 and 2030. *Diabetes Res Clin Pract* 87: 4-14.
3. Harris MI, Klein R, Welborn TA, Knudman MW (1992) Onset of NIDDM occurs at least 4-7 yr before clinical diagnosis. *Diabetes Care* 15: 815-819.
4. Council of Australian Governments. National reform agenda: Victoria's plan to address the growing impact of obesity and type 2 diabetes. Melbourne: Department of Premier and Cabinet, 2007.
5. Kaveeshwar SA, Cornwall J (2014) The current state of diabetes mellitus in India. *Australas Med J* 7: 45-48.
6. Wild S, Roglic G, Green A, Sicree R, King H (2004) Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 27: 1047-1053.
7. Hasan I, Khattoon S (2012) Prevalence of diabetes mellitus and obesity among population of Sultanpurkunjhari and its surrounding area, Haridwar, Uttarakhand. *IRJP* 3:226-229.
8. Joshi AR, Pranita A, Phadke AV (2012) Diabesity: Curse of development. *Int J Med Update* 7:77-78.
9. Aswar NR, Kale KM, Ghorpade KS, Doibale MK, Barure BS (2015): Prevalence of Type 2 Diabetes Mellitus in an Urban Area of Nanded City (Maharashtra, India). *IJHSR* 5:1-10.
10. Deepa R, Sandeep S, Mohan V (2006) Abdominal obesity, visceral fat and Type 2 diabetes - "Asian Indian Phenotype". In: Mohan V, Gundu HR Rao, editors. *Type 2 diabetes in South Asians: Epidemiology, risk factors and prevention*. Jaypee Brothers Medical Publishers, New Delhi: India.
11. Joshi SR (2003) Metabolic syndrome--emerging clusters of the Indian phenotype. *J Assoc Physicians India* 51: 445-446.
12. Fisman EZ, Tenenbaum A (2008) Cardiovascular diabetology: clinical, metabolic and inflammatory facets. Preface. *Adv Cardiol* 45: xi-xiii.
13. Thour A, Das S, Sehrawat T, Gupta Y (2015) Depression among patients with diabetes mellitus in North India evaluated using patient health questionnaire-9. *Indian J Endocrinol Metab* 19: 252-255.
14. Kapoor D, Bhardwaj AK, Kumar D, Raina SK (2014): Prevalence of Diabetes Mellitus and Its Risk Factors among Permanently Settled Tribal Individuals in Tribal and Urban Areas in Northern State of Sub-Himalayan Region of India. *Int J Chr Dis* 1-9.
15. Cordaux R, Weiss G, Saha N, Stoneking M (2004) The northeast Indian passageway: a barrier or corridor for human migrations? *Mol Biol Evol* 21: 1525-1533.
16. Hodson TC (1975) *The Meiteis*. Reprint Edition. New Delhi: BR publishing Corporations.
17. Shah A, Fareed M, Hussain R, Afzal M (2012) Phylogenetic relationships of Muslim populations of Manipur based on morphogenetic markers. *Antrocom Online J Anthropol* 8:463-480.
18. Sharma K, Badaruddin (1991) Meitei Pangal (Meitei Muslim). LaininghalBapu Research center, Imphal.
19. Shah A, Afzal M (2013) Prevalence of diabetes and hypertension and association with various risk factors among different Muslim populations of Manipur, India. *J Diabetes Metab Disord* 12: 52.
20. Shah A, Hussain R, Fareed M, Afzal M (2012) Gene frequency of sickle cell trait among Muslim populations in a malarial belt of India, i.e., Manipur. *Egypt J Med Hum Genet* 13:323-30.
21. Saha N, Tay JS (1990) Genetic studies among the Nagas and Hmars of eastern India. *Am J PhysAnthropol* 82: 101-112.
22. Solnica B, Naskalski JW, Sieradzki J (2003) Analytical performance of glucometers used for routine glucose self-monitoring of diabetic patients. *Clin Chim Acta* 331: 29-35.
23. Baan CA, Ruige JB, Stolk RP, Witteman JC, Dekker JM, et al. (1999) Performance of a predictive model to identify undiagnosed diabetes in a health care setting. *Diabetes Care* 22: 213-219.
24. American Diabetes Association (2004) Screening for type 2 diabetes. *Diabetes Care* 27:S11-S14
25. Weber MB, Oza-Frank R, Staimez LR, Ali MK, Narayan KM (2012) Type 2 diabetes in Asians: prevalence, risk factors, and effectiveness of behavioral intervention at individual and population levels. *Annu Rev Nutr* 32: 417-439.
26. Grant JF, Hicks N, Taylor AW, Chittleborough CR, Phillips PJ; North West Adelaide Health Study Team (2009) Gender-specific epidemiology of diabetes: a representative cross-sectional study. *Int J Equity Health* 8: 6.
27. Venkateshwan P, Narsimhan Reddy RA, Shankaraich P, et al. (2010)Pharmacoepidemiology of diabetes mellitus in Southern India. *Intern J Pharm Sci* 2:400-404.
28. Ramachandran A, Snehalatha C, Dharmaraj D, Viswanathan M (1992) Prevalence of glucose intolerance in Asian Indians. Urban-rural

- difference and significance of upper body adiposity. *Diabetes Care* 15: 1348-1355.
29. McKeigue PM, Shah B, Marmot MG (1991) Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. *Lancet* 337: 382-386.
  30. Aune D, Ursin G, Veierød MB (2009) Meat consumption and the risk of type 2 diabetes: a systematic review and meta-analysis of cohort studies. *Diabetologia* 52: 2277-2287.
  31. Snowdon DA, Phillips RL (1985) Does a vegetarian diet reduce the occurrence of diabetes? *Am J Public Health* 75: 507-512.
  32. Fung TT, Schulze M, Manson JE, Willett WC, Hu FB (2004) Dietary patterns, meat intake, and the risk of type 2 diabetes in women. *Arch Intern Med* 164: 2235-2240.
  33. Schulze MB, Manson JE, Willett WC, Hu FB (2003) Processed meat intake and incidence of Type 2 diabetes in younger and middle-aged women. *Diabetologia* 46: 1465-1473.
  34. Song Y, Manson JE, Buring JE, Liu S (2004) A prospective study of red meat consumption and type 2 diabetes in middle-aged and elderly women: the women's health study. *Diabetes Care* 27: 2108-2115.
  35. van Dam RM, Willett WC, Rimm EB, Stampfer MJ, Hu FB (2002) Dietary fat and meat intake in relation to risk of type 2 diabetes in men. *Diabetes Care* 25: 417-424.
  36. French SA, Jeffery RW, Forster JL, McGovern PG, Kelder SH, et al. (1994) Predictors of weight change over two years among a population of working adults: the Healthy Worker Project. *Int J Obes Relat Metab Disord* 18: 145-154.
  37. Kahn HS, Tatham LM, Heath CW Jr (1997) Contrasting factors associated with abdominal and peripheral weight gain among adult women. *Int J Obes Relat Metab Disord* 21: 903-911.
  38. Damião R, Castro TG, Cardoso MA, Gimeno SG, Ferreira SR; Japanese-Brazilian Diabetes Study Group (2006) Dietary intakes associated with metabolic syndrome in a cohort of Japanese ancestry. *Br J Nutr* 96: 532-538.
  39. Lutsey PL, Steffen LM, Stevens J (2008) Dietary intake and the development of the metabolic syndrome: the Atherosclerosis Risk in Communities study. *Circulation* 117: 754-761.
  40. Lundgren H, Bengtsson C, Blohmé G, Isaksson B, Lapidus L, et al. (1989) Dietary habits and incidence of noninsulin-dependent diabetes mellitus in a population study of women in Gothenburg, Sweden. *Am J Clin Nutr* 49: 708-712.
  41. Meyer KA, Kushi LH, Jacobs DR Jr, Folsom AR (2001) Dietary fat and incidence of type 2 diabetes in older Iowa women. *Diabetes Care* 24: 1528-1535.
  42. Wolff SP (1993) Diabetes mellitus and free radicals. Free radicals, transition metals and oxidative stress in the aetiology of diabetes mellitus and complications. *Br Med Bull* 49: 642-652.
  43. Rajpathak SN, Crandall JP, Wylie-Rosett J, Kabat GC, Rohan TE, et al. (2009) The role of iron in type 2 diabetes in humans. *Biochim Biophys Acta* 1790: 671-681.
  44. Hartemink N, Boshuizen HC, Nagelkerke NJ, Jacobs MA, van Houwelingen HC (2006) Combining risk estimates from observational studies with different exposure cutpoints: a meta-analysis on body mass index and diabetes type 2. *Am J Epidemiol* 163: 1042-1052.
  45. Mohan D, Raj D, Shanthirani CS, Datta M, Unwin NC, et al. (2005) Awareness and knowledge of diabetes in Chennai--the Chennai Urban Rural Epidemiology Study [CURES-9]. *J Assoc Physicians India* 53: 283-287.
  46. Muninarayana C, Balachandra G, Hiremath SG, Iyengar K, Anil NS (2010) Prevalence and awareness regarding diabetes mellitus in rural Tamaka, Kolar. *Int J Diabetes Dev Ctries* 30: 18-21.
  47. Fisman EZ, Tenenbaum A (2008) Cardiovascular diabetology: clinical, metabolic and inflammatory facets. Preface. *Adv Cardiol* 45: xi-xiii.
  48. Thurecht L, Armstrong A, Brown L (2009) Bridging the gap in meeting clinical targets for the treatment of type 2 diabetes. Canberra: University of Canberra. National Centre for Social and Economic Modelling.
  49. Kilkkinen A, Heistaro S, Laatikainen T, Janus E, Chapman A, et al. (2007) Prevention of type 2 diabetes in a primary health care setting. Interim results from the Greater Green Triangle (GGT) Diabetes Prevention Project. *Diabetes Res Clin Pract* 76: 460-462.
  50. El-Hazmi MA, Warsy AS (2001) Association of hypertension and non-insulin-dependent diabetes mellitus in the Saudi population. *Ann Saudi Med* 21: 5-8.