INTRODUCTION

Non-communicable diseases (NCD) contribute a huge burden on the healthcare system in India as compared to past when the burden was due to infectious diseases. More than half of the deaths in India are attributed to NCD of which diabetes is on the forefront and has emerged as an epidemic in India. The severity of the present situation in the Indian context can be judged from the alarming figures that during 2004, diabetes has been directly responsible for 109,000 deaths, 1157 years of life lost and 2263 disability adjusted life years.

India is the second most populated country in the world with wide regional variations of caste, religion, socioeconomic status, lifestyle and food habits. These variations reflect not only in the epidemiology of diabetes but also in its care. A better understanding of the regional variation in diabetes is necessary for better planning of healthcare policies to ensure an effective care. This review delves into the regional disparities of diabetes epidemiology, current management practice and government policies for type 2 diabetes mellitus (T2DM) care in India. It also attempts to identify policy and research gaps, and to suggest corrective measures.

REGIONAL DISPARITIES IN DIABETES PREVALENCE

According to recent data, 62.4 million Indians have been...
reported to have diabetes and the figures are expected to reach 87 million by the year 2030. The occurrence rates of diabetes for urban, semi urban and rural population vary from 5-15%, 4-6% and 3-5%, respectively, showing wide regional disparities with respect to different local settings. Rural population has exhibited a 3 times (2.4% to 6.4%) shift in the prevalence during last 14 years. Such rapidly increasing prevalence has remarkably narrowed the gap between rural and urban areas. Improved socioeconomic status, excessive use of motorized transport, switching over to occupational attributes with increased mechanization, and constricting urban/rural disparity account for this shift. This is evident from rural prevalence rates in Kerala, which have even overtaken urban prevalence rates, so much so that the whole of Kerala can now be considered to be urbanized [Figure 1]. Mostly single center studies have been conducted across four regions of India viz. North, South, East and West to find out the prevalence of DM. Only few multi-centric studies such as the Indian Council of Medical Research (ICMR) studies 1979 and 1991, National Urban Diabetes Survey (NUDS) 2001, The Prevalence of Diabetes in India Study (PODIS) 2004, WHO-ICMR NCD Risk factor Surveillance study 2008 and recently published The Indian Council of Medical Research-India Diabetes (ICMR–INDIAB) study 2011 has given us new insight.

North
A cross-sectional survey among employees aged 20-59 years of a large industry near Delhi (n = 2935) reported crude prevalence of 14-17% and 37% for diabetes and prediabetes, respectively. A study by Misra et al. in a slum area of Delhi showed diabetes prevalence of 10.3%. NUDS also reported the prevalence of diabetes and Impaired Glucose Tolerance (IGT) as 11.6% and 8.6%, respectively in Delhi.

ICMR–INDIAB study demonstrated Chandigarh to have 0.12 million people with diabetes and 0.13 million with prediabetes with overall weighted prevalence of 13.6% and 14.6%, respectively. Though the diabetes prevalence was high in urban (14.2%) than in rural (8.3%); prediabetes prevalence was found to be equal (urban 14.5%; rural 14.7%). The lowest prevalence rates for diabetes (6.1%) and IGT (8.1%) in north was found in Kashmir.

South
Amrita Diabetes and Endocrine Population survey conducted in urban areas of Ernakulam (Kerala) district showed prevalence of diabetes as 19.5%. Results from another study carried out in rural Kerala showed crude and age-adjusted prevalence to be 14.6% and 12.5%, respectively, whereas Impaired Fasting Glucose (IFG) was found to be 5.1% and 4.6%, respectively.

A rise in diabetes prevalence was observed in Chennai from 13.5% (2000) to 18.6% (2006) whereas the prevalence of IGT decreased from 16.8% (2000) to 7.4% (2006). Kancheepuram reported 16.7% diabetes and 4.3% IGT prevalence in 2006. The rise in diabetes prevalence rates from 2000 to 2006 suggests the high conversion rates of prediabetes to diabetes.

In a study conducted among urban Puducherry population, known diabetes was found to be 5.6% (5.31% in males and 6.1% in females). Coastal Karnataka showed an overall diabetes prevalence of 16%. Rao et al. (2010) found that 40-49, 50-59 and 60 years age groups had two-fold, four-fold and six-fold higher risk of diabetes, respectively, when compared to the 30-39 year age group.

West
ICMR–INDIAB study has shown an overall diabetes prevalence of 8.4% in Maharashtra. Urban areas had significantly higher diabetes population than rural part of state (10.9% vs. 6.5%, P < 0.05). Overall prevalence of IFG was higher (8.0%) than IGT (3.1%). The prevalence in rural Maharashtra was shown to be higher (9.3%) in another study. Rural area of Mandur, Goa also showed prevalence of 10.3% (n = 1266).

Jaipur reported an age-standardized prevalence of 8.6%, in a study using American Diabetes Association (ADA) criteria. The prevalence of prediabetes as well as diabetes
was low amongst the subjects of camel-milk consuming rural Raica community from north-west Rajasthan. The age-adjusted prevalence of diabetes, IFG, and IGT in these subjects was significantly lower (0%, 3.2% and 8.6%) than the other-milk consuming Raica subjects (4.6%, 7.8%, and 20.6%) and non-Raica subjects (7.5%, 13.4% and 15.1%), respectively ($P < 0.01$).[23]

East

The overall prevalence of diabetes in Jharkhand was found to be 5.3% with approximately 0.96 and 1.5 million people with diabetes and prediabetes, respectively. The prevalence of diabetes was quite higher in urban (13.5%), than in rural (3%) areas.[13]

Das et al. (2005) reported a prevalence of 1.66 ± 0.58% (male 0.99 ± 0.88; female 1.3 ± 0.75), 3.00 ± 0.74% (male 3.17 ± 1.04; female 2.80 ± 1.04) and 4.8 ± 0.98% (male 5.31 ± 1.43; female 4.27 ± 1.32) in the rural, industrial and urban areas of West Bengal, respectively.[24] However, out of 2160 subjects with a mean age of 36.4 years in the Kolkata policeman study (2008), diabetes was found in 11.5% (10.4% known and 1.1% newly diagnosed) whereas 6.2% had IFG.[25]

The prevalence of diabetes in peri-urban population of Manipur was 4.0%. A community-based survey of the 141 residents of Khowai district, Tripura found 9% of the subjects having pre-existing diabetes. A further 9% had ‘borderline’ (in the IGT range) or elevated levels, with no previous history of diabetes. 24% had normal blood glucose, but an existing risk factor for diabetes (family history or overweight) and 58% had normal blood glucose with no identifiable risk factor.[26]

**Poor Outcome and T2DM Complications as an Indicator of Insufficient Care and Monitoring**

Various studies in India indicate that more than 50% of people with diabetes have poor glyemic control (HbA1c >8%), uncontrolled hypertension and dyslipidemia, and a large percentage have diabetic vascular complications.[11,25–29] Results from Maharashtra region in a recent nationwide study showed that among known ($n = 679$) DM patients, in spite of 93.2% being on pharmacological agents [64.8% on sulfonylureas and 18% on insulin (66.4% on premix and 34.4% on basal)], HbA1c was found to be >7% in 72.7% patients among the people who were tested.

Similarly, in diabetic subjects of Madhya Pradesh ($n = 540$) 72% had HbA1c ≥7%. Among those, 484 (95%) were on oral anti-diabetic agents (OAD), 15 (3%) patients took insulin and 12 (2%) patients took both OAD and insulin.[30]

Recently published Delhi Diabetes Community (DEDICOM) survey including 819 adults from middle and upper socioeconomic background showed that only 13% had their HbA1c estimated in the preceding one year. Dilated eye examination and cholesterol examination were performed in only 16.2% and 32%, respectively. The mean frequency of self-monitoring of blood glucose (SMBG) was reported to be 3.1/month with 42% having HbA1c more than 8%.[27]

Ramachandran et al. in 2008 analyzed and compared the clinical profile and glycemic outcome in known diabetic cases in South Indian urban and peri-urban populations and found that the clinical outcome in known diabetic cases was far from satisfactory even in the cities where specialized diabetes care was available [mean age at diagnosis was 45.3 years, prevalence of hypertension was 57.4% (32% known); 48% were obese and a larger percentage (63.3%) had abdominal obesity; 50% had dyslipidemia].[28]

Suboptimal diabetes management leads to various microvascular and macrovascular complications, which largely influence the mortality and morbidity rates among the diabetic patients. In T2DM, Coronary Artery Disease (CAD) may start even before the onset of diabetes.[31] In an Indian study the prevalence of CAD was 21.4% among diabetic subjects compared to 9.1% in subjects with normal glucose tolerance.[32]

In the Chennai Urban Rural Epidemiology Study (CURES) 17.6% patients were found to have diabetic retinopathy (DR), 26.9% had microalbuminuria and 26.1% had peripheral neuropathy. The study also demonstrated that 1 in every 5 diabetic individual, may develop DR.[33] As per the Chennai Urban Population Study (CUPS), 21.4% had CAD and 6.3% had peripheral vascular disease (PVD).[34]

Another study from South India found retinopathy (23.7%) and neuropathy (27.5%) amongst the most common complications of T2DM. Other complications in this study were cardiovascular disease (CVD) 11.4%; PVD 4.0%; stroke 0.9% and hypertension (in 38% of patients).[35] Foot infection and amputation rates were found to be higher among rural than in urban patients; (34 vs. 26%, $P = 0.0001$) and (8 vs. 3%, $P < 0.05$), respectively.[34] A recent hospital-based observational study from Gujarat showed renal dysfunction in 10% ($n = 62$) and vision impairment in 9% ($n = 57$) of the 622 T2DM subjects.[34]

**Programmes, Policies and Initiatives for T2DM Management in India**

Our discussions so far have underscored the magnitude of the multifaceted problems stemming out of the epidemic
of T2DM. All the stakeholders i.e. patients and their relatives, government bodies and communities should be sensitized towards the growing menace of T2DM. Quite understandably, it will require all round efforts at various levels to implement different plans and strategies in truly meaningful way. Government of India (GoI) along with state governments have launched several programs related to diabetes, aimed to provide awareness about T2DM and its complications, screening and assessment of prevalence of diabetes in Indian masses. Some of the major programs initiated by GoI and state governments are outlined below. An expanded list of such programmes and policies is provided in Table 1.[15,37-49]

**Government of India programs**

**National diabetes control program**
This program was initiated in 1987 with objectives of identifying high risk subjects at early stage, prompt management of complications associated with diabetes and imparting health education to general population. It was started in some districts of Tamil Nadu, Jammu and Kashmir and Karnataka but was suspended due to lack of funds.[37]

**National programme for prevention and control of diabetes, cardiovascular diseases and stroke**
This programme was launched in January 2008 in 7 states (Kerala, Tamil Nadu, Assam, Punjab, Karnataka, Rajasthan and Andhra Pradesh). The objectives were early diagnosis and management of NCDs, training healthcare professionals, and establishing palliative and rehabilitative care.[38]

**Diabetes prevalence and management survey**
It was launched in June 2010 by Ministry of Health and Family Welfare in 8 states of North East.[39]

**ICMR-MRC diabetes prevention project**
Launched in 2012 with joint funding from the ICMR and the Medical Research Council (MRC), UK, to address the current diabetes burden in the respective countries.[40]

**State government programs**

**Chennai rural epidemiology study**
Initiated in August 2001 with objectives to study insulin resistance syndrome (IRS) in rural and urban population and incidence of complications associated with T2DM. In subsequent years, population characteristics and prevalence of diabetic retinopathy, diabetic nephropathy etc., were studied, and the results were published.[41]

**Prevention awareness counseling evaluation**
PACE Diabetes Project was initiated in September 2004, to create awareness regarding diabetes and its complications in Chennai city. Total of 774 education sessions were conducted and 76,645 individuals underwent blood glucose screening. The project was completed by the year 2007. It was estimated that project reached out to approximately 2 million people in Chennai city.[42]

**Prevention and control of diabetes**

Started in January 2012 by Catholic Health Association of India (CHAI), to create awareness for the prevention and control of diabetes with special focus on pregnant women. Regions covered are Lalitpur, Maharaiganj, Varanasi, Sitapur and Shahjahanpur districts of Uttar Pradesh.[43]

**Project MARG**
Initiated in 2007 with aim to create awareness about diabetes, obesity, lipid disorders and heart disease in children and adolescents. 40,196 children (aged 8-18 years), 25,000 parents and 1500 teachers were educated about healthy nutrition, physical activity, non-communicable diseases and healthy recipes in three cities of North India (New Delhi, Agra and Jaipur).[44]

**Policy and Level of Care Gaps in Diabetes Care in India**

As evident, there are number of programs supported by GoI as well as respective state governments but to be effective, the most important aspect is coordination and communication so that best practices of each program is shared and emulated by others. National Diabetes Control Program with its important objective of identifying high-risk individuals and management of complications of T2DM was shelved in between due to lack of funds. Such instances can be detrimental in the bigger canvas of fight against DM. On the other hand, state run initiatives such as CURES is successfully achieving its mission by publishing the important findings on DM associated complications.

A single body should be constituted that can monitor the progress of all these programs at national level and incentives should be given to the programs that are successful in achieving their stated objectives. This body should also be made responsible for co-ordination and exchange of information between different bodies running these programs. The shortcomings in overall diabetes care can stem out of the following factors.

**Lack of awareness**
Lack of awareness, which is the first major obstacle in diabetes care is rather common amongst not only the general population, but the patients also. CURES study reported that approximately 25% of the population was unaware of diabetes and only 41% of diabetic patients...
knew that diabetes could be prevented.\[50\] Similarly, a population-based study by Murugesan N et al. (2007) revealed that only 41\% of adults (>20 years age) in India were aware of risk associated. Over 92\% of the patients approached a general physician for treatment instead of a qualified diabetologist. The awareness of the disease was extremely low in the rural areas and the ratio of unknown-to-known diabetes is 3:1 as compared to 1:1 in the urban areas.\[53\] Data from community-based survey conducted among the residents of Khowai district, Tripura revealed that even though 91\% had heard about diabetes and 44\% were concerned about developing it in the future, only 39\% were aware of its association with overweight status and 37\% knew it required long-term treatment.\[26\] Similar finding from Southern India reveals that 75\% of the patients with diabetes in rural Tamaka, Kolar district of Karnataka were unfamiliar with the long term effects of diabetes and diabetic care.\[31\] These trends and figures clearly show the lack of knowledge about the disease in general and the availability of treatment options.

**Screening and diagnosis**

Early diagnosis and regular screening which is the key for effective management and prevention of complications is not being undertaken as per standard protocols. HbA1c testing is nearly absent at government centers and insignificant in private centers as well. Only 31\% specialized diabetes centers advocate HbA1c testing. Practice of SMBG was not stressed upon in government centers and was inadequate even in specialty centers. These results are comparable to DiabCare Asia study which also suggests poor frequency of SMBG.\[51\]

**Treatment modalities**

Biguanides and sulfonylureas were the only oral hypoglycemics prescribed at the government health centers, regardless of blood glucose values and duration of diabetes. Despite the fact that insulin was available free of cost, it was not initiated in patients who attended government centers due to poor availability of insulin, lack of trained manpower for educating the methods of injection practices and inadequate facilities for storage and maintenance. Similar findings were reported by WHO and results from a rural study.\[53\]

**Inadequate spending**

Healthcare in general and diabetes in particular are very heavily dependent on adequate infrastructure and funding. India spends only 5\% of its GDP on healthcare and DM requires a significant proportion of that amount for effective control and management. A study estimated the total annual cost of diabetes care in the year 2010 varied from 1230 billion to 1837.3 billion Indian Rupees. Although, India has worked continuously to improve its health care system in recent decades and efforts have been made to expand the public health system and reduce the burden of disease, unfortunately treatment outcome is far from optimal in India.\[11,20,27,28\]

**Suggestive corrective/remedial measures**

**Self-management and awareness**

As highlighted earlier, the patient is the key entity in the overall picture of DM. So, it is of utmost importance that patient is armed with the basic tenets of diabetic disease process and care. Lack of awareness can have serious implications; for example, patients who never receive diabetes education may have substantially increased risk of a major complications. Various media sources such as print/audio-visual and information technology (IT) aides should be effectively used to spread the awareness about the disease both in general population and diabetics. Family members of patients should be separately counseled about the disease process and importance of regular monitoring and checkups. School-going children should be made aware about the importance of maintaining healthy lifestyle and physical activities. Healthcare workers, at all levels should be adequately trained to disseminate information to patients regarding diabetes. Being a chronic disease, it is needless to say that patient compliance is the most important factor in fight against T2DM. Self-awareness can effectively increase the patient compliance issues related to adopting healthy diet and lifestyle, regular checkups of glycemic status, and periodic screening.

**Improving dietary habits**

Healthy eating habits and good nutrition can go a long way in preventing and managing diabetes. Healthy food items such as whole grains are rich in components like dietary fiber, starch, fat, antioxidant nutrients, minerals, vitamin, lignans, and phenolic compounds that have been linked to the reduced risk of obesity, insulin resistance, dyslipidemia, T2DM and heart diseases.\[53\]

**Physician approach to care**

Next to the patient, physician is the key component in the management of diabetes. It has been shown that various factors like inadequate knowledge of guidelines, primary focus on acute management rather than the preventive care, competing care demands, somewhat delayed clinical response to poor control, time constraint, inadequate resources and attitudinal issues are some of the physician related issues in diabetes control in India.\[4\] To overcome these shortcomings in the diabetic care specialized CME programs should be constituted to help the physicians to be updated. Also, it has been shown that guidelines arising out of evidence-based medicine (EBM) can effectively reduce the practice variations thereby improving the level
of care, so it makes lots of clinical sense to instill the concepts of EBM among general physicians. To popularize the guidelines formulated from EBM, physicians should be adequately trained, motivated and incentivized to use standard guidelines. These can be also be made legally binding so physicians will have to follow to comply from medico-legal perspective. Physicians also argue that western guidelines are often not applicable to Indian patients. To overcome this, an effort should be made to formulate local guidelines that can accommodate subtle disease variations and patient characteristics in Indian context. It has also been observed that physicians are often reluctant to prescribe insulin due to dosage and mode of administration constraints. A conscious effort has to be made to resolve this vital issue with caregivers.

Psychosocial aspect of diabetes care

Ethnocentric approach

In an evolving model of holistic approach of managing diabetes, psychosocial treatment forms the key to achieve appropriate biomedical outcomes. Lack of awareness amongst healthcare providers in this aspect and absence of proper guidelines forms the basis of diversity among the standards of clinical practice. Recently published evidence-based recommendations for the whole nation are a positive step in this aspect. In a vast country like India geographical, socio-cultural and economic diversity contribute to the complexity of psychosocial care itself. Two recent publications have tried to identify and suggest practical solutions for vulnerable populations from North East India and Uttarakhand.

Assigning a role for the family

The second Diabetes Attitudes, Wishes and Needs (DAWN2) study was performed by interviewing approximately 16,000 respondents, including 9,000 people with diabetes and nearly 5,000 family members of people with diabetes. Participants were belonging from 17 countries across four continents including a mix of developed and developing economies, with varying sociocultural climates and health-care system. This study, examined the psychosocial outcomes, experiences and concerns of family members, cross-national comparisons of perceptions on healthcare provision. DAWN2 has demonstrated the need to increase accessibility to and availability of diabetes self-management education tools. The study also underscored the negative impact on all psychosocial aspects investigated, ranging from 20.5% on relationship with family/friends to 62.2% on physical health.

While India fared poorly in hard parameters of diabetes care delivery, family members of diabetic patients from India had the least likelihood of feeling depressed, and perceiving significant burden in helping the diabetic person they live with. A recent editorial has underscored the need to utilize the services of family members efficiently through suitable strategies in the fight against diabetes.

Government support

While GoI and state governments are contributing in preventing and managing T2DM there remains a great scope for the governments to aid effectively in dealing with this ever-growing epidemic. Special budgetary allocation should be provided to T2DM as it can be a harbinger to many other serious ailments and maladies. A central-monitoring cell should be created to monitor and co-ordinate the workings of all the programs related to diabetes. Special media campaigns should be run by state authorities to promote the awareness of the disease. Direct/indirect incentives should be given to agencies involved in R and D in any aspect of T2DM.

Greater co-ordination and collaboration of stakeholders

There are three key entities namely patients, physicians and government bodies all of which need to work in tandem to fight the epidemic of T2DM. A physician’s job is to treat and make the patient aware regarding the evils of T2DM. Patient’s job is to comply with the treatment regimen and government’s job is to provide robust infrastructure (hospitals, health clinics, awareness campaigns, projects and programs) to effectively deal with T2DM (Figure 2).

Patient Issues and corrective measures

As stated earlier, diabetic patients are not well aware about the treatment options and dreaded complications. This is complicated with the sedentary lifestyle and improper diet. These problems can be overcome with proper education imparted by caregivers.

Figure 2: Role of patients, physicians and government bodies/society in management of T2DM, gaps in the care and suggestive measures to overcome those gaps
Table 1: Enlisted programmes are the major initiatives by the national and various state governments aimed to provide insight to the prevalence of diabetes and create awareness about the disease and its complications amongst Indian masses. For detailed descriptions please see the main text.

| Programme                                      | Date of project implementation and objectives                                                                 | Progress                                                                 | Current status               |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------|
| Initiative by central government               | National diabetes control programme (Pilot basis)                                                          | Initiated on a pilot basis in some districts of Tamil Nadu, Jammu & Kashmir and Karnataka but later suspended due to lack of funds | Not applicable               |
|                                                | IDSP[^35]                                                                                                    | Survey is being carried out regularly. From April 2010 to March 2012, World Bank released funds for Central surveillance unit at NCDC & 9 states | Outlay of Rs. 63 Crore has been approved for 2012-2013 |
|                                                | NRHM[^46]                                                                                                    | In 2009, Andhra Pradesh reported 75% patient satisfaction; however in other states (Uttar Pradesh, Rajasthan and Bihar) it was lower | Not applicable               |
|                                                | NPDCS[^38]                                                                                                   | Presently the NPCDCS programme is implemented in 100 districts across 21 states and is expected to reach 640 districts by 2017 |                              |
|                                                | Diabetes prevalence and management survey[^39]                                                              | Mobile technologies are being used to encourage sustained lifestyle changes for prevention of Type 2 diabetes in India and the UK | Ongoing                      |
|                                                | ICMR-MRC Diabetes Prevention Project[^40]                                                                   |                                                                           |                              |
|                                                | DiaBSmart Foot Research Project[^47]                                                                         | In subsequent years, population characteristics and prevalence of diabetic retinopathy, diabetic nephropathy etc., studied, and results were published. | Ongoing                      |
| State initiatives                              | CURES[^41]                                                                                                   | Initiated August 2001 with objectives to study insulin resistance syndrome in rural and urban population and incidence of complications associated with T2DM | Not Available                |
|                                                | PACE[^42]                                                                                                    | 774 education sessions were conducted and 76,645 individuals underwent blood glucose screening. The project was completed by the year 2007. It was estimated that project reached out to approximately 2 million people in n Chennai city | Completed                    |
|                                                | D-CLIP[^48]                                                                                                  |                                                                           | Not available                |

Contd...
Government issues and corrective measures
The GoI and other bodies have started number of programs but not all of them have been able to achieve their stated objectives. These programs should aim towards greater participation of patients and physicians alike.

CONCLUSION

Although sporadic studies on prevalence of diabetes have been available for several decades, reliable epidemiological data became available in India since the 1970s. Published studies vary in methodologies adopted and sampling frames and hence comparison of prevalence rates is not meaningful.

Focus on diabetes education, proactive physician participation, assigning a strategic role to family members, and well-planned healthcare system oriented towards diabetic care, form main areas of desired intervention. There is need for promoting research for better understanding of diabetes care in India and development of novel, effective and safe therapeutic agents. Another welcome initiative on the part of the government will be to subsidise the treatment and care of patients with diabetes. Thus a combined effort from patients, family members, healthcare professionals, government and NGO's can only help to tide over the situation.

ACKNOWLEDGMENT

We thank USV Limited for their educational grant and acknowledge WorkSure for medical writing assistance.

REFERENCES

1. Ramachandran A, Snehalatha C. Current scenario of diabetes in India. J Diabetes 2009;1:1-28.
2. Anjana RM, Ali MK, Pradeepa R, Deepa M, Datta M, Unnikrishnan R, et al. The need for obtaining accurate nationwide estimates of diabetes prevalence in India-rationale for a national study on diabetes. Indian J Med Res 2011;133:369-80.
3. Roglic G, Unwin N, Bennett PH, Mathers C, Tuomilehto J, Nag S, et al. The burden of mortality attributable to diabetes: Realistic estimates for the year 2000. Diabetes Care 2005;28:2130-5.
Baruah, et al.: Regional disparities in prevailing care of diabetes

4. Venkataraman K, Kannan AT, Mohan V. Challenges in diabetes management with particular reference to India. Int J Diabetes Dev Ctries 2009;29:103-9.

5. Mohan V, Radhika G, Vijayalakshmi P, Sudha V. Can the diabetes/cardiovascular disease epidemic in India be explained, at least in part, by excess refined grain (rice) intake? 2010. Available from: http://imsear.hellis.org/handle/123456789/135445 [Last accessed on 2013 Nov 15].

6. Gupta R, Misra A. Review: Type 2 diabetes in India: Regional disparities. Br J Diabetes Vasc Dis 2007;7:12-6.

7. Ramachandran A. Epidemiology of diabetes in India-three decades of research. J Assoc Physicians India 2005;53:34-8.

8. Vijayakumar G, Arun R, Kutty VR. High prevalence of type 2 diabetes mellitus and other metabolic disorders in rural Central Kerala. J Assoc Physicians India 2009;57:563-7.

9. Kapur A. Economic analysis of diabetes care. Indian J Med Res 2007;125:473-82.

10. Ahuja MMS. Recent contributions to the epidemiology of diabetes mellitus in India. Int J Diab Dev Ctries 1991;11:5-9.

11. Raheja BS, Kapur A, Bhoraskar A, Sathe SR, Jorgensen LN, Moorthi SR, et al. DiabCare Asia-India Study: Diabetes care in India-current status. J Assoc Physicians India 2001;49:717-22.

12. Ramachandran A, Snehalatha C, Kapur A, Vijay V, Mohan V, Das AK, et al. High prevalence of diabetes and impaired glucose tolerance in India: National Urban Diabetes Survey. Diabetologia 2001;44:1094-101.

13. Sadikot SM, Nigam A, Das S, Basaj S, Zargar AH, Prasanna Kumar KM, et al. The burden of diabetes and impaired glucose tolerance in India using the WHO 1999 criteria: Prevalence of diabetes in India study (PODIS). Diabetes Res Clin Pract 2004;66:301-7.

14. Mohan V, Mathur P, Deepa R, Deepa M, Shukla DK, Menon GR, et al. Urban rural differences in prevalence of self-reported diabetes in India-the WHO-ICMR Indian NCD risk factor surveillance. Diabetes Res Clin Pract 2008;80:159-68.

15. Anjana RM, Pradeepa R, Deepa M, Datta M, Sudha V, Unnikrishnan R, et al. ICR–INDIAB Collaborative Study Group Prevalence of diabetes and prediabetes (impaired fasting glucose and/or impaired glucose tolerance) in urban and rural India: Phase I results of the Indian Council of Medical Research-India DIABetes (ICR–INDIAB) study. Diabetologia 2011;54:3022-7.

16. Misra A, Pandey RM, Devi JR, Sharma R, Vilem NK, Khanna N. High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. Int J Obes Relat Metab Disord 2001;25:1722-9.

17. Zargar AH, Khan AK, Masoodi SR, Laway BA, Wani AI, Bashir MI, et al. Prevalence of type 2 diabetes mellitus and impaired glucose tolerance in the Kashmir Valley of the Indian subcontinent. Diabetes Res Clin Pract 2000;47:135-46.

18. Mohan V, Sandeep S, Deepa R, Shah B, Varghese C. Epidemiology of type 2 diabetes: Indian scenario. Indian J Med Res 2007;125:217-30.

19. Purty AJ, Vedapriya DR, Bazroy J, Gupta S, Cherian J, et al. Prevalence of diabetes in camel-milk consuming Raica rural community of north-west Rajasthan. Int J Diab Dev Ctries 2004;24:109-14.

20. Das S, Maji D, Majumder PP. Prevalence of diabetes in various habitats of West Bengal, India. J Indian Med Assoc 2005;103:580-4.

21. Kumar S, Mukherjee S, Mukhopadhyay P, Pandit K, Raychaudhuri M, Sengupta N, et al. Prevalence of diabetes and impaired fasting glucose in a selected population with special reference to influence of family history and anthropometric measurements-the Kolkata policeman study. J Assoc Physicians India 2008;56:841-4.

22. Lau SL, Debarm R, Thomas N, Asha HS, Vasan KS, Alex RG, et al. Healthcare planning in north-east India: A survey on diabetes awareness, risk factors and health attitudes in a rural community. J Assoc Physicians India 2009;57:305-9.

23. Nagpal J, Bhartia A. Quality of diabetes care in the middle- and high-income group populace: The Delhi Diabetes Community (DEDICOM) survey. Diabetes Care 2006;29:2341-8.

24. Ramachandran A, Mary S, Sithish CK, Selvam S, Catherin Seeli A, Muruganandam M, et al. Population based study of quality of diabetes care in southern India. J Assoc Physicians India 2008;56:513-6.

25. Rema M, Premkumar S, Anitha B, Deepa R, Pradeepa R, Mohan V. Prevalence of diabetic retinopathy in urban India: The Chennai Urban Rural Epidemiology Study (CURES) eye study. Invest Ophthalmol Vis Sci 2005;46:2328-33.

26. Joshi SR, Saboo B, Vadivale M, Dani SI, Mithal A, Kaul U, et al. Prevalence of diagnosed and undiagnosed diabetes and hypertension in India-results from the Screening India’s Twin Epidemic (SITE) study. Diabetes Technol Ther 2012;14:8-15.

27. Turtle JR. The economic burden of insulin resistance. Int J Clin Pract Suppl 2000;23:8.

28. Mohan V, Deepa R, Rani SS, Premalatha G, Chennai Urban Population Study (CUPS No. 5). Prevalence of coronary artery disease and its relationship to lipids in a selected population in South India: The Chennai Urban Population Study (CUPS No. 5). J Am Coll Cardiol 2001;38:682-7.

29. Premalatha G, Shanthirani S, Deepa R, Markowitz J, Mohan V. Prevalence and risk factors of peripheral vascular disease in a selected South Indian population: The Chennai Urban Population Study. Diabetes Care 2000;23:1295-300.

30. Viswanathan V, Madhavan S, Rajasekar S, Chamukuttan S, Ambady R. Urban-rural differences in the prevalence of foot complications in South-Indian diabetic patients. Diabetes Care 2006;29:701-3.

31. Ramachandran A, Snehalatha C, Satyavani K, Lahra E, SasiKala R, Vijay V. Prevalence of vascular complications and their risk factors in type 2 diabetes. J Assoc Physicians India 1999;47:1152-6.

32. Patel M, Patel YM, Patil YM, Rathi SK. A hospital-based observational study of type 2 diabetic subjects from Gujarat, India. J Health Popul Nutr 2011;29:265-72.

33. National diabetes control programme. National Institute of Health and Family Welfare [Internet]; Available from: http://www.nihfw.org/NDC/DocumentationServices/NationalHealthProgramme/nationaldiabetescontroldiagram Programme.html [Last cited on 2013 Nov 16].

34. National Programme for Prevention and Control of Diabetes, Cardiovascular Diseases and Stroke (NPDCS). Ministry of Health and Family Welfare, Government of India [Internet]; Available from: http://mohfw.nic.in/WriteReadData/1892s/9457038092 AnnualReportpeopleonhealth.pdf [Last cited on 2013 Nov 16].

35. ICMR-MRC Diabetes Prevention Project [Internet]; Available from:
http://www.ardiabetes.org/ICMR-MRC_Diabetes_Prevention_Project [Last cited on 2013 Nov 16].
41. Deepa M, Pradeepa R, Rema M, Mohan A, Deepa R, Shanthirani S, et al. The Chennai Urban Rural Epidemiology Study (CURES)-study design and methodology (urban component) (CURES-I). J Assoc Physicians India 2003;51:863-70.
42. Prevention and Control of Diabetes, Catholic Health Association of India [Internet]; Available from: http://www.chai-india.org/?page_id=1482 [Last cited on 2013 Nov 16].
43. Project “MARG” : The Path, A Health Awareness Program for the Prevention of Obesity and Diabetes through Healthy Eating and Active Lifestyle. Diabetes Foundation (India) and World Diabetes Foundation (Denmark) [Internet]; Available from: http://www.worlddiabetesfoundation.org/sites/default/files/Booklet_full_280409094320609.pdf [Last cited on 2013 Nov 16].
44. Mohan D, Raj D, Shanthirani CS, Datta M, Unwin NC, Kapur A, et al. Awareness and knowledge of diabetes in Chennai-the Chennai Urban Rural Epidemiology Study (CURES-9). J Assoc Physicians India 2005;53:283-7.
45. Murugesan N, Snehalatha C, Shobhana R, Roglic G, Ramachandran A. Awareness about diabetes and its complications in the general and diabetic population in a city in southern India. Diabetes Res Clin Pract 2007;77:433-7.
46. Muninarayana C, Balachandra G, Hiremath SG, Iyengar K, Anil NS. Prevalence and awareness regarding diabetes mellitus in rural Tamaka, Kolar. Int J Diabetes Dev Ctries 2010;30:18-21.
47. Tharkar S, Devarajan A, Barman H, Mahesh U, Viswanathan V. How far has translation of research been implemented into clinical practice in India? Are the recommended guidelines adhered to? Int J Diabetes Melliti [Internet]; Available from: http://www.sciencedirect.com/science/article/pii/S1877593411000038 [Last cited on 2013 Nov 16].
48. Type 2 diabetes mellitus in india. South Asia Network for Chronic Disease, New Disease [Internet]; Available from: http://sanccd.org/uploads/pdf/factsheet_diabetes.pdf [Last cited on 2013 Nov 16].
49. Kalra S, Sridhar GR, Balhara YP, Sahay RR, Bantwal G, Baruah MP, et al. National recommendations: Psychosocial management of diabetes in India. Indian J Endocrinol Metab 2013;17:976-95.
50. Poudel R, Adhikari B. Diabetes in the Himalayas: Psychosocial barriers and solutions. J Soc Health Diabetes 2013;1:66.
51. Nicolucci A, Kovacs Burns K, Holt RJG, Comaschi M, Hermanns N, Ishii H, et al. Diabetes Attitudes, Wishes and Needs second study (DAWN2TM): Cross-national benchmarking of diabetes-related psychosocial outcomes for people with diabetes. Diabet Med J Br Diabet Assoc 2013;30:767-77.
52. Kovacs Burns K, Nicolucci A, Holt RJ, Williams I, Hermanns N, Kalra S, et al. DAWN2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): Cross-national benchmarking indicators for family members living with people with diabetes. Diabet Med 2013;30:778-88.
53. Holt RJ, Nicolucci A, Kovacs Burns K, Escalante M, Forbes A, Hermanns N, et al. DAWN2 Study Group. Diabetes Attitudes, Wishes and Needs second study (DAWN2™): Cross-national comparisons on barriers and resources for optimal care-healthcare professional perspective. Diabet Med 2013;30:789-98.
54. Integrated Disease Surveillance Project (IDSP), Ministry of Health and Family Welfare, Government of India [Internet]; Available from: http://idsp.nic.in/[Last cited on 2013 Nov 16].
55. National Rural Health Mission, Ministry of Health and Family Welfare, Government of India [Internet]; Available from: http://nrhm.gov.in/ [Last cited on 2013 Nov 16].
56. DiaBSmart-Development of a new generation of DIABetic footwear using an integrated approach and SMART materials [Internet]; Available from: http://www.staffs.ac.uk/diabsmart/[Last cited on 2013 Nov 16].
57. Somannavar S, Lanthorn H, Pradeepa R, Narayanan V, Rema M, Mohan V. Prevention awareness counselling and evaluation (PACE) diabetes project: A mega multi-pronged program for diabetes awareness and prevention in South India (PACE- 5). J Assoc Physicians India 2008;56:429-35.
58. Weber MB, Ranjani H, Meyers GC, Mohan V, Narayan KM. A model of translational research for diabetes prevention in low and middle-income countries: The Diabetes Community Lifestyle Improvement Program (D-CLIP) trial. Prim Care Diabetes 2012;6:3-9.
59. Heller SR. ADVANCE Collaborative Group. A Summary of the ADVANCE Trial. Diabetes Care 2009;32:S357-61.

Source of Support: Research grant from USV ltd, Conflict of Interest: None declared.