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High Prevalence of Diabetes and Cardiovascular Risk Factors Associated with urbanization in India

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ABSTRACT

Aims: To compare prevalence of diabetes, impaired glucose tolerance (IGT), impaired fasting glucose(IFG) and cardiovascular risk factors between a city, a town and periurban villages(PUV) in southern India and to look for temporal changes in city and PUV.

Methods: Subjects aged≥20 years were studied in Tamilnadu, India in Chennai (City, n=2192 M:W-1053:1139), Kanchipuram (Town, n=2290 M:W-988:1302), and Panruti (PUV, n=2584, M:W-1280:1304) in 2006. Demographic, socio economic and anthropometric details, blood pressure, physical activity (PA), diet habits and lipids were studied. Risk associations with diabetes were analysed using multiple logistic regression analyses. Present and previous data in city and PUV were compared.

*Results***:** Mean BMI, waist circumference(WC) and family history of diabetes were significantly lower in PUV. PUV had lower prevalence(%) of diabetes [9.2 (95% CI, 8.0–10.5] ($p<0.0001$) than the city [18.6(16.6–20.5)] and town [16.4(14.1–18.6)]. Approximately 40% were newly diagnosed. Prevalence(%) of IGT was higher ($p<0.0001$) in the city [7.4(6.2–8.5)] than in town [4.3(3.3–5.3)] and PUV [5.5 (4.6–6.5)]. Prevalence of IFG was generally low. Age, family history and WC were significantly associated with diabetes, while PA was not. Overweight, elevated WC, hypertension and dyslipidaemia were more in the city.

*Conclusion***:** In the city, diabetes increased from 13.9% to 18.6% in 6 years and IGT decreased significantly. Town and city had similar prevalences; PUV had lower diabetes prevalence, but prevalence had increased compared to a previous survey. Cardio metabolic abnormalities were more in urban populations.

The rising prevalence of diabetes in India (1-8) and other developing countries (9-11) is chiefly attributed to urbanization. India will continue to have the largest number of diabetic subjects due to rapid urbanization and economic development (2). In Chennai city, the prevalence had increased from 5.2% in 1984 to 13.9% in 2000 (12,13). In 2003, a further increase to 14.3% was reported (4). Prevalence of impaired glucose tolerance (IGT) was also high (13).

The epidemic of diabetes is seen even in rural areas undergoing socio-economic development and urbanization (1,14). Diabetes shows an association with economic status (13,15).

Previous studies in Chennai (13) and in periurban areas (1,16) showed IGT to diabetes ratio of >1 indicating a large pool of prediabetic subjects. Prevalence of IGT and its proportion to prevalence of diabetes will depend on the stage of the 'epidemic', the rapidity of conversion to diabetes and the maximum attainable prevalence of diabetes in the population.

This study was done in three locations namely, the metropolitan city - Chennai, a town (Kanchipuram) and periurban villages (PUV, Panruti), in Tamilnadu. The primary aims were to see whether the prevalence of diabetes differed significantly between the town and city and whether the prevalence had increased since the last surveys in the city and villages. Secondly,the secular changes in diabetes and IGT and a comparative analysis of the risk associations with diabetes were studied. Prevalence rates of cardiovascular risk factors were also assessed.

SUBJECTS AND METHODS.

The survey was conducted from February to June 2006. By census definition the selected PUV are rural areas, however, due to proximity to town they have accessibility to urban facilities. Chennai city was chosen because data from previous surveys were available (3,12,13,16) and the temporal changes could be assessed. Kanchipuram is a typical town in India, 80 kms away from Chennai. Panruti was selected due to its periurban characteristics.

For Chennai, the required sample was 1712 at 80% power with an alpha error of 5% with an assumed increase in prevalence from 13.5% to 17%. Required number in Kanchipuram was 1422 with an assumed change from 7% to 10% and for Panruti, it was 1275 (increase from 6.0% to 9.0%). In each area, higher than the calculated numbers were studied.

In all areas, a multistage, random selection of streets was made to get a fair representation of all socioeconomic strata and all eligible members were studied. In the city, from the 5 corporation zones, areas were randomly selected. In the town, selection was based on the municipal wards and in the villages, census wards were used.

Subjects aged ≥20 years were invited to participate; response rate was 86% (7066 of 8216, (M:W-3321:3745)). Number studied were: City 2192 (M:W-1053:1139), Town 2290 (M:W-988:1302) and PUV 2584 (M:W-1280:1304). Response rates were 82%, 88% and 87% respectively. Demographic and socioeconomic characteristics were similar between the responders and non responders. Participants gave informed consent and study protocol was approved by the institution's ethics committee. Details on demography, anthropometry, medical history, education, monthly income, occupation, physical activity and diet habits (24 hr recall method) were filled in a computerized proforma by personal interview. Height was measured to the nearest centimeter using a tape, stuck to the wall with the subject standing erect. Weight was measured to the nearest 0.1kg using a digital bathroom scale. Body mass index (BMI) was calculated (kg/m^2). Waist circumference (WC), the smallest girth between the coastal margin and the iliac crest, was measured. Average of two blood pressure (BP) readings taken at 5 minutes interval in sitting position was noted. Physical activity at work, during leisure time and in house-hold activities were recorded as minutes of activity per week and were divided in quartiles. Categories of income (INR/month) were: Low-<5000, Middle- 5000-10000, High->10,000. Total calorie consumption and percentage of proximate principles were calculated by a dietitian.

For known diabetic cases fasting and 2hr post prandial blood glucose (FPG and PPG) were measured. Others underwent a standard OGTT (17). Blood samples were kept in ice till plasma or serum was separated. Plasma for glucose collected in fluoride –oxalate was separated within 2 hrs and assayed by glucose-oxidase peroxidase method using Hitachi auto analyzer 912(Roche Diagnostics, Germany). The coefficient of variation was <2%. Diabetes was diagnosed if FPG value was ≥126mg/dl, and/or 2 h post glucose was ≥200mg/dl, impaired fasting glucose (IFG) if FPG was between 110-125 mg/dl, and IGT if the 2 hr values were ≥140mg/dl and <200mg/dl with fasting values <110mg/dl (17). Fasting serum lipid profile was estimated by standard enzymatic procedures (Roche Diagnostics, Germany). High density lipoprotein cholesterol (HDL-C) was estimated by the direct assay method.

BMI >23kg/m^2 and >25kg/m^2 were considered to indicate overweight and obesity respectively. The normal cut off values for WC for men and women were >90cm and >85cms respectively. Hypertension was diagnosed if BP values were >130 and or >85 mmHg or if antihypertensives were being used. Cut off values were: cholesterol >200mg/dl, TG >150 mg/dl, HDL-C<40mg/dl.

This survey and a similar one done in 2000 in the city were compared (12,13). Results for PUV were compared with data in similar areas in 2003 (1). Age specific prevalence of diabetes and IGT and anthropometric characteristics in the city in 2000 and 2006, and in villages in 2003 and 2006 were compared. The comparisons were valid as the methodology was similar in all surveys.

In the national survey done in 2000 (13), Chennai was one of the six cities included. Subjects aged >20 years (n=1668, M:W 708:960 mean age 44 + 15 years) were tested. Capillary whole blood glucose tested and quality check done in every 10^{th} sample with 2h plasma glucose (glucose – oxidase peroxidase method) showed good correlation between the two methods (r = 0.91, p<0.0001). Glucose tolerance was categorized using the same criteria (17). In 2003, a group of villages 40 miles away from the city was studied [n = 1213 (M: W 497:716, mean age 41+6 years)] (1). The screening methodology, anthropometric, biochemical measurements and assessment of physical activity were done by methods used in the present survey.

Statistical Analysis. Prevalence estimates were age standardized by direct standardization method using the census data (2001) for respective populations of ≥20 years in Tamil Nadu and were compared using ‘Z’ statistics. 95% confidence intervals (CI) are reported. Mean and standard deviation (SD) are reported for normally distributed variables. Group comparisons were done using Student’s “t” test or by ANOVA. Multiple logistic regression analyses (forward stepwise addition) were done to find out the variables significantly associated with diabetes in the total group and in each area. Analysis was also done in the full data set taking the areas into consideration. Two areas were compared by creating a dummy variable, which was the PUV, as it was likely to have the lowest prevalence of diabetes. The dependent variable was diabetes vs. normal glucose tolerance (NGT). Independent variables included in all models were age (units of 10), sex, family history of diabetes, BMI (units of 5), WC (units of 5), monthly income (3 categories), physical activity (4categories), education (3 categories) and occupation (3categories). BMI showed significance only in the total group. Interactions of BMI and physical activity with age were not included.

P value of <0.05 was considered as significant. SPSS for windows, version10.0 (SPSS Inc Chicago, IL, USA) was used.

RESULTS

Prevalence of diabetes in the city, town and PUV (%,(95% CI) in respective order were 18.6(16.6–20.5), 16.4(14.1–18.6) and 9.2(8.0–10.5). PUV had significantly lower prevalence Vs city and town (p<0.0001). Men had higher prevalence than women: city- M=20.9 (17.9–23.9), W=16.7(14.2–19.3) (p=0.014), town M=17.1(13.9–20.2), W 15.9(12.6–19.3), PUV M=10.4 (8.6–12.3), W=8.0(6.2–9.7)(p=0.041). Prevalence of IGT was: city 7.4(6.2–8.5), town 4.3(3.3–5.3) and PUV 5.5(4.6–6.5), (City Vs town, p<0.0001, city Vs PUV, p=0.009). In the city, men had higher prevalence of IGT (M (9.4(7.6–11.3) Vs women (7.0(5.4–8.6), p=0.048). Prevalence of IFG was generally low in all areas; city 3.5(2.7–4.3), town (0.8(0.4-1.3)) and PUV (1.9(1.4–2.5) (PUV Vs city p<0.0001 ; Vs town p=0.002).

Proportion of illiterate subjects was the highest (22.8%) and college education was the lowest (5.4%) in the PUV (Table 1). Majority in PUV were labourers or home makers, and were physically active. Lower percentage reported positive family history of diabetes in PUV (7.9 vs 34.2% in city, 30.2% in town (P<0.0001)). Subjects in PUV had significantly lower anthropometric values, BP, cholesterol (Chol), triglycerides (TG) and HDL-C than subjects in city and town (Table 1). Components of diet were similar in all areas, rice was the staple food. Fat consumption was significantly lower (p<0.001) in PUV than in other areas (Table 1).

Prevalence of overweight (>23kg/m^2) and obesity (BMI≥25kg/m^2) and prevalence of abdominal obesity were similar in the city and town and were significantly lower in the PUV (Table 1). Obesity was more in women (M:W–city 30.9vs.50%, town 28.8vs.40.9%, PUV 18.6vs.20.4%, p<0.001 in all). Hypertension, hypercholesterolaemia and hypertriglyceridaemia were more prevalent in city dwellers and low HDL-C was more common in PUV. More than 25% of the adults had some form of dyslipidaemia in any area.

Table 2 shows a comparative analysis of the characteristics of study subjects in the same city (2000 and 2006) and in different PUVs of similar characteristics (2003 and 2006). In the city, BMI and WC had increased in both sexes. In PUV an increase in BMI and obesity occurred only in men.

Prevalence of diabetes increased in both areas by 34% in city and 43.8% in PUV Table 2 and (Figure 1-Panel 1 and 2) while prevalence of IGT decreased (Figure 1-Panel 3 and 4).

Prevalence of diabetes and IGT increased with age in all areas (Figure 1). In the city, diabetes showed an increasing trend with age (Figure 1–Panel 1). In subjects of <35 years, the prevalence decreased in 2006. In all ages, IGT decreased in 2006, most markedly in >64 years (Figure 1–Panel 3). IGT showed an age specific increase in both periods in the city (panel 3) and PUV (panel 4). In the town, a significant fall in diabetes was seen in >64 years (Figure 1–Panel 5).

Mean age of diabetic subjects decreased significantly in the present survey (city - 49.6+15.7 to 45.2+11.3 years, t=4.12, P<0.0001); (PUV-53.2+12.3 to 47.5+10.8

years t=3.9, p<0.0001). In the city, proportion of young diabetic subjects (≤44 years), increased from 25 to 35.7% (Z=2.95, P=0.003) and in PUV it increased from 27.3 to 34.8% (Z=4.6, P<0.0001).

In the total study group, age, BMI, family history of diabetes, WC and higher education were significantly associated with diabetes (Table 3 – Panel 1). Compared with PUV, city and town had higher association with diabetes. Age, family history of diabetes and WC were associated with diabetes in all areas. In the city, high income showed a positive association while school education showed an inverse relation with diabetes. BMI showed an independent association with diabetes only in the total group (Panel 1)

DISCUSSION

This paper reports the secular changes in diabetes based on population surveys in Southern India. There was a significant increase in diabetes not only in the city but also in PUV since the last surveys. Prevalence of diabetes in city and town were similar. IGT decreased in all areas, most markedly in the city, concomitant with an increase in diabetes.

High prevalence of diabetes in the city and town and a rapid increase in PUV could largely be due to urbanization. The influence of urban facilities penetrating into PUV was evident in two of our previous studies (1,16). Urbanization in India is expected to reach 46% by 2030 (11) and therefore in future a larger contribution to the diabetic population would be from rural areas.

Large proportions of known diabetic subjects indicated improved availability of medical facilities and awareness among the population. Medical facilities in villages throughout India are not comparable.

Prevalence of diabetes in Chennai was reported as 14.6% in 2004 by another group (4). A further 27% increase seen in 2 years, might be from a rapid conversion of IGT to diabetes and might partially explain the sharp fall in IGT. Previous studies in rural and semi urban populations, showed higher prevalence of IGT than diabetes (1,16,18). The present unexpected lower prevalence of IGT and IFG could be due to the vulnerability of the subjects to environmental changes resulting in rapid conversion to diabetes. In a prospective study of IGT, we noted a high conversion rate to diabetes (55% in 3 years) (19). Alternatively, a rapid deterioration of susceptible normoglycaemic subjects to diabetes could be occurring as suggested by Mohan et al (4). An increase in diabetes, particularly in the youth poses a severe societal burden.

In the city, a relative increase in diabetes in subjects of >64 years with concomitant reduction in IGT, probably indicated a rapid conversion to diabetes. The reason for the reduction in diabetes in this age group, in the town is unknown.

Generally, diabetes is less prevalent in rural than in urban areas. A rapid transition was seen in several developing countries. In rural Bangladesh, diabetes increased from 2.3% to 6.8% in 5 years (20). In suburban and rural areas in Nepal (21), Pakistan (22) and in South Korea (9) diabetes increased due to urbanization.

In PUV, diabetic subjects had higher BMI and WC but the levels were significantly lower than in the urban counterparts. Increased WC is usually a good reflection of insulin resistance. WC showed a stronger independent association with diabetes in all areas and might be suggestive of the significant contribution of insulin resistance to diabetes. Sedentary physical activity was not an independent contributor, probably due to narrow differences and also the confounding influences of age and occupation on the activity level. The observation of lower HDL-C in the rural population, despite low WC values was unexpected and needs further analyses.

Dyslipidaemia was present in >25% in all areas. Cardiometabolic risk variables were more common in the city and town. Increasing prevalence of glucose intolerance would contribute further to cardiovascular disorders. Ongoing life style changes in PUV are likely to enhance the risk of diabetes and CVD. Metabolic syndrome is common in this population (23, 24). However, we noted that it was not a determinant of conversion rate of IGT to diabetes in this population (25).

The most unexpected findings in the study were the marked increase in prevalence of diabetes in PUV and a sharp reduction in IGT in all areas. One of the limitations was that comparisons were made of studies done in different locations of PUV. Therefore, temporal changes and geographic differences could have contributed to the differences. Demographic and population characteristics of the study populations were similar in these areas. Possible influence of birthweight on glucose intolerance in adult population could not be analysed as birthweights were unavailable. Moreover, we need to study the interaction of birthweight and nutritional factors in early development, in order to draw valid conclusions.

An analysis of DETECT – 2 data from Finland, India (Chennai), the Pacific Islands and North America showed that combined effect of demography, age at onset and mortality could explain only 22% of the observed 6.2% increase in diabetes over a 5 year period in developing regions (26). In other words, nearly 80% of the increase in prevalence remains unexplained.

This study did not indicate the possible differences in the susceptibility factors. Unexplored parameters such as stress might probably show significant differences between the urban and rural groups and should be focused in later studies.

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TABLE 1. Characteristics of the study population and prevalence of cardiovascular risk factors

Variables	**City** n= 2192	**Town** n= 2290	**PUV** n= 2584	χ^2, **P value**
	Values in percentage			
Education Illiterate	8.2	10.9	22.8	174.8, < 0.0001
School	68.0	77	71.7	-
College	17.8	12.1	5.4	144.3, < 0.0001
Occupation Labourers	24.6	33.5	43.0	102.9, < 0.0001
Homemaker/business business	48.0	51.4	48.0	--
Executive /Professional /Clerical/Student/retired/ Unemployed	27.5	18.8	9.1	192.1, < 0.0001
Physical Activity Sedentary	29.9	17.9	10.3	201, < 0.0001
Light	38.1	46.3	40.5	13.5, < 0.001
Moderate	14.0	12.4	19.0	33.5, < 0.0001
Heavy	18.0	23.4	30.1	59.8, < 0.0001
Diet	Values mean ± SD			F & P value,
Total Calorie consumption (kcal)	2022 ± 354	1960 ± 332	1897 ± 304	62.3, < 0.0001
Carbohydrates %	65.4 ± 5.0	66.8±4.2	69.9 ± 3.2	752.9, <0.0001
Protein %	11.1 ± 1.2	10.4±1.1	9.8 ± 0.9	956.4, <0.0001
Fat %	22.8 ±5.0	21.3±4.6	18.6±2.9	627.9, <0.0001
	Values mean ± S.D			
Age (years)	38.2 ± 12.8	36.8± 11.6	38.0±11.9	18.7, <0.0001
BMI (kg/m^2)	24.2±4.7	23.7±4.7	21.5±4.2	249.3, <0.0001
Total Cholesterol (mg/dl)	170.9±50.1	159.9±44.2	148.5±44.6	139.5, <0.0001
Triglycerides(mg/dl)	134.1±94.1	129.8±81.7	119.7±85.2	17.7, <0.0001
Systolic Blood Pressure (mm/Hg)	121.6±13.2	119.6±12.9	118.1±11.9	47.6, <0.0001
Diastolic Blood Pressure (mm/Hg)	76.9±9.4	77.0±8.3	75.3±8.4	31.2, <0.0001
Prevalence of cardiovascular risk factors - n (%)				χ^2, P value
BMI (> 25 kg/m^2)	895 (40.8)	818 (35.7)	504 (19.5)	151 , < 0.0001
BMI (> 23 kg/m^2)	1289 (58.8)	1232 (53.8)	810 (31.3)	157, < 0.0001
Waist circumference (cms) > 90 for Men > 85 for Women	799 (36.5)	736 (32.1)	499 (19.3)	107, < 0.0001
Hypertension > 130/85mmHg	459 (20.9)	361 (15.8)	272 (10.5)	72, < 0.0001
Cholesterol > 200 mg/dl	545 (24.9)	354 (15.4)	250 (9.7)	144, < 0.0001
Triglycerides > 150 mg/dl	660 (30.1)	644 (28.1)	561 (21.7)	28, < 0.0001
High density lipoprotein – cholesterol < 40 mg/dl	714 (27.4)	822 (31.5)	1070 (41.1)	28, < 0.0001

TABLE 2. Comparison of characteristics and prevalence of diabetes and IGT between surveys in the City and PUV

	City			**PUV**		
Year	**2000**	**2006**	**p value**	**2003**	**2006**	**P value**
n	1668	2192		1213	2584	
Mean : Women	708 : 960	1053 : 1139		497 : 716	1280 : 1304	
	(Mean + SD)			(Mean + SD)		
Age (yrs)	44 + 15	38.2 + 12.8	<0.0001	41 + 6	38.0 + 11.9	< 0.0001
BMI (kg/m^2)						
Men	22.6 + 4.1	23.1 + 4.1	0.012	20.7 + 3.9	21.5 + 3.9	< 0.0001
Women	23.8 + 4.8	25.3 + 5.0	<0.0001	21.5 + 4.2	21.5 + 4.5	NS
Waist Circumference (cm)						
Men	82.5 + 10.0	83.8 + 10.8	0.011	79.9 + 10.7	79.1 + 10.0	NS
Women	81.9 + 12.3	83.7 + 11.4	<0.0001	76.4 + 10.6	76.8 + 10.2	NS
BMI > 25 kg/m^2 (%)						
Total	29.8	40.8	<0.0001	17.1	19.5	NS
Men	22.3	30.9	<0.0001	14.3	18.6	0.038
Women	35.4	50.0	<0.0001	19.1	20.4	NS
Prevalence (%)						
DM	13.9	18.6	<0.0001	6.4	9.2	0.004
IGT	16.7	7.4	<0.0001	7.2	5.5	0.048

TABLE 3. Risk Variables for Diabetes – Results of Multiple Logistic Regression Analyses

Dependent Variable: Diabetes Vs. NGT. Independent variables in all models were : age, sex, family history, BMI, waist circumference, income, physical activity, occupation, education..

Panel 1 – Total study population

Significant variables

Variables	β	**S.E of β**	**P value**	**OR (95% of CI)**
Age	0.90	0.04	< 0.00001	2.46 2.27 - 2.66
BMI	0.12	0.06	0.0449	1.12 1.00 – 1.27
Positive Family History	0.75	0.09	< 0.00001	2.12 1.77 – 2.53
Waist Circumference	0.34	0.05	< 0.00001	1.40 1.27 – 1.55
Higher education	0.29	0.13	0.0238	1.34 1.04 – 172
City vs PUV	0.61	0.10	< 0.00001	1.84 1.51 – 2.24
Town vs PUV	0.32	0.10	0.0020	1.38 1.13 – 1.67

Panel 2 – City

Variables	β	**S.E of β**	**P Value**	**OR (95% of CI)**
Age	0.97	0.06	< 0.00001	2.64 2.12 – 2.97
Family History	0.79	0.14	< 0.00001	2.20 1.67 – 2.90
Waist Circumference	0.33	0.08	< 0.0001	1.39 1.19 – 1.63
BMI	0.14	0.10	0.150	1.15 0.95 – 1.40
High income	0.31	0.15	0.0378	1.36 1.11 – 1.83
School education	- 0.45	0.15	0.0025	0.64 0.48 – 0.85

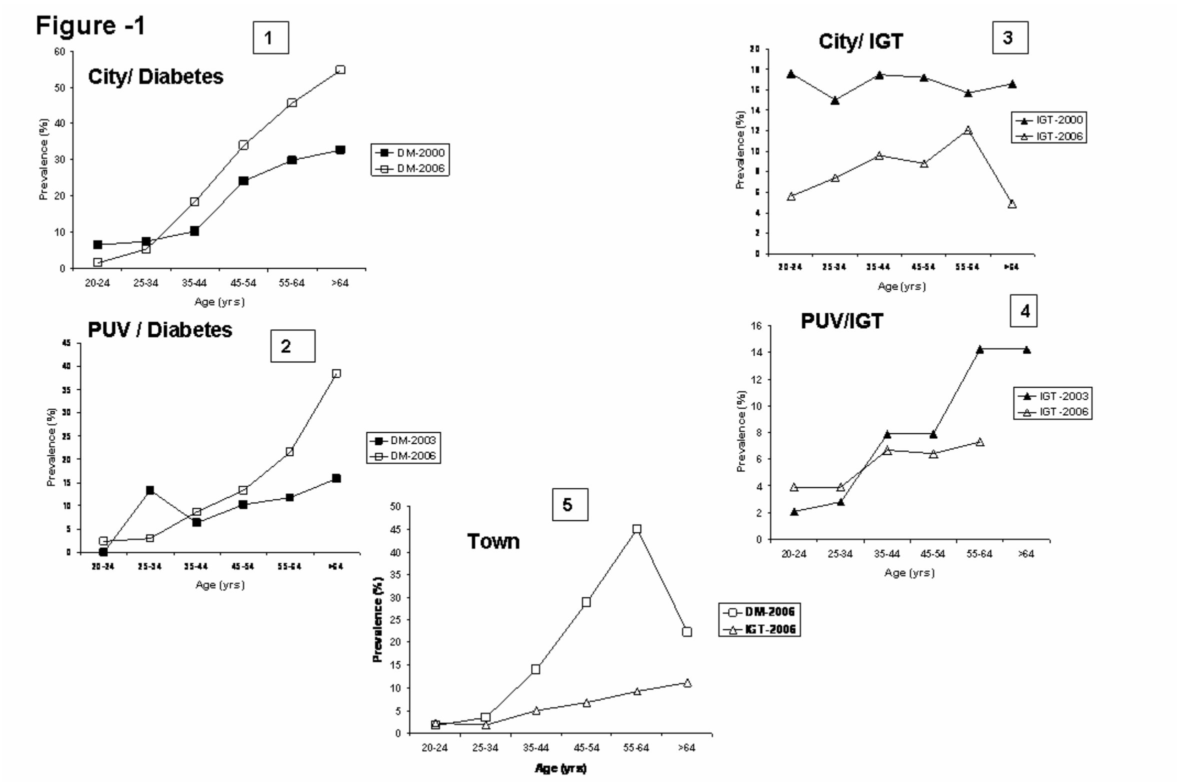
Panel 3 – Town

Variables	β	**S.E of β**	**P Value**	**OR (95% of CI)**
Age	0.98	0.06	< 0.00001	2.67 2.14 – 3.00
Family history	0.55	0.14	< 0.0001	1.73 1.13 – 2.28
Waist Circumference	0.34	0.09	< 0.00001	1.40 1.18 – 1.68
BMI	0.05	0.10	0.624	1.05 0.86 – 1.28

Panel 4 – Periurban village (PUV)

Variables	β	**S.E of β**	**P Value**	**OR (95 % of CI)**
Age	0.70	0.07	< 0.00001	2.01 1.76 – 2.31
Family History	1.28	0.20	< 0.00001	3.61 2.43 – 5.32
Waist Circumference	0.31	0.10	0.001	1.36 1.12 – 1.66
BMI	0.20	0.11	0.072	1.22 0.98 – 1.52

FIGURE 1. shows the age specific prevalence of diabetes and IGT in the three populations.



Panel 1 and Panel 3 - Age specific prevalence of diabetes (1) and IGT (3) in the city – comparison of surveys done in 2000 and 2006.

Panel 2 and Panel 4 - Age specific prevalence of diabetes (2) and IGT (4) in the PUV - comparison of surveys done in 2003 and 2006.

Panel 5 - Age specific prevalence of diabetes and IGT in the town in 2006.