HYPERGLYCEMIA, GLUCOSE INTOLERANCE, HYPERTENSION AND SOCIOECONOMIC POSITION IN EASTERN NEPAL

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Abstract. The present study was undertaken to evaluate differences between urban and rural Nepali populations in terms of hyperglycemia, socioeconomic position (SEP) and hypertension, through a community based survey in Sunsari District, eastern Nepal. Blood glucose levels were measured in participants (*N*=2,006) ≥ 30 years old from urban and rural communities and were classified according to WHO criteria (1998) into normoglycemia (NGY), impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and hyperglycemia (HGY). SEP was assessed by structured health interview along with anthropometric measurements and behavioral variables. Hypertension was classified per Joint National Committee (JNC-VII) criteria. Ten point three percent and 11.9% of subjects in this survey (13.3% urban and 11.0% rural) gave a family history and personal history of diabetes mellitus, respectively. Of urban participants (*n*=736) with no history of diabetes 70 (9.5%) had HGY and 143 (19.4%) had glucose intolerance (IFG and IGT). Of rural participants (*n*=1,270) 114 (9.0%) had HGY and 176 (13.9%) had glucose intolerance. There was an increasing trend in numbers of cases of hyperglycemia and intolerance with increasing age (χ^2 198.2, $p<0.001$), body mass index (BMI) (χ^2 35.1, $p<0.001$), SEP (χ^2 48.5, $p<0.001$) and hypertension (χ^2 130.6, $p<0.001$). Rural participants had a lower odds ratio [0.706; 95% confidence interval (CI) 0.455-1.096] of having hyperglycemia than urban participants. Individuals with medium and higher SEP had a lower odds ratio (0.878; CI 0.543-1.868) and higher odds ratio (1.405; CI 0.798-2.474), respectively, compared to individuals with lower SEP of having HGY. Both urban and rural populations are at risk for hyperglycemia and glucose intolerance. Individuals having a medium SEP had lower risk of diabetes mellitus than individuals from lower and higher SEP.

Keywords: hyperglycemia, glucose intolerance, socioeconomic position, hypertension, eastern Nepal

INTRODUCTION

Diabetes mellitus (DM) is comprised of a group of metabolic disorders that share the phenotype of hyperglycemia caused by a complex interaction of genetics, environmental factors and life-style.

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The prevalence of diabetes and its adverse health effects has risen more rapidly in South Asia than in western countries. India has a larger number of people living with diabetes than any other country, with an estimated 19.4 million in 1995 and 32.7 million in 2000 (King *et al*, 1998). In Bangladesh, the prevalence of diabetes in urban areas is double that in rural areas (8% *vs* 4%) and increased with affluence (Sayeed *et al*, 1997). The International Diabetes Federation estimated diabetes has a prevalence of 12% in Pakistan, with a total of 8.8 million people diagnosed with diabetes in 2000. In Sri Lanka a 1999 census reported the diabetes prevalence as 8% in rural areas and 12% in urban areas. Estimates based on a WHO model project by 2020 a marked escalation in diabetes in South Asia (Ghaffar *et al*, 2004). Pakistan is expected to have 14.5 million people with diabetes by 2025. The number of people with diabetes is expected to rise by 195% in India during 1995-2025, and is expected to reach 57.2 million by this year (King *et al*, 1998). Nepal, a developing country bordering India and China, has an open border, similar diet, race, language, religion and living conditions to both neighboring countries. In recent years, there has been a resurgence of interest in the relationship between health and socioeconomic position (SEP).

Some evidence exists for an association between low SEP and adverse health outcomes in persons with diabetes and other chronic conditions. The pathway through which SEP and health are related in persons with type 2 diabetes is poorly understood, (Brown *et al*, 2004). Impaired glucose tolerance (IGT) is a risk factor for type 2 diabetes and coronary heart disease (Unwin *et al*, 2002). Obesity, a major predictor of impaired fasting glucose (IFG), IGT and type 2 diabetes, is more prevalent among people with a lower SEP (Rathmann *et al*, 2005). Indo-Asian people are at high risk for cardiovascular disease (Jafar *et al*, 2005). Associations between body mass index (BMI), percent body fat and chronic diseases differ between Indo-Asian and European populations (Deurenberg- Yap *et al*, 2000). The impact of obesity and hypertension (HTN), which are closely linked with insulin resistance, on the association between SEP and glucose intolerance has rarely been studied (Gallard *et al*, 1997).

This study was undertaken to assess the association between SEP, defined by race, occupation, income and blood pressure, with IFG, IGT and diabetes in urban and rural populations of Sunsari District, eastern Nepal. The prevalence of diabetes being inversely related to SEP was tested as a hypothesis. We also examined the association between overweight and obesity using BMI and the prevalence of diabetes, IFG and IGT in this survey.

MATERIALS AND METHODS

Geographical area and study population

This study was conducted from September 2005 to July 2006 in Sunsari District, Koshi Zone, eastern Nepal. Sunsari District has 49 village development committees (VDC) and 3 municipalities at elevations of 152 meters to 914 meters along the Indian border. Dharan, a municipality of Sunsari, is an important industrial, economic and educational center. Subjects from ward No. 5 of Dharan considered as an urban population and subjects from Narsingh and Madhuban VDC considered as a rural population were included in the study. A characteristic of both rural VDC was an agricultural occupation. BP Koirala

Institute of Health Sciences (BPKIHS) is an academic medical center and public hospital situated in Dharan, providing comprehensive health care to the people of Sunsari District. It conducts community health services in 16 teaching districts, including Sunsari, eastern Nepal. According to national census data from 2001, the total population of Dharan Municipality was 118,000 and the total population of both VDC was 16,205 (Narsingh; 10,468 and Maduban; 5,737). Sample size was calculated with the formula 4 pq/L^2, where "p" is prevalence, q = 1- p, and L is the maximum allowable error (Mahajan, 1997), 10% of p. The prevalence of diabetes was 19% (Shrestha *et al*, 2006) from a previous study in urban Nepal and the estimated sample size was 1,706 individuals.

Subjects and data collection

All males and non-pregnant females ≥ 30 years old from Dharan Municipality and 10% of the population from the two VDCs were considered eligible for the study. The eligible participants were informed about the objectives and procedures of the investigation. Each subject was requested to attend to a nearby collection center after fasting for at least 8 hours. Subjects were interviewed using a structured health questionnaire to obtain personal details, such as religion, occupation, education, housing, monthly income, number of family members, and history of diabetes. Anthropometric measurements were also taken. The health status of each subject was graded into lower, middle and upper levels based on health determinants (Upadhayay *et al*, 1994; Tang *et al*, 2003). Physical activity with occupation was grouped into four categories from high to low: 1) servant and laborer 2) farmer, housewife, fishermen, milk seller, tailor and haircutter, 3) job holder, police officer, teacher, nurse, doctor and engineer, and 4) business person (Upadhayay *et al*, 1994; Robbins *et al*, 2001). Monthly income in Nepalese Rupees (Rs) was divided into: 1) ≤ Rs 2,500, 2) Rs 2,501-5,000, 3) Rs 6,000-10,000 and 4) ≥ Rs 10,000 (Upadhayay *et al*, 1994; Rabi *et al*, 2006). Measurements of height, weight, waist and hip circumference were taken wearing light cloths, without shoes. The weight scale was calibrated daily with a known standard weight. Only one machine was used in the study. BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Overweight was defined as a BMI ≥ 25 kg/m^2, obesity was defined as a BMI ≥ 30 kg/m^2 (WHO, 1998). Blood pressure was taken after 5 minutes rest with a standard adult mercury sphygmomanometer. Joint National Committee (JNC7) criteria (Chobanam *et al*, 2003) were used to classify subjects: systolic blood pressure (SBP) ≤ 120 mmHg and diastolic blood pressure (DBP) ≤ 80 mmHg and SBP 121-139 mmHg and DBP 81-89 mmHg were considered as normotensive and pre-hypertension (Pre-HTN), respectively. A SBP 140-159 mmHg and DBP 90-99 mmHg and a SBP ≥ 160 mmHg and a DBP ≥ 100 mmHg were considered as HTN stage I and HTN stage II, respectively. This study was approved (Aca 755/062/063) by the ethical review board of B.P. Koirala Institute of Health Sciences, Dharan, Nepal.

Laboratory and statistical methods

Venous blood (2 ml) was collected from each subject for fasting blood glucose (FBG) or random glucose in a vial containing 20 μg potassium oxalate and sodium fluoride (3:1) to minimize the glucose reduction. Plasma from the samples was separated immediately at the collection center and transferred to the Biochemistry Department at BPKIHS for glucose estimation using the

Table 1
Diagnostic criteria for glucose results.

Groups	Diagnostic criteria
NGY	• Fasting glucose up to 109 mg/dl • Random glucose up to 139 mg/dl
IFG	• Fasting glucose 110-125 mg/dl
IGT	• Random glucose 140-199 mg/dl
HGY	• Fasting glucose ≥126 mg/dl • Random glucose ≥200 mg/dl

glucose oxidase (Glucose GOD/POD kit, E. Merck India, Mumbai, India) method following standard norms. To ensure consistency, the same personnel, methodology and equipment were used throughout the study period. Subjects were classified by WHO criteria (1998) into normoglycemia (NGY), impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and hyperglycemia (HGY) groups (Baral *et al*, 2000) (Table 1).

The data were entered in the computer the day of collection. Data were expressed as frequencies and percentages. Association between categorical data was performed by chi-square (χ^2) test. We performed logistic regression analysis specific for complex survey designs that accounted for the clusters, strata (province) and data weighted to the general population of Nepal. Two-way analysis was done to identify the variables directly related to IFG, IGT and HGY. Multinomial regression was performed to determine an association between independent variables and dependent variables. The risk factors quantified were sex (male/female), SEP and monthly income group. We tested the association between diabetes and BMI, SBP and family history of diabetes. A *p*-value ≤ 0.05 was considered as statistical significant. Data analysis was performed using SPSS 11.5 software (License Code: 30001359390, SPSS, Chicago, IL, USA).

RESULTS

According to the National Census Report (2001), the population of ward No. 5 of Dharan Municipality was 1,350 (724 males, 626 females) from 225 households. Fifty-eight point eight percent of eligible subjects ≥ 30 years old were included in this house to house survey. The response rate was 92.7% in this urban population. A total of 1,270 participants were selected randomly from Maduban and Narshigh VDC as a rural population with a response rate of 95%. The socio-demographic characteristics of the study population (*N*=2,006) are shown in Table 2. Sixty-three point three percent of the study population were from a rural area. Most of the population were Hindu (92.3%) and the rest were Muslim. The majority (55.5%) of subjects had a lower socioeconomic position. Sixty-five point four percent were farmers, housewives, milk sellers, tailors or haircutters. One thousand seven hundred seventeen subjects (85.6%) gave a fasting sample and the rest gave a random glucose sample. Some variables (SEP, occupation, income, BMI and blood pressure) were not matched in the study population due to problems during sampling. Ten point three percent of subjects had a family history of diabetes. In all subjects (736 urban, 1,270 rural), 238 (13.3% urban, and 11.0% rural) gave a history of diabetes. In urban subjects 9.5% had HGY and 19.4% had IFG and IGT and in rural subjects 9.0% had HGY and 13.9% had IFG and IGT. Thirteen point two percent of males and 10.2% of females had a past history of diabetes. The frequency of newly detected HGY cases having no past history of diabetes was 10.1% in male and 8.0% in

Table 2
Socio-demographic characteristics and risk factors for diabetes (*N*=2,006) in Sunsari District, eastern Nepal.

Variable	No.	%
Age (years)		
30 - 40	908	45.3
41 - 50	483	24.0
51 - 60	325	16.3
61 - 70	216	10.7
> 71	74	3.7
Sex (*N*=2,006)		
Male	1,096	54.6
Female	910	45.4
Residence (*N*=2,006)		
Urban	736	36.7
Rural	1,270	63.3
Religion (*N*=2,006)		
Hindu	1,852	92.3
Muslim	154	7.7
Socioeconomic position (SEP)(*N*=1,935)		
Lower	1,074	55.5
Medium	565	29.2
Higher	296	15.3
Occupation (*N*=1,935)[a]		
1 High (physical activity)	127	6.6
2	1,267	65.4
3	75	3.9
4 Low (physical activity)	466	24.1
Income (*N*=1,935)[b]		
1 (low)	545	28.2
2	740	38.2
3	361	18.7
4 (high)	289	14.9
BMI (*N*=1,935)		
Healthy weight	1,277	66.0
Overweight	485	25.1
Obese	173	8.9
Past history of diabetes (*N*=2,006)		
Yes	238	11.9
No	1,768	88.1
Family history diabetes (*N*=2,006)		
Yes	206	10.3
No	1,800	89.7
Fasting blood glucose (*N*=1,717)		
Normoglycemia (NGY)	1,177	68.5
Impaired fasting glucose (IFG)	290	16.9
Hyperglycemia (HGY)	250	14.6
Random blood sugar (*N*=289)		
Normoglycemia (NGY)	192	66.4
Impaired glucose tolerance (IGT)	80	27.7
Hyperglycemia (HGY)	17	5.9
Blood pressure (systolic)(*N*=1,935)		
Normotensive	571	29.5
Pre HTN	752	38.8
HTN I	489	25.2
HTN II	126	6.5

[a] Four groups were categorized according to the self reports from high to low based on occupationally work pattern: active, moderate, light and inactive physical activity.
[b] Income was classified into four groups according to the lowest, low, middle and high incomes in a study population based on per capita income for family (Sunsari District Health Profile, Ministry of Health, 1993).

Table 3
Prevalence of past history of diabetes and newly identified glucose intolerance and hyperglycemia by fasting plasma glucose and random plasma glucose.

Past history of diabetes		No history of diabetes		
Variables		Normoglycemia (NGY)	Glucose intolerance	Hyperglycemia (HGY)
Sex				
Male (*N*=1,096)	145 (13.2%)	672 (61.3%)	168 (15.4%)	111 (10.1%)
Female (*N*=910)	93 (10.2%)	593 (65.2%)	151 (16.6%)	73 (8.0%)
Residence				
Urban (*N*=736)	98 (13.3%)	425 (57.8%)	143 (19.4%)	70 (9.5%)
Rural (*N*=1,270)	140 (11.0%)	840 (66.1%)	176 (13.9%)	114 (9.0%)
Total (*N*=2,006)	238 (11.9%)	1,265 (63.0%)	319 (15.9%)	184 (9.2%)

females and newly detected IFG and IGT were 16.6% in females and 15.4% in males.

Table 4 shows the age-specific prevalence of HGY, IFG and IGT had an increasing trend with increasing age (χ^2 198.2, p=0.001). The prevalence of diabetes was higher among males in both urban and rural subjects with a significant difference (χ^2 10.8, p= 0.013). Table 4 shows an increasing trend in prevalence (χ^2 26.9, p= 0.0001) of HGY, IFG and IGT in both urban and rural subjects. But the prevalences of HGY among Hindus and Muslims were not different (χ^2 2.1, p= 0.569). Furthermore, An increase in HGY was seen with increasing SEP (χ^2 48.5, p= 0.001). The prevalence of IFG was lowest in subjects with a medium SEP. The prevalences of IFG, IGT and HGY were significantly associated with decreased physical activity but in the case of IGT, there was a higher prevalence among those with a third grade physical activity level. IFG, IGT and HGY were significantly associated with higher BMI and blood pressure.

We used logistic regression to quantify the individual effects of dependent variables (age, sex, residence, religion, SEP, BMI and blood pressure) using glucose intolerance (IFG and IGT) and HGY and independent variables. We did not include income and occupation because these are socio-economic indicators. Table 5 shows the higher level of HGY in males than females [odds ratio 0.817, 95% confidence interval (CI) 0.602-1.661]. Glucose intolerance in females was slightly more common than in males (odds ratio 1.022, 95% CI 0.791-1.320). Subjects > 71 years old were at the highest risk of having HGY and glucose intolerance (odds ratio 3.311, 95% CI 1.793-6.489 and odds ratio 4.605, 95% CI 1.960-9.736) among the 30-40 year old subjects. Rural subjects had a lower risk of HGY (odds ratio 0.706, 95% CI 0.455-1.096). Although fewer Muslims were sampled (7.7%), they had a greater risk of diabetes [2.888 (95% CI 1.790-4.661)] than Hindus. Obese subjects had the highest risk of HGY [2.070 (95% CI 1.302-3.294)] when compared to subjects with a normal weight. HTN stage II subjects had a higher risk for diabetes (odds ratios 2.401, 95% CI 1.451-3.970) and glucose intolerance

Table 4
Prevalence (%) of IFG, IGT and HGY.

Variable	IFG (%)	IGT (%)	HGY (%)	χ^2	p
Age (years) (*N*=2,006)					
30 - 40	9.5	2.8	6.6	198.2	0.001
41 - 50	18.6	3.5	11.2		
51 - 60	19.1	4.0	24.3		
61 - 70	17.6	8.8	24.5		
> 71	44.6	8.1	25.2		
Sex (*N*=2,006)					
Male	14.4	4.4	15.4	10.8	0.013
Female	14.8	3.5	10.8		
Residence (*N*=2,006)					
Urban	17.0	5.9	15.8	26.9	0.001
Rural	13.3	2.9	12.0		
Religion					
Hindu	14.5	3.9	10.8	2.1	0.569
Muslim	16.3	1.6	9.8		
Socioeconomic position (*N*=1,935)					
Lower	13.4	3.0	12.2	48.5	0.001
Medium	12.4	5.0	12.2		
Higher	23.1	6.4	19.0		
Occupation (*N*=1,935)					
1 High (physical activity)	15.0	0.8	9.4	19.3	0.003
2	13.9	3.8	12.1		
3	9.3	9.3	12.0		
4 Low (physical activity)	17.2	5.0	17.7		
Income (*N*=1,935)					
1 (low)	14.7	3.3	9.4	59.3	0.001
2	12.3	2.7	13.5		
3	12.2	6.4	13.9		
4 (high)	23.3	6.3	19.1		
BMI (*N*=1,935)					
Healthy weight	13.4	3.6	10.9	35.1	0.001
Overweight	15.7	5.4	16.7		
Obese	20.2	4.0	20.8		
Blood pressure (systolic) (*N*=1,935)					
Normal	11.2	2.6	9.1	130.6	0.001
Pre HTN	14.0	2.9	10.1		
HTN I	19.1	4.5	20.7		
HTN II	15.9	15.9	22.2		

IFG, impaired fasting glucose; IGT, impaired glucose tolerance; HGY, hyperglycemia
HTN I, hypertension stage I; HTN II, hypertension stage 2

Table 5
Multiple logistic regression analyses of HGY, IFG and IGT.

	Glucose intolerance (IFG and IGT)		Hyperglycemia (HGY)	
Variables	Odds ratio	95% CI	Odds ratio	95% CI
Age (years)				
30 - 40[a]	1.0	-	1.0	-
41 - 50	1.095	0.549 - 2.181	1.117	0.550 - 2.269
51 - 60	1.319	0.681 - 2.558	1.132	0.577 - 2.223
61 - 70	1.804	0.947 - 3.436	3.362	1.678 - 6.736
> 71	3.311	1.793 - 6.489	4.605	1.960 - 9.736
Sex				
Male[a]	1.0	-	1.0	-
Female	1.022	0.791 - 1.320	0.817	0.602 - 1.108
Residence				
Urban[a]	1.0	-	1.0	-
Rural	0.815	0.556 - 1.196	0.706	0.455 - 1.096
Religion				
Hindu[a]	1.0	-	1.0	-
Muslim	1.323	0.814 - 2.152	2.888	1.790 - 4.661
SEP				
Lower[a]	1.0	-	1.0	-
Medium	0.762	0.489 - 1.268	0.878	0.543 - 1.868
Higher	1.941	1.199 - 3.140	1.405	0.798 - 2.474
BMI				
Healthy weight[a]	1.0	-	1.0	-
Over weight	1.351	0.862 - 2.116	1.218	0.763 - 2.073
Obese	1.817	1.201 - 2.751	2.070	1.302 - 3.294
Blood pressure(Systolic)				
Normal[a]	1.0	-	1.0	-
Pre HTN	1.406	0.872 - 2.266	1.007	0.581 - 1.718
HTN I	1.966	1.212 - 3.191	1.728	0.982 - 3.023
HTN II	2.401	1.451 - 3.970	1.858	1.033 - 3.336

[a] Reference group
HGY, hyperglycemia; IFG, impaired fasting glucose; IGT, impaired glucose tolerance

(odds ratio 1.858, 95% CI 1.033-3.336) than normal blood pressure subjects.

DISCUSSION

Hyperglycemia, caused by a complex interaction of genetics, environmental factors and life style choices, contributes to cardiovascular disease. Nepal is experiencing rapid urbanization, with widening income gap and social inequalities. A national survey of diabetes conducted in 6 major cities in India during 2000 showed a diabetes prevalence among urban adults of 12.1%; the prevalence of IGT was 14.0%, and the age-standardized prevalence of diabetes was 23.8% and of IGT was 16% in people aged ≥ 40 years (Ramachandran *et al*, 2001).

In a field survey of 7 urban populations of Nepal in 2002, the age and sex standardized prevalence of diabetes (known and newly diagnosed), IGT and IFG were 19.0, 10.6 and 9.9%, respectively (Shrestha *et al*, 2006). Our previous hospital based study showed a prevalence of 6.3%, among urban eastern Nepal (Karki *et al*, 2000). The present survey showed having a past history of diabetes, HGY and glucose intolerance (IFG + IGT) were found in 11.9% (13.3% urban, 11.0% rural), 9.2 % (9.5% urban, 9.0% rural) and 15.9% (19.4% urban, 13.9% rural), respectively. One study in Chennai, India reported the prevalence of diabetes increased with increasing age up to 70 years old (Mohan *et al*, 2003). In a review of global data, the prevalence of diabetes increased with increasing age. The peak prevalence occurred during the sixth decade of life, followed by a decline in the seventh decade, presumably because of greater mortality among diabetic individuals (King and Rewers, 1993). Table 4 shows the age specific prevalence of HGY with a peak prevalence among 51-70 year olds. The crude prevalence of diabetes was 4.3% and of IFG was 12.4% in rural Bangladesh (Sayeed *et al*, 2003). Our results showed a higher prevalence of HGY (12.0%) and IFG (13.3%) in rural Nepal.

A strong inverse association was seem between SEP and the odds of having undiagnosed diabetes among woman aged 55 to 74 years in the population-based KORA (Cooperative Health Research in the Region of Augsburg) survey in 2000 from Germany (Rathmann *et al*, 2005). Connolly *et al* (2000) found people living in the most deprived areas in a health district of the UK had the highest prevalence of type 2 diabetes. Odds ratios from multiple regression analysis (Table 5) show subjects with a medium SEP category had the lowest risk of HGY and glucose intolerance. The impacts of diabetes on subjects with a higher SEP and a lower SEP are likely to be different in terms of both principal causes and manifestations. Subjects with a higher SEP are less likely to be active, and with a lower SEP are less likely to consume fruits and vegetables. Poor diets may lead to HGY and glucose intolerance in both urban and rural populations (Ramachandran, 2007). Socioeconomic environment influences lifestyle and nutrition which in turn influences the prevalence of glucose intolerance, diabetes and its complications.

Diabetes, a life-long metabolic disorder, is an expensive illness for subjects in developing countries. In Nepal the financial burden is often shared by relatives of the patients. The amounts spent by subjects from higher and lower SEP were similar; therefore, the percentage of the income spent was higher among those from a lower SEP. Health insurance is not popular. Government employee insurance is available, but not utilized fully. Little or no reimbursement of expenses is made by employers.

The American Diabetes Association (ADA) has developed an interactive Diabetes Risk Test score based on a set of variables, not requiring laboratory tests, that can be used to identify individuals who are likely to develop diabetes in the near future (ADA, 2007). The variables include age, BMI, waist circumference, history of hypertension and history of diabetes in parents or siblings. The results show 10.3% of the population had a family history of diabetes. Elevated BMI and blood pressure (systolic) are significantly associated with HGY and glucose intolerance in both urban and rural populations. The association between diabetes and hypertension is well known (IDF, 2003). Both elevated systolic and diastolic blood pressures were associated with diabetes in a study from a southern Indian Population (Mohan *et al*, 2003).

The present population based study reveals primary prevention of diabetes is important in combating this disease in Nepal. Prevention of diabetes and obesity requires coordinated policies and legislation with attention being given to both urban and rural environments, workplace, education, exercise and diet. We did not carry out post-prandial or oral glucose tolerance testing (OGTT) or blood cholesterol levels.

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