

DIABETES IN BANGLADESH: PREVALENCE AND DETERMINANTS

Muhammad Abdur Rahim

**A thesis submitted in partial fulfillment of the requirements for the
degree of Master of Philosophy in International Community Health.**



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Abstract

Objective: The study was designed to estimate the prevalence of type 2 diabetes among the urban slum population and to make a valid comparison of differential prevalences along with its risk factors. Further, the agreement between of FBG and 2-h BG were also examined.

Methods: The study utilized two sets of data, one including the prevalence of type 2 diabetes among the urban slum population in Dhaka city, and a previous study conducted in selected rural areas. The rural study was performed among 5000 individuals (aged ≥ 20 years) both males and females in 1999. The urban study was conducted among the urban slum dwellers (migrants) from those specific rural areas. A cross-sectional study was conducted among 1555 slum population both male and females aged ≥ 20 years in 2001. Capillary fasting blood glucose levels, and 2-h post glucose test after a 75-g glucose drink were measured for a number of selected subjects from both urban (n=476) and rural (n=1046) population. Important anthropometrical indicators (Height, weight, waist and hip circumference) including blood pressure and socio-demographic information were collected.

Results: A higher prevalence of diabetes was found among the urban subjects 8.1 percent compared to rural population 2.3 percent. The study population was lean both for urban and rural with mean BMI (rural 20.2 and urban 19.4). Female had higher prevalence of diabetes compared to male both in urban and rural (urban female-8.5%, male 7.7% and rural female-2.5%, male-1.9%). Age, sex and waist to hip ratio for male were found to be significant risk factors following FBG and 2-h glucose values adjusted for a number of confounding variables. Poor agreement was observed of between FBG and 2-h BG values.

Conclusion: Increased risks for the development of diabetes were observed among the urban subjects compared to its source population. The risk factors were mostly similar for both urban and rural subjects. This may indicate that we are representing a unique form of type 2 diabetes in our lean population without obesity and hypertension. Applicability of universal cut-off points for obesity status may call for an examination in order to classify the people at risk. Further FBG did not appear to provide an under estimation of DM prevalence compared to 2-h BG.

Key words: Age, sex, body mass index, waist to hip ratio, type 2 diabetes, prevalence, urban, rural, Bangladesh.

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List of acronyms

ADA	- American Diabetes Association
AI	- Asian Indians
BIRDEM	- Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders.
BP	- Blood Pressure
BG	- Blood Glucose
BMI	- Body Mass Index
CI	- Confidence Interval
CVD	- Cardio Vascular Disease
CHD	- Coronary Heart Disease
CPR	- Contraceptive Prevalence Rate
CBR	- Crude Birth Rate
CDR	- Crude Death Rate
DM	- Diabetes Mellitus
dHTN	- Diastolic Hypertension
DFG	- Diabetic Fasting Glucose
DAB	- Diabetes Association of Bangladesh
DECODE	- Diabetes Epidemiology: Collaborative analysis of Diagnostic Criteria in Europe
FBG	- Fasting Blood Glucose
GDP	- Gross Domestic Product
HTN	- Hypertension
HT	- Height
IGT	- Impaired Glucose Tolerance
IFG	- Impaired Fasting Glucose
ID	- Identification number
ICMR	- Indian Council of Medical Research
LBW	- Low Birth Weight
MA	- Mexican Americans

MOHFW	- Ministry of Health and Family Welfare
NHN	- National Health care Network
NDDG	- National Diabetes Data Group
NHW	- Non – Hispanic Whites
NFG	- Normal Fasting Glucose
OGTT	- Oral Glucose Tolerance Test
OR	- Odds Ratio
PEM	- Protein Energy Malnutrition
sHTN	- Systolic Hypertension
sBP	- Systolic Blood Pressure
TFR	- Total Fertility Rate
UKPDS	- United Kingdom Prospective Diabetes Study
UNFPA	- United Nations Fund for Population Activities
WHO	- World Health Organization
WT	- Weight
WHR	- Waist to hip Ratio
χ^2	- Chi square value

A brief overview of Bangladesh

Geography

Bangladesh is situated in the northeastern part of the South Asian subcontinent on the largest delta in the world. It is mostly surrounded by India except for a small tip in the southeast, which is bordered by Myanmar. The Bay of Bengal lies to the south. It has a total area of 144,000 square kilometers.

Apart from a few small hills in the north and southeast, most of the country is relatively low and flat. Very little of the country is more than 12 meters above sea level and with the arrival of normal monsoons, one third of cultivated land is flooded. However, the estuaries of the Ganges and Bramhaputra rivers have enriched the topography with lush, green and extremely fertile alluvial soil. The climate of the country is mainly tropical and marked by sweltering temperatures and high humidity.

History

Bangladesh has many thousands of years of history. Ancient Bangladesh was probably settled around 1000 BC by a tribe named “Bang” arising out of Central and Middle East Asia (1). Due to its position at the crossroads of South and South East Asia and its fertile agricultural land, it has been invaded and influenced by a large number of ethnic groups. Numerous waves of settlers and invaders have come from India and other neighboring countries to settle, and thus contributed to its culture and ethnic diversity. Muslim kings ruled the country as a province of the Indian subcontinent from the early thirteenth century until the eighteenth century, when the British took over (2). Dutch and French trading companies as well as the British East India Company also visited to trade.

With India's independence from the British in 1947, Bengal was partitioned into two parts and the largely Muslim east was incorporated into Pakistan and became known as East Pakistan (2). After twenty-four years of increasingly traumatic Pakistani rule, Bangladesh finally became an independent country in 1971, following a very bloody war known as the Liberation War (3).

Since its independence, Bangladesh has tried to rebuild itself despite its long experience of exploitation and ravages of war. However, its high population, recurrent natural disasters and political instability have made the task difficult. Thus, Bangladesh still remains one of the poorest countries in the world.

People

According to the last national census, conducted in January 2001, the population of Bangladesh was about 130 million, with a population density of 819 per square kilometers (4). Despite the dramatic decrease in the country's population growth rate from 3 to 1.6 percent in the past ten years; it still remains one of the most populous and densely populated countries in the world (4).

The vast majority of the population is poor illiterate and predominantly young; almost half of them are 15 years of age or younger (4). The literacy rate is low, with only about 51 per cent of the population over fifteen years of age being able to read and write. Adult male literacy is 63 percent and female literacy is particularly low at 49 per cent (4).

Although during recent years there has been a large migration from rural to urban areas, seventy-nine per cent of the total population live in rural areas. The society is characterized by a remarkable degree of ethnic homogeneity, with over 98 per cent of the population sharing a common language, Bangla. Of the total population, about 83 per cent are Muslims, 16 per cent Hindus, 0.6 per cent Buddhists and the remaining 0.4 per cent Christians (4).

Economy

With an average per capita income of about US \$369, Bangladesh is one of the poorest countries in the world (4). With an agrarian-based economy, 30 per cent of the country's GDP is accumulated from production related to agriculture; this sector provides employment to 65 per cent of Bangladeshi workers (4). The main food crop is rice, while

wheat, jute, tea, sugar cane; tobacco, oil seeds, pulses and potatoes are the principal cash crops. Vegetables, spices and fruits are also produced. Efforts to increase food production and to diversify crops are occurring; however, traditional farming methods, frequent natural disasters and an increasing population keep continual pressure on production.

The industrial sector, which contributes around 18 per cent of the GDP, is dominated by jute, textile and garment factories (4). Sugar, shrimp processing, paper and newsprint, fertilizers, tanneries and cement are other growing industries. The country has very limited mineral wealth except for reserves of natural gas, extensively used for power generation, urea production, domestic and other industrial purposes (4).

Urbanization

Like many other developing countries, Bangladesh has a major problem of rapid urbanization. Increasing landlessness and riverbank erosion in rural Bangladesh may have contributed to urban migration. Dhaka city alone is having 2-3 million such destitute people. In 1961, only about five per cent of the total population lived in the urban areas. While into 1991 census reported that about 21 per cent of the country's population was residing in urban areas (5). At present about 25 percent, 30 million people are living in urban areas (5)

About 27 per cent of the total urban populations of the country live in Dhaka, the capital and the largest metropolitan city in the country. In 1981, population in Dhaka was estimated as 3.5 million whereas the number increased to about 10 million by the year 2000 (6).

Accommodation, facilities and other public services in Dhaka has clearly not kept pace with the rapid growth of its population. As a result, most of the areas are densely populated. Further, a high proportion of migrant city dwellers live in squatters referred to as slums and shanty towns (7). At present, about one third of the total population of Dhaka lives in such settlements, which are scattered throughout the city (5). A recent study estimates a population density of up to 225,000 per square kilometers in the urban slums of Dhaka, a figure that is 16 times higher than the other cities (8).

Overall, environmental conditions in Dhaka city is very poor; the International Population Crisis Committee has ranked Dhaka as being among the five worst metropolises in the world in regard to availability and access to public health services (5). This situation is even worse in slum and squatter settlements. There are many slums without any civic amenities such as latrines, water, electricity and gas supplies. As a result, human excreta are very often disposed of openly. This is a major source of environmental pollution and risk to health.

In addition to the adverse effects outlined above, urbanization has also served to emphasize the gap between social classes by reinforcing social inequalities. Although certain aspects of urbanization have been regarded as beneficial, the ultimate benefit has been limited to certain social groups. For example, while urbanization has improved access to employment and education for middle and upper social classes, poor urban dwellers are becoming poorer. In addition, they are deprived of basic human requirements, such as food and education, and they still suffer from poor health status and bear an enormous disease burden.

Health problems in urban Bangladesh

According to the report of the Bangladesh department of statistics and health information cell, the health indicators and health facilities show better health conditions in urban population compared to rural. But there are important differences related to accessibility to health care and health status among the different strata of urban population.

The urban slum population has a lower rate of immunization coverage against all antigens about 58 percent, compared to 77 percent in non-slum areas. Contraceptive use is 50 percent in the slum and 58 percent in the non-slum areas and antenatal

coverage in urban slum is about 55 percent lower than the non-slum areas (9). Infant mortality rate is 80 (per 1000 live births) and under-5 mortality rate is 140(per 1000 live births) in urban slums which are ranked the highest in the world. In Bangladesh more that 90 percent of the children are malnourished and 25 percent of the families live below the line of hard-core poverty. In urban slums 39 percent babies are born with low birth weight (< 2.5kg) compared to 23-27 percent in other urban areas (10). In urban slums, infant death registries showed 45 percent among of all deaths. Fifty four percent of infant deaths are related to vaccine preventable diseases (5). But over the years there have been some remarkable success in control and prevention of communicable diseases in urban and rural areas, while non-communicable and chronic diseases are increasing. It has been shown that now a day Diabetes, Coronary Heart Diseases (CHD), Hypertension, neoplastic and mental diseases are becoming a growing threat for the urban population (10).

Urbanization and its consequences for development of chronic diseases.

Any country that experienced to urbanization and industrialization also witnessed with a change of disease pattern from infectious to non-communicable and chronic diseases.

In the last two decades Bangladesh was experiencing fast urbanization, expanding industrialization, rising income and improved primary health care services resulting in increased life expectancy at birth longer than 60 years, Primarily due to so far success in reducing child mortality. But changing in life styles, eating habits, sedentary life, increased use of tobacco and deteriorating environmental conditions are likely to develop non-communicable diseases. At the same time non-communicable diseases and metabolic disorders linked with diabetes (DM), hypertension (HTN) and coronary heart diseases (CHD) are increasing.

Diabetes mellitus, a chronic disease once thought to be uncommon in Bangladesh, but now it has emerged as an important public health problem. At present it is estimated that about 3.6 million people are affected through out the country.

The prevalence of diabetes in adult varied from 2.2 percent to 8.0 percent and the higher prevalence was found in urban areas predominantly among women.

Unfortunately, there is still inadequate awareness about the real dimension of the problem in the general public. There is also lack of awareness about the existing interventions for preventing diabetes and management of complications.

The health care system in Bangladesh

The organizational structure of Health Services of Bangladesh follows the general administrative division of the country.

Administratively, the country is divided into 6 divisions, 64 districts, 460 upazilla (sub-district) of which 397 are rural and remaining 63 are sadar (district town) and 4451 unions. Each

union consists of 9 wards and two/ three villages constitute a ward. A ward has an average of 2500 population and is the lowest administrative unit. Each ward has an elected representative.

At the national level, the Ministry of Health and Family Welfare (MOHFW) is responsible for policy, planning and decision making in macro level. Under MOHFW, there are two major implementing wings, The Director General of Health Services and the Directorate of Family Planning. The Director general of Health Services is responsible for planning and implementation of health programmes and providing technical guidance to the Ministry. The Directorate of family Planning is responsible for planning, implementing of family planning programmes and providing family planning related technical advice to the Ministry.

Health status indicators in Bangladesh

For the last two decades, the government has developed a large network of field workers to provide health and family planning services. As a result a large proportion of population particularly women and children have benefited.

Life expectancy at birth has now reached at 61 years in 1998 from just over 44 years in 1971. The Total Fertility Rate (TFR) has been reduced from 7.7 in 1975 to 2.8 in 2000. The

Contraceptive Prevalence Rate (CPR) have increased from 7.7% in 1975 to 51.5% in 1998 and expected to increase further. The Crude Birth Rate (CBR) has also dropped from 17/1000 in 1973 to 4.8 in 1998 and expected to decline further. The Crude Death Rate (CDR) has been reduced from 47/1000 live births in 1973 to 19.9/1000 live birth in 1998. The Infant Mortality Rate (IMR) stood at 57/1000 live births in 1998 compared to 140/1000 live births in 1973. The Maternal Mortality Rate (MMR) has been reduced from 30/1000 live births in 1970 to 3.0/1000 live births in 1998 (4).

**Source: Bangladesh Bureau of Statistics (BBS) Population Planning Wing, Bangladesh Planning Commission
Statistical Pocket Book of Bangladesh 1999
Baseline service delivery survey of HPSP (June 1999),
MOHFW.**

A short description of Global diabetes prevalence and revised diagnostic criteria.

Global Estimates of Diabetes

Diabetes mellitus, particularly type 2 diabetes is now recognized as a major chronic public health problem throughout the world. It affects large number of people of wide range of ethnic and economic levels in both developed and developing countries.

Globally, 135 million adults with diabetes were estimated in 1995. By the year 2025, the figure is projected to rise to 300 million, an increase of approximately 120%. Whereas the rise will be of the order of 40% in the developed and 170% in the developing countries. As a result, more than 80% of persons will be diabetic in the developing countries by the year 2025 (11).

For both in 1995 and 2025, the countries with the highest prevalence of diabetes are in India, China and United States of America (11)

The Future Burden of Diabetes

Diabetes is an increasing threat to the world's health service. Formerly described as a "disease of affluence", it has now become evident that, owing to demographic changes, cultural transition and population ageing, diabetes is now also a "developing countries problem"(44). The prevalence of diabetes in adults' globally was estimated to be 4.0% in 1995 and is projected to rise to 5.4% by the year 2025. The prevalence of diabetes is higher in developed countries 6% in 1995, 6.2% in 2000 and will 7.6% in 2025. The developing world has a lower estimated prevalence; 3.3% in 1995, 3.5% in 2000, and 4.9% in 2025. It is projected that there will be a 42% increase in the number of individuals with diabetes, from 51 to 72 million in the developed countries and 170% increase, from 84 to 228 million, in the developing countries. The majority of the people with diabetes in developing countries are projected to be younger, aged 45 to 64 years, while those in developed countries will be aged 65 years. Diabetes will be increasing concentrated in urban areas, with the greater burden among women (11).

Since 1988, WHO has been collecting standardized information on the prevalence of diabetes and impaired glucose tolerance (IGT) in adult communities worldwide. Within the age range 30-64 years, diabetes and IGT were found to be absent or rare in a small number in Melanesia, East Africa and South America. In populations of European origin, the prevalence of diabetes and IGT lay in the range 3-10% and 3-15% respectively; but migrant Indian, Chinese and Hispanic American groups were at higher risk of DM (15-20%). The highest prevalence was found in the Pima Indians and Arizona and in the urbanized Micronesians of Nauru, in whom approximately one –half of the population in the range 30-64 years had diabetes (12).

The prevalence of total glucose intolerance (diabetes and IGT combined) was greater than 10% in almost all populations, and was within the range of 11-20% for Europe and United states among white population. However, the prevalence of total glucose intolerance reached almost 30% in Arab Omanis and United States blacks and affected one-third of all adult Chinese Mauritius, migrant Indians, urban Micronesians and lower income urban Hispanic in United States. In Naururans and Pima Indians, approximately two-thirds of all adults in the age 30-64 years range were affected (45).

Thus the highest prevalence of diabetes is now to be found in the developing countries, and in the ethnic minorities and disadvantaged populations of the industrialized countries.

Rising trend of type 2 diabetes in non-industrialized populations

The prevalence of type 2 diabetes is rising rapidly in all non-industrialized populations. By 2025, three-quarters of the world's 300 million adults with diabetes will be in non-industrialized countries, and almost a third in India and China alone. This epidemic has been triggered by social and economic development and urbanization, which is linked with general improvements in nutrition and longevity, but also with obesity, reduced physical exercise and other diabetogenic factors (11).

The prevalence of type 2 diabetes is lowest among people who still have a conventional or primitive lifestyle as either hunter-gathers or subsistence farmers. Examples are the Mapuche Indians in Chile, rural Bantu in Tanzania, and rural communities in the Pacific islands and South Asia (13-15). The prevalence is higher in people who have moved away from the traditional way of life, either to live in towns and cities or through migration to another country. Among South Asians, it is less than 5% in rural South India, around 12% in urban South India, and 15-20% in migrants to Mauritius, Fiji, Singapore, and Tanzania. Among Chinese, it ranges from less than 3% in rural China to 15%-20% in urban Taiwan and Mauritius, and among people of African origin, from less than 3% in Cameroon, to around 10% among people of West African descent living in Jamaica, and 15% in Jamaicans living in the UK (49-52).

The evidence is that high rates of disease in urban centers have arisen within a single generation. The largest increases are described in populations which have undergone the most rapid and extreme change, such as Ethiopian Jews who migrated to Israel, moving from severe malnutrition and a traditional way of life to modern urban settings. They have a prevalence of 9% compared to 1-2% in Ethiopia itself (53).

Although the prevalence will remain higher in industrialized countries, the proportional rise will be greater in non-industrialized countries (48%), and greatest in China 68% and India 59% because of the large populations involved, 75% of world diabetics will be in non-industrialized countries. India will have more people with diabetes (57 million) than any other country, followed by China (38 million) and the highest prevalence rate will be among the people of aged 45-64 years (11,17).

Table-1: TOP TEN COUNTRIES WITH DIABETES, 1995 AND 2025

No	1995		2025	
	Country	No (millions)	Country	No (millions)
1	India	19.4	India	57.2
2	China	16.0	China	37.6
3	U.S.A.	13.9	U.S.A.	21.9
4	Russian Fed	8.9	Pakistan	14.5
5	Japan	6.3	Indonesia	12.4
6	Brazil	4.9	Russian Fed	12.2
7	Indonesia	4.5	Mexico	11.7
8	Pakistan	4.3	Brazil	11.6
9	Mexico	3.8	Egypt	8.8
10	Ukraine	3.6	Japan	8.5

Source: Diabetes Care, Volume 21, Number 9, September 1998, page no 1417.

Prevalence of type 2 diabetes among Indians and migrant Indians

The first reliable data on prevalence of diabetes in India was available from the Indian Council of Medical Research (ICMR) in the early seventies. It was reported a prevalence of 2.3% in the urban and 1.5% in rural areas (18). Two decades had passed without much added toward the information. Recently, there has been an upsurge in the epidemiological data from India. High prevalence rates of diabetes were reported in-migrant Indians in the UK (11.2%), Fiji (11%), Singapore (12.8%), Tanzania (7.1%), and South Africa (10.4%)(19). This may have been to the privileged status and change of lifestyle compared to the native Indian population.

Ramachandran et al, Conducted in a study among Dravidians in south India showed that the age-adjusted prevalence of diabetes in urban population was 8.2% and 2.4% in the rural population. The study has shown an ample difference in prevalence in urban and rural India (20).

Study among urban Indians revealed that a 40% increase in prevalence of type 2 diabetes from 8.2% in 1989 to 11.6% in 1995 (16), another recent survey report by (Ramachandran et, al) had showed that further increased up to 13.2% in 2000, with a 30 percent in Chennai alone (22).

Only in Fiji, rural and urban Indians had similar prevalence of diabetes (13.1 vs. 12.9% for males, 11.3 vs. 11,0% for females).Cheah and Thai reported in the 7th congress of the Asian Federation of Endocrine Society in 1993, an increasing prevalence of type 2 diabetes in Singapore, the overall prevalence raised from 1.99% in 1975 to 4.7% in 1984

and further to 8.6% in 1992. The rise in prevalence occurred in Chinese, Indians and Malays; but most predominant change in Indians who had a 44% rise, from 8.9% in 1984 to 12.8% in 1994.

Situation of type 2 diabetes in Bangladesh

Bangladesh is a densely populated country having approximately 130 million people in an area of 144000 sqkm. Despite of having a well-structured health care delivery system, people are increasingly suffering from a variety of chronic health problems.

Diabetes mellitus particularly type 2 diabetes is now recognized as a major chronic public health problem in Bangladesh. The magnitude of diabetes remains unknown due to lack of countrywide survey. More than 80% of country population lives in rural areas but some studies showed that the prevalence is higher in urban areas. However, some small-scale survey conducted by Mahtab et, al (1983), Ali et, al (1985) and Sayeed et, al (1985) showed that the prevalence of DM in the age group ≥ 15 years varied from 1.0 to 1.5% in urban areas and 0.5 to 1.0% in rural areas (23-25).

Sayeed et, al in 1995 conducted a study in rural Bangladesh and found the prevalence of type 2 diabetes was 2.1% (male 3.1% and female 1.3%). Age adjusted (30-64 years of age) prevalence was 2.23%(24).

Recently, another study in 1997 among the rural, urban and sub urban population of Bangladesh showed that the combine prevalence among the rural and urban population was 5.2% of which rural prevalence was 3.8% and urban prevalence was 7.8%. Age adjusted (30-64 years) prevalence urban 8.0% and rural 3.8%(26).

An increasing trend of diabetes registration in all the referral centers in Bangladesh has been noticed in recent years. From Diabetes registry in Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM), it was found that the number of registered diabetes in the year 1956 was 39, which has been increased to 15,296 in 1998. Among the registered diabetic patients, on average 60 percent are male and 62 percent from urban, 32 percent from rural and 6 percent from semi-urban.

The overall estimated prevalence of diabetes in Bangladeshi population is 5.6% and in which more than 96 percent is reported to have type 2 diabetes (47).

If the trend continues to grow in this population where the growth rate is 1.8% and in approximately 130 million people the problem of DM as a health issue should certainly alarm the health planners.

Existing Diabetes Health Care Services in Bangladesh.

The comprehensive diabetic health care delivery in Bangladesh is a unique program of Diabetes Association of Bangladesh (DAB). The Association executes its program primarily through its central institute called the Bangladesh Institute of Research and Rehabilitation in Diabetes, Endocrine and Metabolic Disorders (BIRDEM), and through the Satellite Diagnostic Clinic at different peripheral region to provide services at doorsteps. The association was established on 28th February 1956 in Dhaka at the initiative of the late National Professor M Ibrahim and a group of social workers, philanthropists, physicians and civil servants. Over the year the Center has turned into a diabetes care and research complex at Shahbag, Dhaka. After the demise of Prof M Ibrahim in 1989, it has been renamed as the Ibrahim Memorial Diabetic Center. Ibrahim Memorial Diabetes Center is a 550-bed teaching and training hospital affiliated to BIRDEM. Now days, BIRDEM is recognized as the Center of Excellence and Reference center in diabetes care.

To improve the diabetic care and enlarge the service for a wide range of population, Diabetic association has established National Health Care Net Work (NHN) through out the country. A four-tier network has been envisaged with the central being at the capital, the Supra Regional Diagnostic Center in Division, Regional Diagnostic Center at Division, Regional diagnostic Center at District and peripheral Diagnostic centers at the Thana levels.

The need for such a diagnostic network emanated from the pressure of diabetic and non-diabetic patients at BIRDEM. With the pressure gradually mounting provision of health care from one single source become impossible. The implementation of NHN programs was started in 1999-2000 and it provides service through the central laboratory and 10 centers in Dhaka city. In addition to diagnosis, the NHN center provided services to the out patients departments for the treatment and certain test free of cost.

Definition and description of diabetes mellitus

Diabetes mellitus is a group of metabolic disorders characterized by chronic hyperglycemia with disturbance of Carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both. The chronic hyperglycemia of diabetes is associated with long-term damage, dysfunction and failure of various organs, specially the eyes, kidneys, nerves, heart and blood vessels.

Several pathogenic processes are involved in the development of diabetes. These range from autoimmune destruction of the beta cells of the pancreas with consequent insulin deficiency to abnormalities that result in resistance to insulin action. The basis of the abnormalities in carbohydrate, fat and protein metabolism in diabetes is deficient action of insulin on target tissues. Deficient insulin action results from inadequate insulin secretion and /or diminished tissue response to insulin at one or more points in the complex pathways of hormone action (48). Impairment of insulin secretion and defects in insulin action frequently coexist in the same patient, and it is often unclear which abnormality, if either alone or both is the primary cause of the hyperglycemia. (48)

Diabetes mellitus may present with characteristics symptoms such as polyuria, polydipsia, weight loss with sometimes polyphagia, and blurred vision. Impairment of growth and susceptibility to certain infections may also accompany with chronic state of hyperglycemia. Acute life-threatening consequences of diabetes are hyperglycemia with ketoacidosis or non-ketotic hyperosmolar syndrome.

Long-term complications of diabetes include retinopathy with potential loss of vision; nephropathy leading to renal failure; peripheral neuropathy with risk of foot ulcers, amputation and Charcot joints; and autonomic neuropathy causing gastrointestinal, genitourinary, and sexual dysfunction. People with diabetes are also greatly increased risk of cardiovascular disease (43)

Types of diabetes

Type 1 diabetes

Type 1 diabetes is an autoimmune disease, and patients are usually severely insulin deficient and dependant on exogenous insulin for life. Both genetic and environmental factors contribute its etiology. It is thought that certain environmental factors such as viral infection may precipitate the onset of diabetes in genetically prone individuals. Type 1 diabetes develops most often in children and young adults but the disorder can appear at any age. Clinical symptoms usually present when about 90 percent of the insulin producing beta cells have been destroyed. Symptoms include increase thirst and urination, constant hunger, weight loss, blurred vision and extreme fatigue. If not diagnosed and treated with insulin, a person can lapse to a life threatening diabetic coma, also known as diabetic ketoacidosis.

Type 2 diabetes

Type 2 diabetes is the most common form of diabetes and is characterized by disorders of insulin secretion or insulin action, either, of which may be the predominant feature. Both are usually present at the time that this form of diabetes is clinically manifest. About 90 to 95 percent of the people with diabetes have type 2. This type of diabetes usually develops in adult age 40 and older and is most common in adults over age 55 years.

The majority of the patients of this form of diabetes are obese and type 2 diabetes is often part of metabolic syndrome. When type 2 diabetes is diagnosed pancreas is usually produce enough insulin, but for unknown reasons, the body cannot use the insulin effectively, a condition called insulin resistance. After several years insulin production decreases, then body needs exogenous insulin for good control of type 2 diabetes.

The symptoms of type 2 diabetes develop gradually. They are not as sudden in onset as type 1 diabetes. Some people have no symptoms; symptoms may include fatigue, or nausea, frequent urination, unusual thirst, weight loss, blurred vision, frequent infections, and slow healing of wounds or sores (48).

Gestational diabetes

Gestational diabetes develops only during pregnancy. Mothers blood glucose rise due to hormone secreting during pregnancy and then the mother cannot produce enough insulin to handle the higher blood glucose levels. Although gestational diabetes returns to normal after delivery, eventually the mother is at higher risk of developing type 2 diabetes at later life. Like type 2 diabetes it occurs more often in African Americans, Americans Indians, Hispanic Americans and people with family history of diabetes.

Secondary diabetes

Diabetes may occasionally develop as consequences of other diseases or drug therapy. Some causes of secondary diabetes; Pancreatic disease (pancreatitis, surgery, carcinoma), Endocrine disease (acromegally, Cushing's Syndromes), Drugs (steroids, contraceptives, diuretics). But this condition is very rare (48).

Clinical diagnosis of diabetes

The clinical diagnosis of diabetes is often prompted by symptoms such as increased thirst and excessive urination, recurrent bacterial or fungal infections of skin, urinary tract or external genitalia, unexplained weight loss in severe cases drowsiness and comma. In these cases high levels of glycosuria are usually present. Here single blood glucose estimation in excess of diagnostic values establishes the diagnosis. An oral glucose tolerance test (OGTT) to establish the diagnostic status is need only if random blood glucose values lie in the uncertain range (between the level of establish or exclude diabetes) and fasting blood glucose values are below those that establish the diagnosis of diabetes.

For epidemiological and population screening purposes, the fasting or 2-h value after 75 g oral glucose may be used alone. For clinical purposes the diagnosis of diabetes should always be confirmed by repeating the test with a second positive result on a different day.

Diagnostic criteria for Diabetes mellitus

The new criteria

The diagnostic criteria for diabetes mellitus have been modified from those previously recommended by the National Diabetes Data Group (NDDG) in 1979(27) and WHO report on 1985(28). New diagnostic criteria for diabetes mellitus were approved by the American Diabetes Association (ADA) in 1997(29). And in 1998 the World Health

Organization (WHO) Consultation published their provisional report (30). The American Diabetes Association recommended two changes in the diagnostic criteria for diabetes. First, the committee suggested using only fasting glucose without an oral glucose test (OGTT) to diagnose diabetes in clinical and epidemiological applications. In addition the committee created three new categories based on fasting Plasma glucose level; normal fasting glucose (NFG), glucose <6.1 mmol/L; impaired fasting glucose (IFG), glucose 6.1-7.0 mmol/L; and diabetic fasting glucose (DFG), glucose ≥ 7.0 m mol/L The World Health Organization (WHO) has also reviewed the same issue and recommend the same lowering fasting threshold 7.8 to 7.0mmol/L but concentration of 2-h plasma glucose (2h-PG) following a 75-g oral glucose tolerance test (OGTT) remain unchanged at 11.1mmol/l and continued to recommend using the OGTT for screening of diabetes.

Table-2: Values for diagnosis of diabetes mellitus and other categories of hyperglycemia.

	Glucose concentration, mmol/L (mg/100mL)			
	Whole blood		Plasma	
	Venous	Capillary	Venous	Capillary

Diabetes mellitus				
Fasting	≥6.1 (≥ 110)	≥ 6.1 (≥ 110)	≥ 7.0 (≥ 126)	≥ 7.0 (≥ 126)
2-h post glucose load	≥10.0(≥180)	≥11.1(≥ 180)	≥11.1 (≥ 200)	≥12.2 (≥220)
Impaired Glucose Tolerance (IFG)				
Fasting (If measured)	<6.1 (< 110)	<6.1 (<110)	<7.0 (<126)	<7.0 (<126)
2-h post glucose load	≥6.7(≥120) and<10.0 (<180)	≥7.8(≥140) and<11.1(<200)	≥7.8(≥140) and<11.1(<200)	≥8.9(≥160) and<12. (<220)
Impaired Fasting Glycaemia (IFG)				
Fasting	≥5.6(≥100) and < 6.1 (< 110)	≥5.6 (≥100) and <6.1 (<110)	≥6.1(≥110) and <7.0 (<126)	≥6.1(≥110) and <7.0(< 126)
2-h (if measured)	<6.7(<120)	<7.8(<140)	<7.8(< 140)	2-h <8.9(<160)

Source: An Update on Diabetes, including HbA1c and micro albumin, First edition August 2000; page no 8, Jak Jervell, university of Oslo. Norway.

Rational for the revised diagnostic criteria

The revised criteria are still based on measures of hyperglycemia. Whereas many different diagnostic schemes have been used on some measurements of blood or urine glucose, as reviewed by McCance et al. (31).

Plasma glucose concentrations are distributed over a continuum, but there is an approximate threshold separating those subjects who are at substantially increased risk for some adverse outcomes caused by diabetes (i.e. micro vascular complications) from those who are not.

Based in part on estimates of the thresholds for micro vascular diseases, the previous WHO criteria defined diabetes by FPG ≥ 140 mg/dl (7.8mmol/L), 2-h PG ≥ 200 mg/dl (11.1mmol/L) in the OGTT, or both. These criteria effectively defined diabetes by the 2-h PG alone because the fasting and 2-h cut point values are not equivalent. Almost all individuals with FPG ≥ 140 mg/dl (7.8mmol/L) have 2-h PG ≥ 200 mg/dl (11.1mmol/L) if given an OGTT. Whereas only about one-fourth of those with 2-h PG ≥ 200 mg/dl (11.1mmol/L) and without previously known diabetes have FPG ≥ 140 mg/dl (7.8mmol/L) (46). Thus the cut point of FPG ≥ 140 mg/dl (7.8mmol/L) defined a greater degree of hyperglycemia than did the cut point of 2-h PG ≥ 200 mg/dl (11.1mmol/L). It is the consensus of the Expert Committee that this discrepancy is unwarranted and that the cut point values for both tests should reflect a similar degree of hyperglycemia and risk of adverse outcomes. In addition, the previous DFG threshold of ≥ 7.8 mmol/L was judged to be too high. The DFG level therefore was lowered to ≥ 7.0 mmol/L, a level determined to correspond more closely to individuals with 2-h plasma glucose level of ≥ 11.1 mmol/L after 75-g oral glucose load (32). There are several reasons for these recommendations. Two cross-sectional (33) and one prospective study (31) had shown that FPG in the interval of 7.0-to-7.8 mmol/L was associated with increased risk of micro vascular and retinal complications. One prospective study had shown that slightly elevated (but not diabetic) FPG values were associated with an increased mortality from coronary heart diseases (34). Several studies have shown that, at the time of clinical diagnosis of diabetes, the prevalence of microvascular complications may be as high as 30-40% (35) and the estimated median duration of DM at the time of clinical diagnosis is more than 5 years (36). Thus the ADA Expert Committee and WHO both recommended a lowering of the FPG values to define diabetes and according to the WHO recommendation, 7.0mmol/L was chosen to represent a value, which in most persons is of approximately equal diagnostic significance to that of the 2-h post load concentration.

In summary the diagnostic criteria are revised 1) In order to avoid the discrepancy between the FPG and 2-h PG cut point values and 2) facilitate and encourage the use of a simpler and equally accurate test—fasting plasma glucose for diagnosis of diabetes (37).

Impact of new diagnostic criteria for diabetes on different populations

For epidemiological purposes, it has now been recommended that a fasting plasma glucose value of 7.0 mmol/L can be used to diagnose diabetes, instead of a 2-h value of 11.1mmol/L (ADA). Over the last decade, most epidemiological studies have followed the WHO's 1985 guidelines (28), and have used the 2-h plasma glucose (2-hPG) alone to diagnose diabetes. This significant change in the classification of diagnostic procedures from the 2-h PG threshold to the new FPG threshold. However, it is not clear how this will affect the estimation of the overall prevalence of diabetes.

To validate the applicability of new criteria for diagnosis of diabetes, many recent studies have examined the variability of two diagnostic procedures. The exclusive use of fasting glucose for diagnosis of diabetes is questioned. Three concerns have been raised. 1) ADA fasting glucose criterion is highly specific, but sensitivity is variable (38). 2) Normal fasting glucose (NFG) is a heterogeneous group, which include many patients with impaired glucose tolerance (IGT), and diabetic glucose tolerance (DGT), therefore may be at increased risk for diabetes related complications including CVD (39). And 3) IFG

has correlated poorly with IGT, a known risk factor for future development of diabetes and CVD (40).

The European DECODE study and Hoorn Study both found a lack of sensitivity in using the ADA fasting glucose criteria in their Europeans population (41). In DECODE study it was shown that if fasting glucose is used alone, the 31% of diabetic subjects with a nondiabetic fasting glucose but a diabetic 2-h glucose, will not be diagnosed. Impaired fasting glycaemia (IFG) and impaired glucose tolerance (IGT) do not identify the same people, and the risk profile of people with impaired fasting glycaemia (IFG) depends on 2-h glucose concentrations (41). Surveys on southern hemisphere islands based on nine populations showed that a total of 31% individuals who were diabetic on fasting value were not diabetic on the 2-h value, and 32% of those with diabetes on the 2-h value were not having the condition following fasting value (38).

Study among the Japanese Americans have shown that the ADA criteria are markedly less sensitive than the revised WHO standards for diagnosis of diabetes and for detecting impaired glucose homeostasis. WHO criteria detected more than twice the number of diabetic individuals compared to ADA Fasting criteria's (32).

Data from the Indian urban study mentioned that, the prevalence of newly diagnosed diabetes was 5.2% according to the WHO criterion and 4.3% by the new criteria and the prevalence is slightly underestimated by new criteria (43).

In conclusion from all the studies, the fasting glucose criteria may have a place in the diagnosis of diabetes in clinical settings, in which simplicity and specificity are very important, because it is less time consuming, easy to perform and less expensive. It may be used as an alternative to oral glucose tolerance test (OGTT) in large surveys.

However, it must be mentioned that for epidemiological studies (especially those investigating the diabetes over time) OGTT should be recommended in capturing the pathophysiology of type 2 diabetes. Further OGTT can categorize individuals who provide valuable information on etiology and pathogenesis of both type 2 diabetes and its complications (32).

Therefore, a major change of diagnostic practice should have clear justification from a variety of studies that confirm its validity in terms of pathophysiological process, risk factors, complications and screening strategies.

Objectives of the study

General objective- To estimate the prevalence of type 2 diabetes mellitus along with its risk factors among the urban slum population in Dhaka city and to make a valid comparison with its source population i.e. rural.

Specific objectives:

- To observe the occurrence of diabetes in relation to the following variables;
 - Demographic (age and sex)
 - Socio-economic (occupation, income and level of education)
 - Anthropometrics (HT, WT, WHR and BMI)
 - Biophysical (blood pressure)

- To observe the differential prevalence's of Diabetes between rural to urban.

- To examine the agreement between FBG and OGTT in this population.

Materials and Methods

In conjunction with a previous study in the rural areas (n=5000), which secured as a source population another cross-sectional study was conducted in the urban slums of Dhaka city (n=1600, migrant population).

Selection of the study area

At the outset we have identified of 5 slums in Dhaka city with a major concentration of people migrating from the Gazipur and Tangail district. From those five slums two were randomly selected.

This two-slum area is located in the northeast part of the Dhaka metropolitan area; the local names of the slums are Karail and Mohakahali Bastee (Bastee means slum). The residents of the slums comprise of migrants from the rural areas of Gazipur and Tangail. The environmental conditions of these two slums resemble to other slums of Dhaka city having little access of urban facilities. The majority of the population are poor. They have no stable job and most of them are working in garment factories or as a daily labours like rickshaw pullers, carpenters and construction workers. Their

stable food is rice and other food items are pulses, vegetables and occasionally meat or fish. The literacy rate is low compared to the national level, only 47% have different levels of education. Rationality for choosing these slum communities relating to a defined rural population was to make a valid comparable study in order to observe the impact of urbanization for differential prevalences of diabetes.

Selection of the study population

About 5,000 individuals (both male and female) \geq 20 years of age were identified by a census prior to the commencement of the survey. All the subjects are migrants from the rural areas of Gazipur and Tangail. The identified individuals were registered in a logbook and were given a unique identification number. Among those 1600 subjects were selected following a simple random sampling procedure, of these 1555 subjects were investigated and 45 people refused to participate in the survey.

Sample size determination

In order to determine the required sample size the following Student's formula was used.

$$N = Z^2 PQ / d^2$$

Where, Z = 1.96, P for known prevalence of diabetes.

Q = 1-P, and d = allowable error of known prevalence.

Data collection

Training of health personnel and preparation of fieldwork

A physician who had prior knowledge in diabetes and community based studies, and an anthropometrist who had also previous knowledge on measuring the anthropometrical indicators were recruited for conducting the survey. In addition, two male and four female field volunteers were recruited from the local slum areas. A meeting was arranged by the local supervisor, with the main investigator and other project workers to discuss the objectives and methodology of the study. Four days of training (both theoretical and field) for the project workers were conducted prior to the beginning of the field survey.

A structured questionnaire was developed and translated in to Bengla language (local language) and revised after pre-testing. The questionnaire comprises four parts; part- A, for socio-economic and general information this was filled up by the field volunteers, part -B, anthropometrical measurements, (HT, WT, waist and hip circumferences) were taken by the same anthropometrist during the whole survey period, part- C and D were biophysical (Blood pressure) and biochemical (Blood glucose, FBG and OGTT) measurements were accomplished by a trained physician and by the researcher himself.

Survey procedures

After completion of training for the field workers, the population were identified and randomized during the month of July to August in 2001. Randomization was done following a simple random procedure. Fasting blood glucose, blood pressure and socio-demographic data were collected for the selected 1555 subjects during the months of September to November 2001. Further oral glucose test (OGTT) was done on a selected (n=476) participants.

Anthropometric measurement

Anthropometrics measurements for height, weight, hip and waist circumference were taken. Weight was taken with light cloths and without shoes by a modern digital bathroom scales placed on a flat surface. The weighing machine was checked

each day by a standard weight and the team members also checked their own weight as an additional daily check. The weight was recorded to the nearest 0.1kg.

Height was measured without shoes, with the subjects standing fully erect on a flat surface. Heels, buttocks and shoulders should be flat on the measuring wall, which should be straight, and the subjects should look straight ahead (a line between the angle of eye and the upper point of attachment of ear should be horizontal). Fixing a measuring tape to the wall and measuring the height with a movable headboard with a sufficient vertical dimension to ensure constancy of the measuring wall. The headboard must be in contact with the topmost point of the head with sufficient pressure to compress the hair and height was taken to the nearest centimeter.

Waist girth was measured by placing a plastic dressmaker's tape horizontally midway between the lower border of the ribs and iliac crest on the mid –axillary's line. The measurement was recorded at the nearest cm.

Hip circumference was measured to the nearest cm at the greatest protrusion of the buttocks and at the level of greater trochanter and symphysis pubis horizontally.

BMI was calculated as $\text{wt in kg/ht in m}^2$ and WHR was taken as waist/hip circumference.

Measurement of blood pressure

Blood pressure (BP) was taken after completion of interview and finishing the anthropometrical measurements. To reduce the variation of BP the subjects was asked to take rest and relaxation at least 10 minutes in sitting position before BP record. The pressure was measured on the right arm using normal cuffs for adults fitted with a standard mercury sphygmomanometer, placing the stethoscope bell lightly over the pulsatile brachial artery.

Pressures were usually recorded to the nearest 2mm Hg from the top of the mercury meniscus. Systolic pressure was recorded at the first appearance of sounds, and diastolic pressure was measured at phase V, disappearance of sounds.

Blood glucose (BG) estimation

The selected participants were instructed during recruitment and the evening prior to the examination by the field volunteers not to intake any food item after 23.00 hours at night until the test following morning in the temporary field survey center. When the participants arrived in the center they were seated and asked about their fasting status by the physician or by the principal researcher.

The investigation was carried out only after reporting of fasting state by the participants.

Subjects were asked to sit on a chair and an appropriate 2nd drop of blood was taken from the fingertip by using lancing device. The hanging blood drop was obtained by the tip of the HEMOCUE glucose cubets slide and the slide was immediately introduced to the HEMOCUE machine. Within 20 to 30 seconds the blood glucose value was displayed in the HEMOCUE window, the blood glucose values were recorded with subject's ID numbers and name. In case of abnormal high values subjects were referred to the Diabetic hospital for clinical diagnosis.

The HEMOCUE machine was calibrated with a standard range of reading (control) prior to start estimation, and it was rechecked after every 20 patients.

Fasting Blood Glucose (FBG) from capillary whole blood was performed from 1555 individuals following the new WHO diagnostic criteria (29). Further 2-h glucose values were estimated after a 75-g oral glucose load, all those with FBG values ≥ 6.1 mmol/L (n=126), and FBG values between 5.6 - 6.0mmol/L (n=131). In addition OGTT was performed on 219

subjects, randomly selected from those, whose FBG values were found to be <5.6mm/L in the survey.

Accordingly, we have performed OGTT on 476 individuals.

Data analysis and statistical methods

Data were registered using Microsoft Access data entry. Control of data entry was secured through both Programme appliance and manually. The prevalence rates of DM were determined by simple percentages. Statistical comparisons between different groups were made using χ^2 test. The odds ratio (OR) with 95% confidence interval (CI) for risk factors was calculated taking the least prevalence of complications or clinically relevant criteria as a reference value. All P- values presented are two tailed. Multiple logistic regressions were executed to adjust for potential confounding factors; using SPSS 10.0 software for all statistical analysis.

Ethical consideration

The local slum leaders were invited for a meeting with the project team. They were oriented of the purpose of the study and requested for their opinion and/or comments. Their co-operation was sought in a participatory manner. Each of them was given a specific task (organizing, motivating, identifying the subjects, co-ordination with the field survey team and feedback to the main researcher).

The local field volunteers (two male and four female) were responsible to inform of the objectives of the study and to secure their verbal consent prior to inclusion in the study. They were also informed of their right to withdraw from the study at any time or to restrict their data from analysis.

The Norwegian and Bangladesh ethical committee for medical research approved the protocol.

SUMMARY OF RESULTS

PAPER 1

Prevalence of type 2 diabetes in urban slum of Dhaka, Bangladesh

The paper attempts to describe the prevalence of type 2 diabetes and its associated risk factors among the urban slum population in Dhaka, Bangladesh. This study was conducted among the urban migrants from a selected rural area. The study subjects were in transitional stage of urbanization with little change of their traditional rural life and most of them were hard-core poor. Earlier we have conducted another prevalence study in the rural areas about 35 miles north from the Dhaka city in the district of Gazipur and Tangail in 1999. We undertook the study in two slums of Dhaka metropolitan area among the migrants from those specific rural areas in 2001.

In this cross-sectional survey we investigated 1555 individuals randomly both male and female ≥ 20 years of age. For estimating the prevalence of diabetes we performed fasting capillary blood glucose (FBG) and 2-h post glucose test for a selected number of subjects. We also measured some important anthropometrical indicators (HT, WT, waist and hip girth) including systolic and diastolic blood pressure. Further, Demographic and socio-economic information were collected following a pre-tested structural interview. For diagnosis and defining the diabetes state in our study population we used revised WHO criteria.

Among our study subjects 731 were male, 824 were female, most of the population were young with a mean age 33 years, and about 78 percent were in age category between 20-40 years. Others socio-economic indicators showed that 81 percent had a monthly income below 3000 taka, 47 percent were literates who could read or write their own name and 25 percent were employed in service. Among the female subjects 76 percent were housewives and 19 percent were engaged in job. But most of the males about 68 percent were working in garment industries and or as a daily labors like rickshaw pullers, carpenters and construction workers.

The study revealed that the total prevalence of diabetes in this population were 8.1 percent and female had a higher prevalence rate (8.5%) compared to male (7.7%). The prevalence of diabetes was increased with the increasing of age for both males and females. The females had higher prevalence of diabetes in all age categories compared to males and it was almost two fold higher in age group 41-50 years.

We have observed a higher rate of increment in mean blood glucose among females subjects compared to males according to fasting blood glucose values (FBG). Among the older age group >50 years the male had higher level of mean blood glucose values compared to females, though the differences were not statistically significant. This was probably a consequences of fewer (1/2) female participants in this age group compared to males. 2-h BG values showed the heightened values, among females at an earlier age compared to males.

Poor to moderate agreement were observed between fasting blood glucose and 2-h glucose values on 476 subjects (kappa 0.41, $P < 0.001$). The differences in mean blood glucose values followed by FBG or OGTT may at least in part explain the observed poor agreement.

Prevalence of systolic hypertension (sBP >140 mmHg) and diastolic hypertension (dbp >90 mmHg) were found to be 1.3% and 2.3% respectively. But we did not find any association between systolic and diastolic hypertension among the diabetic subjects following FBG or OGTT.

Forty seven percent of our study subjects were literates and the prevalence of diabetes among the literates were found to be 9.5 percent compared to illiterates 6.9 percent ($p < 0.05$).

Our study subjects appeared to represent a lean population with mean BMI 19.4 and only 6.2 percent were defined as over weight(BMI >25.0).

No significant association was observed between BMI and the occurrence of diabetes in our study population. Rather a protective effect was found among the subjects with BMI between 16.0-18.4 compared to normal BMI (18.4-24.9).

Waist-to-hip ratio (WHR >0.9) was found to be a significant risk factor for the development of diabetes for men following both FBG and OGTT criterions.

Age, sex, literacy and waist to-hip-ratio for male were found to be statistically significant risk factors for the development of type 2 diabetes both in bivariate and multivariate analysis controlling for potential confounding factors following both FBG and 2-h BG values. Never the less, the strength of association varied with in the limit of statistical significance.

Paper II

Determinants to differences in Prevalence of type 2 Diabetes between Rural an Urban slum population in Dhaka, Bangladesh.

The objective of the study was to investigate the differences in prevalence of type 2 diabetes and associate risk factors in rural compared to urban population. In addition, the diagnostic procedures were examined both among the rural and urban subjects.

In this comparative analysis, a total 4757 subjects from rural and 1555 subjects from urban areas ≥ 20 years of age were examined. Among the rural subjects 2037 were male, 2720 were female, in urban area 731 were male, and 824 were female.

The prevalence of diabetes was found to be higher among the urban subjects 8.1% compared to rural 2.3%. Almost three to five fold higher prevalence was found with increasing age in urban subjects compared to rural.

Females had a higher prevalence of diabetes both in urban and rural compared to males (urban female 8.5% and male 7.7%, rural female 2.5% and male 1.9%) and in all age groups the difference was found statistically significant ($P < 0.05$).

The prevalence of DM did not appear to differ in urban or in rural population following either FBG or OGTT procedures for a selected subjects (urban 476 and rural 1046).

Equal poor agreement was found between FBG and OGTT for both in urban and rural population (kappa 0.41 in urban and kappa 0.40 in rural).

The differences in mean blood glucose values were fairly similar for both sexes in urban and rural areas following FBG up to the age of 50 across all age groups, but after the age of 50 the mean glucose values for men were found to be higher compared to women despite of equal prevalence of DM among the urban male and female subjects. This may indicate a weakness related to fewer female participants in this age category. In contrast

2-h BG values showed elevated levels of mean BG values among the female participants at an earlier age both in rural and urban population.

Age, sex and waist-to-hip ratio for male were found to be important risk factors for the development of diabetes among urban and for rural population following FBG and OGTT.

Systolic hypertension was found to be marginally associated with DM cases in rural population (OR, 2 and 95%CI 1.0-3.9) but this association was not apparent among the urban subjects.

No association was observed with BMI and the occurrence of diabetes in our population for the urban or in rural subjects. We observed a four-fold raise of diabetes in urban population compared to rural in spite of almost similar level of mean BMI (for urban 19.4 and rural 20.2 subjects). However, the risk of diabetes was notably higher for the obese individuals (BMI >30.0) both in rural and urban but the apparent statistical significance was not observed in multivariate analysis because of fewer numbers of subjects belonging to this group (rural 11 and urban 7).

Conversely a protective effect was observed among the urban subjects with BMI 16.0-18.4 compared to normal BMI 18.5-24.9 (OR, 0.6 and 95% CI 0.3-0.9).

Waist to hip ratio (WHR>0.9) for male were found to be a risky state for the development of diabetes both in urban and rural population following FBG and OGTT in multivariate model after adjusting for a number of confounding variables.

GENERAL DISCUSSION

The general objective of the study was to estimate the prevalence of type 2 diabetes among the urban slum dwellers of Dhaka city and to make a valid comparison in differential prevalences and its related risk factors compared to its source population i.e. rural. Further diagnostic criterias were examined for selected subjects following FBG and OGTT both for the urban and rural subjects in order to facilitate discussion related to predicommments of the applicability of diagnostic procedures.

The discussion section will focus on rising and differential prevalences of diabetes between urban and rural population including the risk factors and its influence for the occurrence of DM.

Further, applicability of diagnostic procedures was also examined.

We have observed a significantly higher prevalence of type 2 diabetes among the urban slum population 8.1% compared to our rural population 2.3%($p < 0.01$). Earlier studies in Bangladesh showed the prevalence of type 2 diabetes in urban population was 7.9% and in rural population 3.8% in the age category 30-64 years (24-26). In our urban population the prevalence of diabetes increased about four times higher compared to rural subjects. The findings of our urban study showed a similar and consistent results with other Indian studies (55,56) and studies performed in Bangladesh (26). Our rural study showed somewhat lower prevalence of diabetes compared to a previous rural study in Bangladesh (24) probably because of lower age composition in our population ≥ 20 years and

different diagnostic procedures applied. However, FBG did not appear to underestimate the prevalences of DM compared to 2-h BG values either in rural or urban population.

The differences in prevalence cannot be explained either by obesity or central adiposity, hypertension or by socio-economic status. This may indicate the stressful life conditions, unfavorable settings rather than traditional belief that modified food behavior as a consequence of urbanization will result in higher obesity. Which in turn will increase DM to metabolic syndrome.

The prevalence of diabetes increased with increasing age both for urban and rural population. This observation is almost uncontroversial. In our urban population in each age category, there was almost three to five fold higher prevalence of diabetes compared to rural population and the risks increased by an incremental order for the development of diabetes for the older subjects compared to younger both in urban and rural population.

We have observed a higher occurrence of diabetes among females in all age categories compared with males both in urban and rural and the prevalence of diabetes was found to be even higher among the females following 2-h glucose tolerance procedure but the differences were not statistically significant. In our urban subjects we found two fold increased prevalence of diabetes among females in the age category 41-50 years compared to males (20.4% vs10.5%). The findings of the predominance of the state by sex in this population were consistent in previous studies (24-26). Although the reason for this phenomenon is unknown but women appeared to have higher BMI compared to males. The higher BMI among women compared to men also observed in Indians and Pima Indians study (61).

The higher prevalence among women than their male counter parts in our population is not known but possibly women had under nutrition in their early infancy or fetal life (58,59) or may have some roots in the traditional practices make female neglected both as mothers or infants.

The mean blood glucose levels for females showed a fairly different values compared to male following FBG in our urban and rural population and this differences were more distinct following OGTT for a selected subjects. Female had a significantly higher BG values in their early life for rural subjects compared to males following OGTT and a similar pattern of BG levels were also observed among the urban subjects up to age of 50, after which female had markedly lower mean BG values.

Systolic hypertension (sHTN >140 mmHg) was marginally associated with the occurrence of type 2 diabetes in our rural population following FBG but this association was not retained after OGTT. This may have occurred as a result of lower numbers of participants were investigated in 2-h post glucose procedure. In compared to rural population no association was observed with blood pressure and DM in urban population. Hypertension in our lean population was found to be almost non-existing. But in a selected rural study found the prevalence of sHTN and dHTN was 10.5% and 9.0% respectively (62).

Literacy showed an important association for the occurrence of diabetes in our urban subjects. Literacy may be associated with better economic condition and thereby a proxy indicator for socio-economic status. Earlier studies in Bangladesh have also shown that the risk of diabetes was higher among the people with improved socio-economic status (26).

Waist-to-hip ratio was found to have a statistical association for the development of DM for male both in urban and rural subjects but this association was not apparent for the women. Our male population showed 39 % higher waist/hip ratio (WHR>0.9) though evidence of normal BMI, which may explain as an excess accumulation of body fat in the abdominal region other than, hips and lower extremities. It may be hypothesized that our

population remained undernourished in their infancy and adolescents' periods and their food intake increased at adult life resulting in increased central adiposity other than generalized obesity that may cause insulin resistance, metabolic syndrome and type 2 diabetes.

Generalized obesity measured by body mass index (BMI) appeared to recognize as a prime indicator for the development of type 2 diabetes. Our study population both in urban and rural, represented a lean population with a mean BMI (urban-19.4 and rural-20.2) and only 3.6 % in rural and 6.2% in urban population were defined as overweight. We did not observe any significant association between BMI and DM following FBG or OGTT either in urban or rural subjects. But there is an exceeding risk for the development of diabetes among the obese, however, no conclusion could be made as fewer numbers of subjects belonged to this category. As it has been shown that the prevalence of diabetes was significantly higher among the urban migrants compared to its source population despite of similar levels of obesity status, This may be explained that most of the study subjects were hard core poor people and had low birth weight and or under nutrition in their infancy which could be attributed for rising prevalence of diabetes in adult life. In addition, stressful life conditions and traumatic environmental settings of urban slum may have added to its manifested risk as LBW babies from infancy.

Further, it is also possible that we are witnessing a unique form of type 2 diabetes in this population comparable to the Indian population in this sub-continent where more than 60 percent of type 2 diabetes cases are non-obese and many are actually lean with body mass index <18.5 and referred as "lean type 2 diabetes" (60).

The evidence may call for readjusted BMI cut-off values in the local context in order to identify people for metabolic syndrome. However, we need to understand the metabolic and hormonal profiles from future studies in order to establish culturally sensitive BMI categories.

OVERALL CONCLUSION AND RECOMMENDATIONS

The study showed a four fold higher prevalence of type 2 diabetes among the urban poor migrants compared to its sources population i.e. rural. The findings were consistent with other studies on developing countries. The risk factors identified for the development of type 2 diabetes for urban and rural population are largely the same but the reasons for increased risk for the urban population were not identified in the study.

BMI Measures useful to indicate people at risk for the development of type 2 diabetes were not found to be appropriate in our population. This may call for re-examination for BMI categories in different population in order to identify the people at risk for the development of diabetes.

Procedures applied to measure prevalence of diabetes in our lean population did not differ significantly either following FBG or OGTT, rather we could say that FBG did not provide an under estimation of the prevalence of DM compared to OGTT procedure. Suitability of the diagnostic procedures in different population may vary and there fore deserves an examination for its applicability.

In general, hard-core poor people migrate from rural to urban slums in search of better life. As poverty and LBW are interlinked entity it may be presumed that LBW babies carry a higher risk of diabetes in adulthood irrespective of their obesity status. Alleviation of poverty may still be the key factor for the prevention of DM in lean population affecting millions of people in the developing world.

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Paper I

Prevalence of type 2 diabetes in urban slum of Dhaka, Bangladesh.

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Prevalence of type 2 diabetes in urban slum of Dhaka, Bangladesh.

**OBJECTIVE- To estimate the prevalence of type 2 diabetes
along with its risk factors in urban slum population of
Bangladesh.**

RESEARCH DESIGN AND METHODS- A random sample of 1555 slum dwellers of Dhaka city (age ≥ 20 years) was included in a cross-sectional study. Capillary blood glucose levels, fasting and 2-h after 75g oral glucose load (for a selected subjects) were measured.

Height, weight, waist and hip circumference including blood pressure and important information regarding socio-demographic, economic condition was collected.

RESULTS- The study population was lean with a total prevalence of type 2 diabetes 8.1 percent, and 7.7 percent for men and 8.5 percent for women. Age, sex, literacy and waist to hip ratio for men were found to be significant risk factors following both fasting blood glucose and 2-h post glucose values adjusted for a number of confounding variables. Kappa agreement between fasting blood glucose (FBG) and 2-h BG was 0.41 ($p < 0.001$). The agreement was nearly close to between male and for female (0.45 male and 0.37 for female).

CONCLUSION- Anthropometrics measurements and its cut-off values in different population may call for a re-examination.

Prevalence of diabetes was found to be lower following 2-h glucose values in the selected population compared to the FBG procedure. Poor agreement between FBG and 2-h BG may raise concern for the dependability of diagnostic procedures.

Higher prevalence in the urban-slum compared to the rural population may indicate an epidemiological transition due to fast urban migration and possibly urbanization.

Key words Age, sex, body mass index, waist to hip ratio, type 2 diabetes, obesity, prevalence, slum, Bangladesh.

Introduction

The recent WHO report on diabetes prevalence alarmed that diabetes has posed a serious threat to developing countries in respect to their existing health care services (1). Further, the prevalence of diabetes is predicted to increase dramatically over the next 25 years, mostly as a result of type 2 diabetes (2).

Diabetes mellitus particularly type 2 diabetes is now recognized as a major chronic public health problem of Bangladesh. Some small-scale survey on community level has shown that the prevalence of glucose intolerance and hypertension is high (3-5). Diabetes, hyperinsulinemia and coronary risk factors are more prevalent in Bangladeshis compared with other South Asian migrants (Indian, Pakistani) settled in United Kingdom (8) and with the native population (9,10). It has been reported that Bangladeshis among all other

South Asian immigrants had higher morbidity and mortality from CHD in UK (10). In recent years the magnitude of diabetes is increasing and an emergent trend of diabetes registration are shown in all referral centers of Bangladesh, and studies have shown that the prevalence is higher in urban population than their rural counterparts (6).

In the last few decades, the urban population of the developing world has grown rapidly due to migration from rural areas. Bangladesh is no exception to this trend; the population growth rate of urban areas is three times higher (6-7%) than the national population growth 2% per year (11). According to the recent report, at the current pace of urbanization and territorial extension, Dhaka is expected to become the ninth mega city of the world for population density by the year 2015(12). At present 30 percent of total population of Dhaka city about 3 million are residing in different slums (13). Urban slum dwellers are exposed to poor environmental settings such as overcrowding, no access of gas and electricity, poor quality of drinking water and sanitation, and no removal of waste. All these factors are likely to contribute for the development of a variety of acute infection to chronic health problems.

Some small-scale surveys on the prevalence of diabetes showed that type 2 diabetes is higher in urban areas than the rural and it is increasing (6). Earlier studies showed that people in transitional stage of urbanization is likely to change their life style resulting in increasing prevalence of diabetes (14). This phenomenon could be applicable to the most of the rural population of Bangladesh who are in an in-between the stage of urbanization.

But sound comparative studies are almost non-existing in Bangladesh as to show the impact of urbanization on the possible development of diabetes. We have already conducted a study in the rural areas of Gazipur and Tangail district located approximately 35 miles north in Dhaka city in 1999.

This study attempts to estimate the prevalence of type 2 diabetes and important risk factors in Bangladeshi urban slum population, further comparison of prevalences and risk factors were examined with its sources population.

Materials and Methods

Selection of the study area

Initially we made a list of 5 slums in Dhaka city with a major concentration of people migrating from the Gazipur and

Tangail district. Amongst the 5 slums we have randomly selected two slum communities.

This two-slum community is located in the northeast part of the Dhaka metropolitan area; the local names of the slums are Karail and Mohakhali Bastee (Bastee means slum).

The residents of the slum comprise rural migrants from different parts of the country and mostly from the northern area of the Dhaka city particularly from, Tangail, Gazipur Mymensingh and Sherpur district. The physical characteristics of these two slums are similar to other slums of Dhaka city having little access of urban facilities. Most of the population have low income. They have no permanent service and the majority of them are working in garment factories or as a daily labor. Their staple food is rice and other food items are pulses, vegetables and occasionally meat and fish. The literacy rate is low compared to the national level, only 47% have different grades of schooling. Rationality for choosing these slum communities was to observe the impact of urbanization for differential prevalences of diabetes among the urban migrants and compared to the sources population i.e. rural.

Selection of the study subjects

About 5,000 individuals (both male and female) ≥ 20 years of age were identified by a census prior to the commencement of the survey. All the subjects are migrants from the rural areas of Gazipur and Tangail. The identified individuals were registered in a logbook and were given a unique identification number by the members of the survey team. Among those 1600 subjects were selected following a simple random sampling procedure, of these 45 people refused to participate in the survey leaving 1555 people for investigation.

Ethical consideration

The local slum leaders were invited for a meeting with the project team. They were oriented of the purpose of the study and requested for their opinion and/or comments. Their co-operation was sought in a participatory manner. Each of them were given a specific task (organizing, motivating, identifying the subjects, co-ordination with the field survey team and feedback to the principal researcher).

Field volunteers (two male and four female) were recruited from the local slum community and trained by the principal investigator. The local volunteers were responsible to inform of the objectives of the study and to secure their verbal consent

prior to inclusion in the study. They were also informed of their right to withdraw from the study at any time or to restrict their data from analysis.

The Norwegian and Bangladesh ethical committee for medical research approved the protocol.

Survey procedures

Four days of training (both theoretical and field) for the project workers were conducted prior to the beginning of the field survey. The identification of population, census and numbering of the study subjects were made during the months of July-August 2001. Fasting blood glucose, biophysical examination and socio-demographic information was collected for the chosen 1555 subjects during the months of September – November 2001. Further oral glucose tolerance test (OGTT) was done on a particular 476 participants.

Anthropometrical measurement

Four anthropometrics measurement for height, weight, hip and waist circumference were taken. Weight was taken with light cloths and without shoes by a modern digital bathroom scales placed on a flat surface. The weighing machine was checked each day by a standard weight and the team members also checked their own weight as an additional daily check.

The weight was recorded to the nearest 0.1kg. Height was measured without shoes, with the subjects standing fully erect on a flat surface. Heels, buttocks and shoulders should be flat on the measuring wall, which should be straight, and the subjects should look straight ahead (a line between the angle of eye and the upper point of attachment of ear should be horizontal). Fixing a tape measure to the wall and measuring the height with a movable headboard with a sufficient vertical dimension to ensure stability of the measuring wall. The headboard must be contact with the topmost point of the head with sufficient pressure to compress the hair and height was taken to the nearest centimeter.

Waist girth was measured by placing a plastic dressmaker's tape horizontally midway between the lower border of the ribs and iliac crest on the mid –axillary's line. The measurement was recorded at the nearest cm.

Hip circumference was measured to the nearest cm at the greatest protrusion of the buttocks and at the level of greater trochanter and symphysis pubis horizontally.

BMI was calculated as wt in kg/ ht in m^2 and WHR was taken as waist/hip circumference.

Measurement of blood pressure

Blood pressure (BP) was taken after administration of the questionnaire and finishing the anthropometrical measurements. To reduce the variation of BP the subjects was ensured rest and relaxation at least 10 minutes in sitting position before BP was record. The pressure was measured on the right arm using normal cuffs for adults fitted with a standard mercury sphygmomanometer, placing the stethoscope bell lightly over the pulsatile brachial artery. Pressures were usually recorded to the nearest 2mm Hg from the top of the mercury meniscus. Systolic pressure was recorded at the first appearance of sounds, and diastolic pressure was measured at phase V, disappearance of sounds.

Blood glucose (BG) estimation

Fasting Blood Glucose (FBG) from capillary whole blood was performed from 1555 individuals following the new WHO diagnostic criteria (15). Further 2-h post glucose values were estimated after a 75-g oral glucose load, all those with FBG values ≥ 6.1 mmol/L (n=126), and with FBG values between 5.6 - 6.0mmol/L (n=131). In addition OGTT was performed on 219 subjects, randomly selected from those whose FBG values were found to be < 5.6 mmol/L in the survey.

Accordingly we have performed OGTT on 476 individuals.

The HEMOCUE glucose analyzer was used in the field to estimate the glucose value. The machine was calibrated with a standard range of (control) reading prior to start estimation, and it was rechecked after every 20 patients.

Data analysis and statistical methods

Data were registered using Microsoft Access data entry. Control of data entry was secured through both Programme appliance and manually. The prevalence rates of DM were determined by simple percentages. Statistical comparisons between different groups were made using χ^2 test. The odds ratio (OR) with 95% confidence interval (CI) for risk factors was calculated taking the least prevalence of complications or clinically relevant criteria as a reference value. All P- values presented are two tailed. Multiple logistic regressions were executed to adjust for potential confounding factors; using SPSS 10.0 software performed all statistical analysis.

Results

Of the 1555 subjects investigated, 731 were male and 824 were female. The prevalence of diabetes between male and female were 7.7% and 8.5% respectively and overall prevalence of diabetes was found to be 8.1%(Table-1).

Prevalence of diabetes increased with the increasing of age for both males and females. Though non- significant, females had higher prevalence of diabetes in all age groups compared to males other than older participants (aged >50 years). This may have been due to lesser number of female subjects in the age group > 50 years.

Poor to moderate agreement were observed between fasting blood glucose and 2-h glucose values on 476 subjects (kappa 0 .41, $p < 0.001$) (Table 2). The agreement was even poorer between impaired fasting glucose and impaired glucose tolerance (data not shown).

High levels of mean fasting blood glucose (FBG) and 2-h BG values were observed with increasing age both for males and females (Fig1). The variation in glucose values following FBG criterion was fairly similar for both sexes until the age of 50 years after which the glucose values decrease remarkably for women. The differences were not statistically significant. But according to 2-h BG measures females had significantly higher levels of BG values in the age group 20-30 compared to males. Similar to FBG values the 2-h BG values had also decreased for females in the age range of 50 and above but the differences were not statistically significant.

Age, Sex, literacy and WHR for males showed to be important risk factors for the occurrence of type 2 diabetes in the multivariate analysis adjusted for a number of confounding variables following both FBG and 2-h BG criterion (Table-3).

The risk for diabetes was almost four fold higher among the participants between the age of 41-50 years and more than five fold higher above the age of 50 years compared to the younger age group 20-30 years following fasting blood glucose levels.

Waist to hip ratio (WHR>0.9) was found to be statistically significant for the development of DM in men. Literates appeared to have a significant higher risk of DM compared to illiterates.

Similar associations were also observed with the diabetic cases for age, sex, blood pressure, Body mass index, waist to hip ratio and for literacy rate in the multivariate model following OGTT. However, the strength of associations varied to a certain extent probably because of the lesser number of subjects were included in the model compared to the procedure applied to the DM state following FBG criterion.

Discussion

This study showed a high prevalence of type 2 diabetes 8.1% among the urban slum population aged 20 years and above. The prevalence of type 2 diabetes was found 7.9% in urban, 4.5% in suburban and 3.8% in rural Bangladesh among the subjects of age category 30-64 years (4-6). Our study showed somewhat an increasing prevalence among urban population, Owing to the fact the prevalence measurement in our study was established following FBG criterion while the referred study was based on OGTT values. Further the applied criterion to be different to define the state of diabetes.

Further type 2 diabetes was found 11.6% in urban, 5.9% in suburban and 2.4% in rural Indians of adult population (≥ 20 years of age)(14,18,22,). The rate was found to be 7% in adult population (≥ 20 years of age) and 10-50% in the minority communities as well as Asians in the USA (20).

Sequential cross-sectional or prospective studies (16-20) have shown that the prevalence of type 2 diabetes have been rising in almost all population. Recent studies showed that urbanization and economic development are causing high prevalence of type 2 diabetes in the developing countries (21,22).

In our study it was noted that rising trend of type 2 diabetes among the same ethnic population with a difference in prevalence between rural-urban areas is consistent with other studies.

Further, our study also showed that the differences in prevalence between urban poor and rural population remained despite of similar BMI and socio-economical state. This may

indicate that stress and environmental factors may have contributed to the differential prevalence rather than the traditional belief that modified food behavior and higher BMI may have been responsible for the higher prevalence of diabetes.

We have observed a higher prevalence of diabetes among females 8.5% compared with males 7.7%. The higher rate was also consistent in different age category other than older age group >50 years and it was almost two fold higher in age group 41-50 amongst females compared to males. This difference in prevalence was even more distinct following 2-h glucose values. The findings of this study higher predominance in women were consistent with most of the other previous studies (4,5,6). Some of the recent Indian investigations have shown a considerably higher prevalence of DM in women 12.7%, men 10.4% (14) and 13.7% in women compared to 11.1% in men (22). Non-significant higher prevalence of type 2 diabetes for women was also observed (2.2% compared to 1.6% in men) among the Mexican Indians (24). But the European studies have shown a higher prevalence of type 2 diabetes in males compared to female (25).

The prevalence of type 2 diabetes increased with increasing age. This observation is almost uncontroversial. We have observed increasing level mean FBG with increasing age (Fig 1). Age determination of people in the developing countries is somewhat uncertain. We have used local volunteers who construct a local calendar year with some historical events in order to determine age.

Prevalence of systolic hypertension (sBP>140 mmHg) and diastolic hypertension (dBP>90mmHg) were 1.3% and 2.3% respectively. Younger had lower prevalence for both systolic and diastolic hypertension. Studies conducted in rural Bangladesh found that the rate of systolic and diastolic hypertension was 10.5% and 9.0%(25) and an association between hypertension and hyperglycemic status was also observed. Another study also found that the prevalence for sHTN and dHTN was 23.6% and 13.6% among the newly diagnosed type 2 diabetes patients (28). We did not find any association between systolic or diastolic hypertension among the diabetic subjects following both of the procedures FBG or 2-h BG.

Our previous study with the source (rural) population showed only a marginally significant association with systolic HTN following FBG but not with diastolic HTN. Though this association was not established with 2-h tolerance procedure.

The prevalence of diabetes among literates and illiterates were 9.5% and 6.9%. Paradoxically, literacy was found to be significantly associated with higher occurrence of DM in our population compared to illiteracy. The association remained even after adjusting for a number of confounding variables in the multivariate model. Literacy may have played as a proxy indicator for socio-economic condition. Previous studies have shown to higher the risk of DM in people with improved socio-economic status.

Body Mass Index (BMI) was considered as an indicator for obesity and often referred as the prime determinant for the development of type 2 diabetes but we did not observe any association between BMI and diabetes in our population. In bivariate analysis we have seen an excess risk of diabetes among the subjects with BMI (30->) compared to normal subjects (BMI 18.5-24.9) and no conclusion could be made as only 7 subjects in the group. For the severe PEM (BMI <16.00) and moderate PEM (BMI 16.0-18.4) the risk was reduced to almost half. After adjusting with other potential confounders in multivariate model BMI showed the similar association for diabetes. Interestingly significant protective effect was observed for the moderate PEM subjects for the occurrence of DM. This observation is an agreement with our parent investigation with source of population. Our study subjects appeared to represent a lean population with only 6.2% people defined as overweight. Data from previous study in urban and rural population had showed higher risk of type 2 diabetes with higher BMI for both men and women (4,5). Studies in the urban and peri-urban Indian population showed a strong association between DM and BMI and central obesity for both sexes however women showed an excess risk compared to men. (14,18). The association with BMI and type 2 diabetes appeared to differ in different ethnic groups. Epidemiological data from Asian Indians (AI) and Mexican Americans (MA) and non-Hispanic Whites (NHW) from San Antonio heart study showed that MA had the higher rate of obesity and highest prevalence of diabetes (men 19.6%; women 11.8%). NHW had also high rates of obesity but low prevalence of diabetes (men 4.4%; women

5.7%). while AI had lower BMI than MA, the risk present by BMI was equally high in AI and MA than NHW (26).

Waist to hip ratio (WHR) for male showed to be remarkably associated with the occurrence of diabetes in our study population following both FBG and OGTT criteria. In a review of 59 references it was found that average waist-to-hip circumference ratios are higher in South Asians than in Europeans of same BMI (27). Previous study in Bangladesh also showed that the prevalence of diabetes was related to WHR (28). Data from Indian study also showed that a strong association with DM and WHR for the both sexes (22). In our rural study we have also found that the WHR for the male was statistically associated with DM. We have observed 39% men and 88% of women had central obesity with normal BMI in our population (data not shown).

We are witnessing different classes of type 2 diabetes in the Asian population. More than 80% of patients with type 2 diabetes present in Europe and America are obese. Whereas countries like India report that more than 60% of type 2 diabetes are non obese and many are actually lean with a body mass index of <18.5 and are referred to as “lean type 2 diabetes”(29). Only 0.5% of our population termed as obese with a BMI >30 .

Approximately 46% of our cases appeared to have a BMI <18.5 termed as Protein Energy Malnutrition (PEM) and 48% cases with a BMI between 18.5-24.9 termed as normal.

Measures useful to exemplify obesity in relation to the occurrence of type 2 diabetes in different population appeared to present incoherent results. Individuals with an excess deposition of fat in abdomen showed various metabolic disorders, including insulin resistance compared to those having fat mostly distributed in the lower extremities (28).

Therefore it is rational to evaluate and validate the cut-offs used in different anthropometric indices in different population in order to identify the population at risk.

This study suggested that higher prevalence of diabetes among the urban poor migrants population compared with previous studies. The findings were likely to be related with other studies among urbanizing people of developing countries. We require more epidemiological investigation based on family history, nutritional status on early life and

other environmental aspect in a larger sample population to identify the possible risk factors for the development of DM.

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Table- 1 Prevalence of diabetes by age and sex, urban slum Dhaka, Bangladesh 2001.

Age group in years	Male			Female			Total		
	Diabetic cases	n	Prevalence per 100	Diabetic cases	n	Prevalence per 100	Diabetic cases	n	Prevalence per 100
20-30	10	330	3.0	25	489	5.1	35	819	4.3
31-40	19	194	9.8	19	201	9.4	38	395	9.6
41-50	13	124	10.5	19	93	20.4	32	217	14.8
51->	14	83	16.9	7	41	17.0	21	124	16.9
Total	56	731	7.7	70	824	8.5	126	1555	8.1

Table- 2 Relationship between fasting blood glucose values and the 2-h glucose test in 476 participants, urban slum Dhaka Bangladesh 2001

Fasting Blood Glucose mmol/L (mg/100ml)	Oral Glucose test mmol/L (mg/100ml)		
	<11.1 (<180)	≥11.1 (≥180)	Total
<6.1 (<110)	344	6	350
≥6.1 (≥110)	82	44	126
Total	426	50	476

P for the difference in observation <0,001

Kappa 0,41

Table 3 Prevalence and odds ratio (OR) and 95% CI of diabetes following fasting blood glucose and 2-h glucose values by the following risk factors, in urban Bangladesh, 2001

Variables	cases	non cases	prevalence	OR (1) 95% CI 95% CI	OR (2) 95%CI Per 100	OR (3)
Age						
20-30	35	784	4.3	1.0	1.0	1.0
31-40	38	357	9.6	2.4 (1.4-3.9)	2.4 (1.4-3.9)	5.0 (2.1-15.9)
41-50	32	185	14.7	3.9 (2.3-6.6)	3.8 (2.2-6.5)	10.6 (3.7-30.0)
50->	21	103	16.9	4.7 (2.6-8.8)	5.2 (2.8-9.8)	8.5 (2.6-27.6)
Sex						
Male	56	675	7.7	1.0	1.0	1.0
Female	70	754	8.5	1.1(0.7-1.6)	1.5 (1.0-2.3)	1.8 (0.9-3.6)
Systolic BP						
≤140 normal	123	1412	8.0	1.0	1.0	1.0
>140 High	3	17	15.0	2.0 (0.3-7.4)	0.9 (0.2 –3.8)	0.0 (0.0-5.1)
Diastolic BP						
≤90 Normal	120	1399	7.9	1.0	1.0	1.0
>90 High	6	30	16.7	2.2 (0.8-5.7)	1.1 (0.4-3.2)	1.2 (0.2-5.9)
BMI						
18.5-24.9	72	671	9.7	1.0	1.0	1.0
< 16	7	121	5.5	0.5 (0.2-1.2)	0.5 (0.2-1.2)	0.6 (0.1-3.0)
16.0-18.4	31	550	5.3	0.5 (0.3-0.8)	0.6 (0.3-0.9)	0.6 (0.3-1.5)
25-29.9	14	82	14.6	1.6 (0.8-3.1)	1.0 (0.5-2.0)	0.7 (0.2-2.1)
30->	2	5	28.6	3.7 (0.3-22.1)	2.1 (0.3-13.0)	0.8 (0.04-14.0)
WHR						
Male						
≤0.9 Normal	23	498	4.4	1.0	1.0	1.0
>0.9 Fat	33	177	15.7	4.0 (2.2-7.3)	2.3 (1.1-4.6)	4.5 (1.0-19.0)
Female						
≤0.8 Normal	5	130	3.7	1.0	1.0	1.0
>0.8 Fat	65	624	9.4	2.7 (1.0-7.8)	1.8 (0.6-4.7)	1.2 (0.2-6.0)
Education (years of schooling)						
0-0 Illiterates	56	759	6.9	1.0	1.0	1.0
1-> literates	70	670	9.5	1.4 (1.0-2.1)	1.5 (1.0-2.3)	2.2 (1.0-4.8)

OR (1)= Crude odds ratio following fasting blood glucose

OR (2)= Adjusted odds ratio related to fasting blood glucose values for age, sex, systolic and diastolic blood pressure, BMI, WHR and literacy.

OR (3)= Adjusted odds ratio related to 2-h blood glucose values for age, sex, systolic and diastolic blood pressure, BMI, WHR and literacy.

BMI= Body Mass Index refers to the ratio of body weight in kg/height in meter square (BMI=kg/m²)

WHR=It refers to waist circumference divided by hip circumference (Waist/hip circumference)

Fig 1: Mean fasting and 2-h blood glucose values by age and sex, urban Bangladesh, 2001.



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Paper II

Determinants to differences in Prevalence of type 2 Diabetes between Rural an Urban slum Population in Dhaka, Bangladesh.

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Determinants to differences in Prevalence of type 2 Diabetes between Rural and Urban slum Population in Dhaka, Bangladesh.

Objective- To provide a valid comparison related to prevalence of type 2 diabetes mellitus along with its risk factors among the rural and urban population in Bangladesh. Further diagnostic criterias (FBG & OGTT) were compared and reviewed.

RESEARCH DESIGN AND METHODS- A total of 1555 subjects from urban and 4757 from rural communities (age \geq 20 years) with similar ethnic background were chosen randomly for a comparative analysis. Fasting blood glucose values following WHO criteria and 2-h post glucose capillary blood samples after a 75g- oral glucose load in a selected number of subjects (urban-476, rural-1046) were investigated.

RESULTS- *A higher prevalence of diabetes was found in urban 8.1% compared to rural 2.3% population. Age, sex and waist to hip ratio for male were found to be significant risk factors for both urban and rural subjects following fasting and 2-h post glucose values adjusted for a number of important confounding variables. Poor agreement was observed between the two procedures (FBG and OGTT) for both urban (kappa 0.41) and rural (kappa 0.40).*

CONCLUSIONS- We have observed a four fold higher prevalence of DM in urban population compared to rural subjects. The proportion of subjects with the characteristics related to risk factors were similar in both urban and rural areas. Poor agreement was observed between two procedures (FBG & OGTT), and FBG did not show an under estimation of diabetes prevalence compared to OGTT. It appears that applicability of diagnostic procedure is likely to vary in different population.

Key words Age, sex, body mass index, waist-to-hip ratio, type 2 diabetes, prevalence, urban, rural, Bangladesh.

Introduction

Studies related to the occurrence of differential prevalences of diabetes between urban and rural areas showed that the urban population had a higher prevalence of diabetes (1-3). Migrant Indians in different parts of the world have showed a high risk of type 2 diabetes that may have been increased due to changed living conditions in different environmental settings (4-7). Urbanization and urban migration have been established as a risk factor for an increased occurrence of diabetes (8). The trend has been authenticated by the World Health Organization (WHO)(9).

During the last two decades the urban population of Dhaka city has grown rapidly due to urban migration and fast expanding urbanization (32). The rural people usually come to the city with an expectation to improve their socio-economic conditions. Most of the rural migrants settled in urban slums and squatters and exposed to a number of unhealthy life conditions like, Unhygienic environment, contaminated water, air, vector and water born infection, overcrowding and stress, thereby an accumulated effect of all the adverse conditions the slum dwellers suffer from a variety of health problems from communicable to non-communicable diseases like diabetes mellitus (DM), coronary heart diseases (CHD) and hypertension (HTN).

More than 80% of the countries total population in Bangladesh lives in rural areas (33). Some small-scale surveys in Bangladesh have also shown the rising trend of diabetes among the urban population compared to rural (10,11).

But valid studies to compare the differences in prevalence of DM rural to urban population in order to provide an estimation of the increased risk are scarce.

The purpose of this study was to investigate the differences in prevalence of DM and related risk factors in urban compared to a rural population.

MATERIALS AND METHODS

Description of population and sample selection

Two populations belonging to the same ethnic background were chosen for the survey. The rural population was chosen from a selected rural community approximately 35 miles north of Dhaka city between Gazipur and Tangail. The characteristics of the rural people reflect the occupation mainly linked to agrarian activities like ploughing, fishing, pottering etc. These areas are still considered as rural but due to fast territorial extension of Dhaka city the localities will change into a semi –urban areas in a short while. The dwellers of the area have no access to urban facilities like housing provided with water, gas and sanitation. Ten villages were randomly selected from five areas with a population of approximately 20,000 both male and female of ≥ 20 years of age. All the individuals were given an identification number including a household number. Among those, 5000 subjects were selected following a simple random procedure, of these 4757 subjects were investigated.

The urban population were chosen from two slum communities of Dhaka city. Primarily we have identified the slums communities with major concentration of people migrating from our selected rural areas (Gazipur and Tangail). We have then selected two slum areas out of five following random procedure and these two slums are situated in the northern part of Dhaka city named Mohakahali and Karail Baste (Baste is the local terms for slum). Most of the slum dwellers belong to low-income group and working in garment industries or as a daily labors like rickshaw pullers and carpenters or construction labours.

About 5000 slum dwellers both male and female aged ≥ 20 years (all are migrants from the rural areas of Gazipur and Tangail) were identified and listed with an identity number. Among those 1600 subjects were selected following a simple random procedure. Of these 45 people refused to take part in the study leaving 1555 people for the analysis. Rationality for choosing these slum communities was to make the subjects as similar as possible between urban and rural population.

Survey procedures

All eligible subjects were examined for height, weight, waist and hip circumference and also interviewed for important socio-economic information. The height and weight were taken while the subject was standing in bare foot with light clothes. Waist and hip girths were taken with the subjects standing and wearing thin clothes. Waist was defined as the smallest girth between the costal margin and iliac crests and hip as the circumference at the level of the greater trochanters. The same trained health workers took all readings during the survey. Measurement of blood pressure was taken with special precaution, to ensuring 10 minutes rest for each individuals before BP was record.

Blood glucose (BG) estimation

Fasting Blood Glucose (FBG) from capillary whole blood was estimated from all individuals using the HEMOCUE glucose cubets and following the WHO new diagnostic criteria (34).

Further 2-h post glucose values were measured after a 75-g oral glucose load for selected subjects from both the urban and rural areas. From rural subjects we performed OGTT for 93 of 108 cases with FBG values ≥ 6.1 mmol/L, 130 of 156 individuals with FBG values between 5.6-6.0 mmol/L. In addition, 823 of 1000 randomly selected individuals from 4493 subjects with FBG values <5.6 mmol/L were tested for 2-h post glucose challenge. Accordingly a total 1046 person were tested. Like wise among the urban subjects we performed OGTT on 126 cases with FBG values ≥ 6.1 mmol/L, 131 individuals with FBG values between 5.6-6.0 mmol/L. Additional 219 subjects were tested for OGTT through random selection amongst those with FBG values <5.6 mmol/L. Accordingly we have performed OGTT on 476 individuals in the urban areas.

Data analysis and statistical methods

Data were registered using Microsoft Access data entry. Control of data entry was secured through both Programme appliance and manually. The prevalence rates of DM were determined by simple percentages. Statistical comparisons between different groups were made using χ^2 test. The odds ratio (OR) with 95% confidence interval (CI) for risk

factors was calculated taking the least prevalence of complications or clinically relevant criteria as a reference value. All P- values presented are two tailed. Multiple logistic regressions were executed to adjust for potential confounding factors using SPSS 10.0 software for all statistical analysis.

Results

A total of 1555 urban and 4757 rural subjects were examined. The response rate was 97% in the urban population and 95% in the rural population. Among the urban subjects 47% were male and 53% were female, and in the rural 43% were male, and 57% were female. In the urban area 126 out of 1555 had diabetes (56 men and 70 women). In the rural area 108 out of 4757 had diabetes (39 men, 69 women). The Prevalence of DM was higher in urban 8.1% than in rural 2.3%. Diabetes prevalence increased with increasing age both for urban and rural areas but the increment was almost three to five folds higher among the urban population in compared to rural (Table- 1).

Among the urban subjects the prevalence of diabetes was found to be significantly higher in both male and female subjects compared to rural population (urban male 7.7%, rural male 1.9% and urban female 8.5%, rural female 2.5%) (Table-2).

Females had higher prevalence of diabetes in all age category compared to male both in urban and rural areas. Among the urban subjects in the age category 41-50 female had two-fold higher prevalence compared to male but in the rural subjects the difference was widened among the older age group (>50 years). While no such difference was observed for the urban population.

Almost equal poor agreement was observed between FBG and OGTT for both in urban (kappa 0.41, $p < 0.001$) and in rural population (kappa 0.40, $p < 0.001$) (Table- 3 A, B).

Elevated levels of mean blood glucose (BG) were observed with growing age both for male and females following (FBG and 2-h BG values) among both urban and rural subjects (Fig 1). The difference in glucose values following FBG criterion was to some extent similar for both sexes in urban and rural until the age of 50. Among the rural

subjects the glucose values increased notably for women after the age of 50 years but in urban subjects this was not evident. This may have occurred due to fewer female participants in the mentioned age category in urban population compared to rural areas.

According to 2-h BG measure females had significantly higher levels of BG values in their early life compared to males both in urban and rural areas. This may at least in part explain the observed poor agreement between FBG and OGTT.

Age, sex, waist-to-hip ratio for male showed to be significant risk factors for the development of diabetes both in urban and rural subjects following both FBG and 2-h BG criterion.

Systolic blood pressure was found to be marginally statistically associated with DM following only FBG in rural subjects. However, this association did not retain after 2-h BG values.

Literacy showed an important association among the urban subjects; however, this relation was not ascertained for the rural population.

We did not observe any association with BMI for the occurrence of DM. Conversely a significant protective effect was shown with BMI 16.0-18.4 compared to those with BMI 18.5-24.9 (normal) in the urban population. However the risk of DM was notably higher for the obese individuals but apparent significant association was not noted because of fewer subjects belonging to this group.

Waist to hip ratio (WHR>0.9) were found to be significantly associated with the diabetic state in men both in rural and urban areas after adjusting for a number of potential confounding variables. But this association was not observed for female participants.

Discussion

We have observed a significant higher prevalence of type 2 diabetes in urban slum population aged 20 years and above 8.1% compared to rural 2.3%. Our study showed that the risk of diabetes was about 3-4 fold higher in each age category in urban slums compared to rural population and same observation was also observed for male and

female subjects. The findings of our study are an agreement with other Asian studies (14,15) and also study in Bangladesh (16).

The differences in prevalence cannot be explained either by generalized obesity, or central obesity or by hypertension. This may have been attributed to the stressful life conditions, hajerious environment rather than risks associated with obesity.

Further, the prevalence of diabetes did not differ significantly irrespective of the diagnostic criteria applied (FBG and OGTT) for both urban and rural population. In the rural areas it was evident that Impaired glucose tolerance IGT (≥ 7.8 - <11.1 mmol/L) was found to be significantly higher 27.6% compared to impaired fasting glucose IFG levels (≥ 5.6 - <6.1 mmol/L) of 12.4% and in urban population similar pattern was also observed (IGT was 17.2% and IFG was 8.4%). This observation may have been due to selection procedure as subjects for OGTT had an elevated level of BG according to $FBG \geq 5.6$. But the prevalence of DM either in rural or urban population was not found to be higher following 2-h BG procedures compared to FBG in a selected population. However, poor agreement was observed between the two procedures related to identify DM cases. This may raise concern over the ethical and or clinical responsibility for the security of the patient treatment. This may indicate a unique form of type 2 diabetes observed in our lean population other than the new concept that lower prevalence of diabetes will result in Asian population if FBG criterion is taken as a diagnostic procedure.

We have observed a higher prevalence of diabetes among females in all age categories both in urban and rural areas compared to males. Though non significant, the prevalence of diabetes was found to be even consistently higher among the females following 2-h glucose tolerance procedure. In our rural study female had significantly higher level of blood glucose in early age following 2-h BG and this findings was apparent for the urban females subjects up to the age of 50. In contrast with FBG method 2-h glucose tolerance showed the larger differences by sex, this might explain the observed poor agreement between the two diagnostic procedures. The findings of the study of female predominance were consistent with most of the other previous studies in Bangladesh (17-

19). Non-significant higher prevalence of type 2 diabetes was found among women in a recent investigation in India (20). In contrast to our findings, European population had shown higher prevalence of type 2 diabetes among men compared to female (21).

Prevalence of type 2 diabetes increased with increasing age. We have observed increasing level of FBG with increasing age both for urban and rural population (Fig 1). Female had a stronger increment of BG level following FBG after the age of 50 among the rural subjects. But this relationship was not observed in the urban population. This is possibly because of almost half of women participants in this age group compared male participants or rural participants. Women are more likely to return to village (place of origin) when they become less attractive for employment (hard labor) followed by men.

The prevalence of Systolic hypertension (sHTN>140 mmHg) and diastolic hypertension (dHTN >90mmHG) were higher among the rural participants compared to urban subjects (rural sHTN 7.9%,dHTN 7.8%, urban sHTN 1.3%,dHTN 2.3%)

Among the rural subjects systolic hypertension was found to be associated with the prevalence of diabetes in the multivariate analysis following FBG procedure, but this association did not retained following 2-h glucose load. This may have been consequence of fewer numbers of participants in the 2-h glucose model. Earlier study among rural subjects showed a significant association with hypertension (systolic and diastolic) and higher glycaemic status (21).

We did not find any association between systolic and diastolic hypertension with the occurrence of diabetes type 2 in urban population. Studies conducted in native urban Asians Indians it was noted that hypertension was not associated with insulin resistance (22). The lack of an association between insulin concentration and hypertension has been previously reported in many ethnic groups, including Mauritians (23), Micronesians, Polynesians and Melanesians (24), Pima Indians, Americans black and some Europeans populations (25). Ethnic differences in the role of insulin in determining blood pressures are evident from the above studies.

The prevalence of diabetes was found to be associated among the literates compared to illiterates in our urban subjects, but this association was not examined in among the rural population. Literacy may be a proxy indicator for socio-economic conditions. Earlier studies have shown a higher risk of DM in people with improved socio-economic status (19).

Despite the fact that, generalized obesity appeared to develop type 2 diabetes we have not observed any important association of BMI and diabetes in our population following FBG and OGTT either among the rural or urban subjects. Even for a significant protective effect was observed for those with BMI 16.0-18.4 compared to BMI 18.5- 24.9 (normal). Mean BMI in our urban population was 19.4 despite of a four fold increased DM prevalence compared to rural population with mean BMI 20.2. Data from previous studies have shown a higher risk for type 2 diabetes with higher BMI for both sexes (26,27). However, study in India (4) found the prevalence of diabetes was high even though the rates of obesity were low among the Indian rural and urban population (mean BMI 21.3 urban and 17.4 for rural).

This may suggest that the present cut-off values for BMI may not be applicable for our population as to indicate the people at risk.

Waist-to-hip ratio (WHR) appeared to be significantly associated with the occurrence of diabetes in men for both urban and rural subjects but this association was not apparent for women. The association between WHR and occurrence of DM was also observed in the previous studies in Bangladesh (28). Many epidemiological studies have shown an association between WHR and type 2 diabetes (29). Studies on South Asians migrants also showed that the waist/hip ratio was higher than in Europeans population of equal BMI (30). Our population represents an atypical appearance of body shape, very often an accumulation of fat in the abdominal region other than lower extremities. We are witnessing a lean population may be ascribed as a unique form of type 2 diabetes and appeared to be some what similar to the DM described in Indian population (31).

We could not identify the risk (4 fold higher) factors responsible for the increased risk of DM in urban population. It may be postulated that accumulated poor hygienic condition in the urban slums, changed lifestyle (not for the better) and stress may interfere with the metabolic process for glycaemic control. Further, owing to the fact the rural poor migrated to urban slum and poverty is related to Low birth weight (LBW). Therefore it is not unreasonable to think that LBW babies carry a high risk for the development of DM, metabolic syndrome and CHD irrespective of their obesity status.

Suitability of the diagnostic procedure needs to be examined prior to its application as this may differ in different population.

Acknowledgements

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Table- 1: Prevalence of diabetes by age in rural and urban people, Dhaka, Bangladesh.

Age group in years	Rural			Urban			<i>P value</i>
	Diabetic cases	n	Prevalence Per 100	Diabetic cases	n	Prevalence Per 100	
20-30	32	2080	1.5	35	819	4.3	<0.01
31-40	27	1252	2.1	38	395	9.6	<0.01
41-50	19	655	2.9	32	217	14.8	<0.01
51->	30	770	3.9	21	124	16.9	<0.01
Total	108	4757	2.3	126	1555	8.1	<0.01

Table- 2: Prevalence of diabetes by sex, in rural and urban people, Dhaka, Bangladesh.

Male	Rural			Urban			P value
Age group	Diabetes cases	n	Prevalence per 100	Diabetes cases	n	Prevalence per 100	
20-30	8	700	1.1	10	330	3.0	<0.03
31-40	10	589	1.7	19	194	9.8	<0.01
41-50	9	337	2.6	13	124	10.5	<0.01
51->	12	411	2.9	14	83	16.9	<0.01
Total	39	2037	1.9	56	731	7.7	<0.01
Female	Rural			Urban			
20-30	24	1380	1.7	25	489	5.1	<0.01
31-40	17	663	2.5	19	201	9.4	<0.01
41-50	10	318	3.1	19	93	20.4	<0.01
51->	18	359	5.0	7	41	17.0	<0.01
Total	69	2720	2.5	70	824	8.5	<0.01

Table 3- A: Agreement between fasting blood glucose values and the 2-h glucose test for 1046 participants in rural, Bangladesh.

Fasting Blood Glucose mmol/L(mg/100ml)	Oral Glucose Tolerance Test Mmol/L (mg/100ml)		
	<11.1 (<180)	≥ 11.1 (≥180)	Total
<6.1 (<110)	899	54	953
≥ 6.1 (≥110)	53	40	93
Total	952	94	1046

P for the difference in observation <0.001
Kappa 0,4

Table- 3 B: Agreement between fasting blood glucose values and the 2-h glucose test for 476 participants, urban slum Dhaka ,Bangladesh.

Fasting Blood Glucose mmol/L (mg/100ml)	Oral Glucose test mmol/L (mg/100ml)		
	<11.1(<180)	≥11.1(≥180)	<i>Total</i>
<6.1(<110)	344	6	350
≥6.1(≥110)	82	44	126
Total	426	50	476

P for the difference in observation <0,001
Kappa 0,41

Table 4 Odd ratio (OR) with 95% CI of diabetes following fasting blood glucose and 2-h post glucose values by the following risk factors in urban and rural Bangladesh.

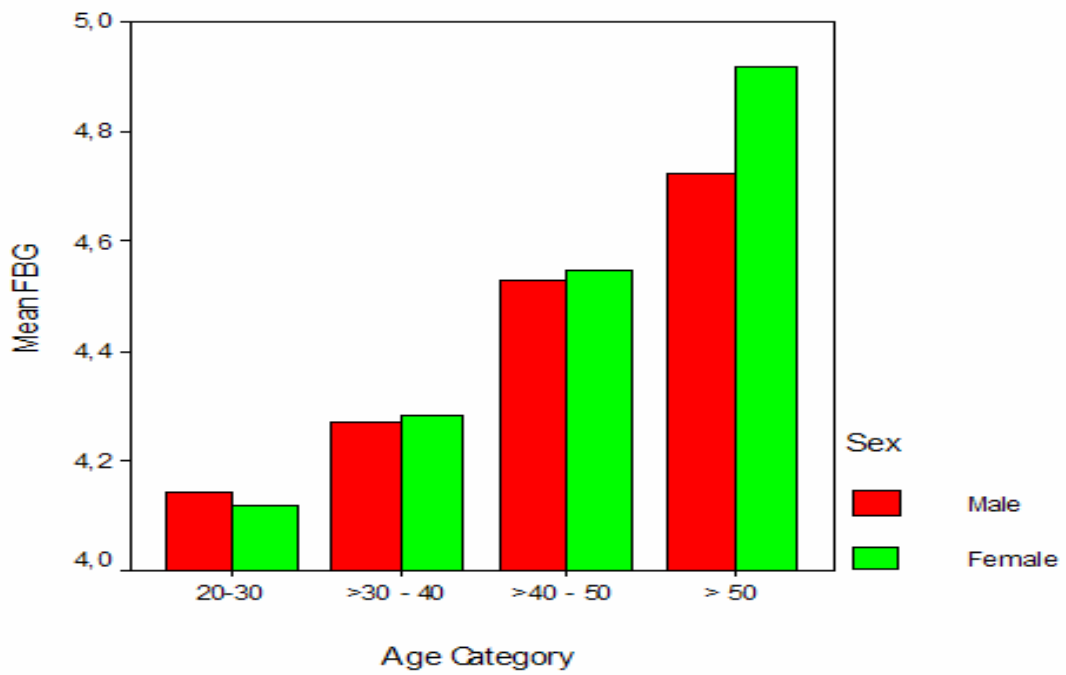
Variables	OR(1) urban	OR(2) rural	OR(3) urban	OR(4) rural
	FBG		OGTT	
Age				
20-30	1.0	1.0	1.0	1.0
31-40	2.4 (1.4-3.9)	1.4 (0.9-2.2)	5.0 (2.1-15.9)	1.1(0.6-2.1)
41-50	3.8 (2.2-6.5)	2.0 (1.1-3.6)	10.6 (3.7-30.0)	1.6 (0.8-3.1)
50->	5.2 (2.8-9.8)	2.6 (1.5-4.5)	8.5 (2.6-27.6)	2.7 (1.4-5.1)
Sex				
Male	1.0	1.0	1.0	1.0
Female	1.5 (1.0-2.3)	1.4 (1.0-2.2)	1.8 (0.9-3.6)	2.1 (1.3-3.5)
Systolic BP				
=140 normal	1.0	1.0	1.0	1.0
>140 High	2.2 (0.3-7.4)	2.0 (1.0-3.9)	0.9 (0.2-3.8)	1.8 (0.9-3.9)
Diastolic BP				
= 90 normal	1.0	1.0	1.0	1.0
>90 High	1.1 (0.2-3.2)	0.7 (0.3-1.5)	1.2 (0.2-5.9)	1.8(0.9-3.9)
BMI				
18.5-24.9 Normal	1.0	1.0	1.0	1.0
< 16.0 Severe PEM	0.5 (0.2-1.2)	0.8 (0.4-1.7)	0.6 (0.1-3.0)	1.1 (0.6-2.5)
16.0-18.4 mod PEM	0.6 (0.3-0.9)	0.7(0.5-1.2)	0.6(0.3-1.5)	0.6 (0.3-1.0)
25.0-29.9 Over weight	1.0 (0.5-2.0)	1.6 (0.7-3.7)	0.7 (0.2-2.1)	2.1 (0.9-5.1)
30.0 -> obese	2.1(0.3-13.0)	4.1 (0.5-33.3)	0.8 (0.04-14.0)	3.9 (0.6-25.7)
WHR				
Male				
= 0.9 Normal	1.0	1.0	1.0	1.0
> 0.9 Fat	2.3 (1.1-4.6)	1.7 (1.1-2.7)	4.5(1.0-19.0)	2.0 (1.1-3.6)
Female				
= 0.8 Normal	1.0	1.0	1.0	1.0
>0.8 Fat	1.8 (0.6-4.7)	1.0 (0.6-1.6)	1.2 (0.2-6.0)	1.2 (0.7-2.0)

OR= Adjusted odds ratio for age, sex, Systolic and diastolic blood pressure, BMI and WHR for urban and rural population.

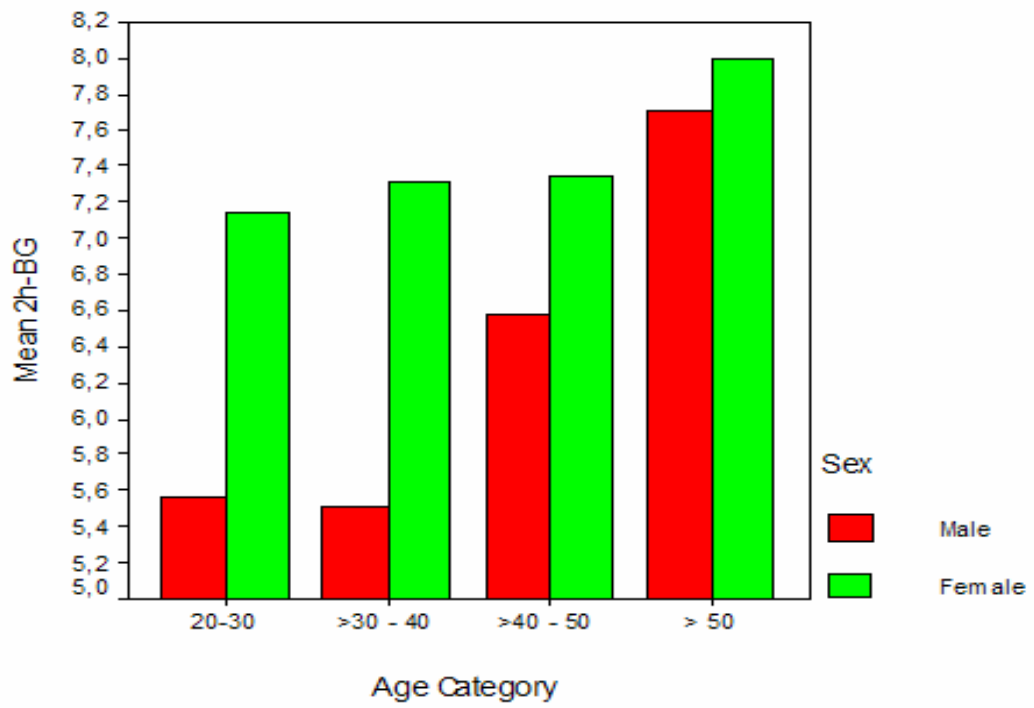
PEM= It refers to protein energy malnutrition.

Fig 1: Mean fasting and 2-h blood glucose values by age and sex in rural Bangladesh.

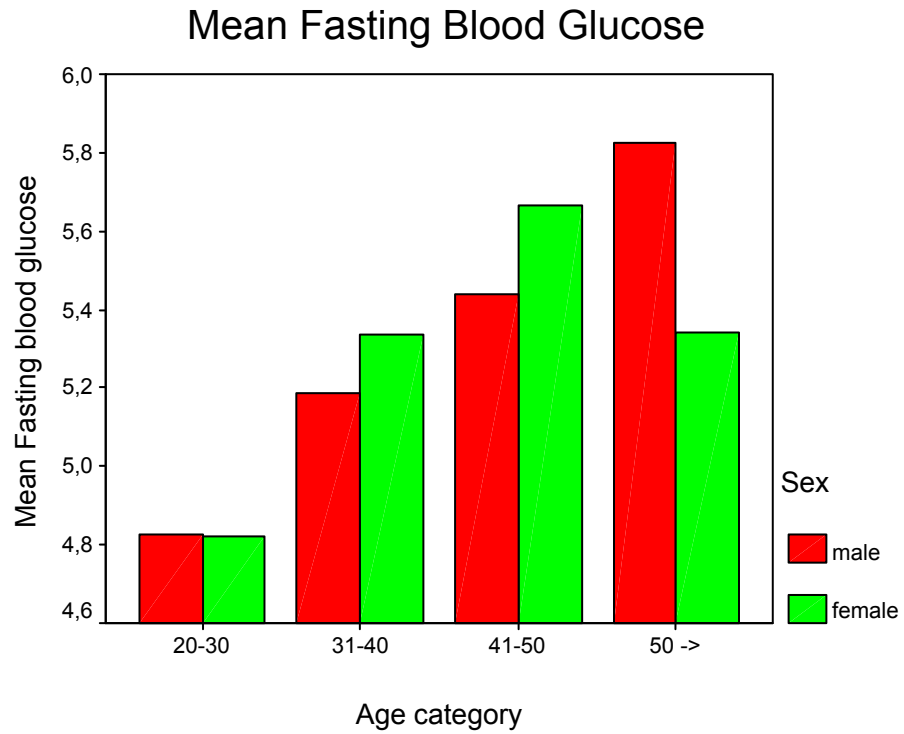
Mean fasting blood glucose



Mean 2-h Blood Glucose



Mean fasting and 2-h blood glucose values by age and sex in urban Bangladesh.



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Annex 4

Pictures from the field work



Picture 1: Drawing blood sample from a female subject.



Picture 2: Measurement of blood pressure.



Picture 3: Measuring height during survey.



Picture 4: Subjects are being given oral glucose.

Annex 2

INSTITUTE OF GENERAL PRACTICE AND COMMUNITY MEDICINE
DEPARTMENT OF INTERNATIONAL HEALTH
UNIVERSITY OF OSLO NORWAY.

QUESTIONNAIRE

On

PREVALENCE OF TYPE 2 DIABETES AMONG THE URBAN SLUM DWELLERS IN DHAKA CITY, BANGLADESH

Part –A: Socio-demographic information

1. ID number:

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2. Date of interview:

--	--	--

3. Name of the respondent:

4. Age in years: (≥ 20 years)

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5. Sex: 1=Male, 2=Female

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6. Present address:

7. Years of stay in the slum:

--

8. Rural or home address:

9. Marital status: 1=Unmarried, 2=Married

3=Widow, 4=Divorced, 5=Separated,

--

10. Religion: 1= Islam, 2=Hinduism, 3=Christianity, 4=Buddhism,

11. Years of schooling:

12. Occupation: 1= unemployed, 2=service, 3=business, 4= Daily labor,
5= others (specify)

13. Monthly family income (in taka for all house hold members):

14. No of house hold members:

15. Living area of family in sqm:

Part-B: Anthropometrical Measurements

16. Height (in cm):

17. Weight (in kg):

18. Waist circumference:

19. Hip circumference:

20. BMI:

21. WHR:

Part- C: Biophysical

Blood pressure

22. Systolic Blood Pressure (mmHg):

23. Diastolic Blood Pressure (mmHg):

Part-D: Biochemical

24. Fasting Blood Glucose (in mmol/l):

25. Blood Glucose 2 hours after 75g glucose intake (mmol/l):