

Prevalence of Diabetes and Impaired Glucose Tolerance in Funagata Area, Japan

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OBJECTIVE— To determine the prevalence of diabetes mellitus and IGT in the Funagata area of Japan.

RESEARCH DESIGN AND METHODS— The total eligible subjects was 1163, all were ≥ 45 yr of age, and 52 were known diabetic patients. Data collected included body height, weight, and answers to medical questionnaires. A 75-g OGTT was done in the morning. WHO criteria were used to classify the current diabetes status of study participants.

RESULTS— Of the 1111 scheduled for the OGTT, 868 took the test; the participation rate was 77.8%. The prevalence of diabetes was 10.5 and 12.9%, and the prevalence of IGT was 14.7 and 18.0% for men and women, respectively. The prevalence of undiagnosed diabetes (4.9%) was almost equal to that of previously diagnosed diabetes (4.5%).

CONCLUSIONS— The prevalence of diabetes in the Funagata area was two to four times higher than that of previous reports in Japan, in which many investigators used a urinary glucose test as a preliminary test. This difference is attributed to the method of determining the prevalence of diabetes.

It is important to accurately estimate the prevalence of diabetes in a given area. First, it allows for the establishment of an appropriate therapeutic plan.

Second, by comparing the prevalence with that in other geographical areas and analyzing the various factors affecting the prevalence, one might determine possi-

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IGT, IMPAIRED GLUCOSE TOLERANCE; OGTT, ORAL GLUCOSE TOLERANCE TEST; GTT, GLUCOSE TOLERANCE TEST; WHO, WORLD HEALTH ORGANIZATION; NDDG, NATIONAL DIABETES DATA GROUP; BMI, BODY MASS INDEX.

ble risk factors for the disease, permitting the planning of further epidemiological study and preventive policies (1,2). According to the 1988 patients' survey by the Ministry of Health and Welfare, the prevalence of diabetes mellitus in Japan is $\sim 2\%$ (3). This figure was based on the assumption that the number of undiagnosed diabetes patients equals the number of diagnosed patients found by a hospital from the survey. On the other hand, a recent nutritional survey and a mortality survey (4) indicate an increase in the number of diabetic patients in Japan. Moreover, among Japanese Americans, the prevalence of diabetes and IGT is reported to be 20 and 39.2%, respectively (5). Compared with Caucasians, Japanese are believed to be more susceptible to diabetes. Because of the current trend toward Westernization of the Japanese life-style, it was thought that the diabetic population in Japan would far exceed 2%.

To ascertain the prevalence of diabetes mellitus, a sample study (2,5,6) or GTT involving the entire population group (7-9) must be conducted. The prevalence of diabetes mellitus in three studies done in Japan with WHO criteria (10) or NDDG criteria (11) was 4.0, 3.6, and 3.7% (12-14). In these reports, however, the data were obtained from patients visiting a hospital (12) or from volunteers (13). In another population-based study in Oguni, Yamagata (14), the subjects were examined for postprandial urinary glucose for the primary screening, and a GTT was given to those who exhibited positive reactions at the primary screening. None of these studies gave the OGTT to the total population, as in the study of Pima Indians (7).

In 1990, we conducted OGTTs on residents > 45 yr of age in the Funagata area, Funagata Town, Yamagata prefecture, to assess the prevalence of diabetes mellitus and IGT.

RESEARCH DESIGN AND METHODS

Funagata Town of Yamagata prefecture is an agricultural re-

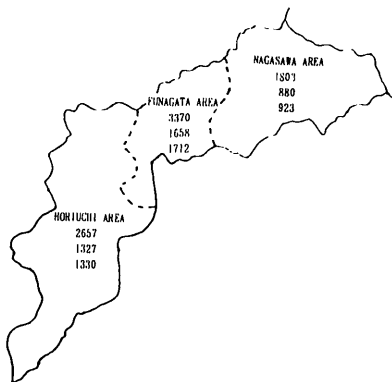


Figure 1—The map shows subareas of Funagata Cho, Yamagata Prefecture, Japan. The top number in each subarea is total number of residents. The lower numbers are numbers of men and women, respectively, according to 1990 official census reports.

gion located ~400 km north of Tokyo. Most of the population engages in agriculture but, because the region is covered with deep snow in winter, many inhabitants go out of town to seek seasonal employment. Of the families engaged in agriculture, >90% also rely on other occupations for a livelihood.

Funagata Town is divided into three areas—Central Funagata in the middle area of Funagata, Horiuchi in the east, and Nagasawa in the west (Fig. 1).

Since 1979, we have conducted a mass screening of inhabitants >40 yr of age in each area for diabetes by testing postprandial urinary glucose as a preliminary test, followed by OGTTs on those individuals with positive reactions. For these procedures, a good working relationship has been established with the people in the local municipality.

The subjects were >45 yr of age and registered in Central Funagata in August 1990 (Fig. 2). Among these, 123, with cerebral vascular disease or other disabilities that made examination difficult, were excluded. In August of the same year, public-health nurses inquired by telephone or home visits whether the remaining 1163 subjects suffered from diabetes, and if so, what their treatment

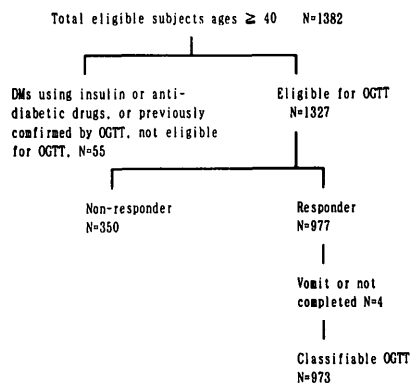


Figure 2—Flow diagram of survey.

was. If the response to the latter question was medication with insulin or oral hypoglycemic agents, the details of treatment were confirmed through the physicians at the hospital or clinic in charge; in addition, one of the authors reviewed the medical records, and the subjects were classified as known cases of diabetes mellitus. Those individuals who had been diagnosed with diabetes in previous surveys mentioned above were also included in the category of known cases. These 52 people were excluded from the current OGTT. Thus, 1111 residents were subjected to the OGTT.

Maximizing participation

To maximize the participation of the Central Funagata population in the GTT, we obtained the cooperation of the municipal office throughout the program. In August 1990, we arranged a meeting with the leaders in the town and explained in detail the significance of the OGTT. In addition, area physicians held several public health-education sessions on diabetes mellitus. The time and dates of the OGTT were announced through a newsletter from the town office, and buses were provided to transport individuals who did not have cars or lived far from the sites where the OGTT was conducted.

Data collection

The OGTT was conducted at the Funagata Town Training Center starting at

0630 on 9 and 16 September 1990. The test subjects were instructed to abstain from food or drink beginning at 2000 on the previous day. Their body heights and weights were measured while they were wearing light clothing without shoes. BMI was calculated as weight (kg)/height (m²). At 0700 before the GTT, blood samples were taken. For this procedure, 20 individuals were assigned, and each collected venous blood at a rate of two samples every 5–10 min. The blood specimens were collected for testing plasma glucose, and the remaining sample was preserved. Within 10 min of the initial blood specimen collection, an OGTT was conducted with 75 g of glucose. Then a medical history was taken by public-health nurses covering the areas of hypertension, angina pectoris, myocardial infarction, cerebral vascular disease, renal diseases, hepatic diseases, and gastrectomy, as well as any treatment they had received or were receiving then. Blood samples were also taken to measure plasma glucose levels 2 h after glucose loading.

To determine the plasma glucose level, a 1-ml blood sample was placed in a test tube containing NaF, was centrifuged for 15 min, and then the serum was stored at 4°C. Serum glucose levels were measured by the glucose oxidase method (Ruto Stat GA-1122, Kyoto Daiichi Kagaku, Kyoto).

OGTT procedure

OGTTs were administered according to NDDG recommendations (11), which require that 1) the subjects fast overnight for 10–16 h; 2) the OGTT is performed in the morning; 3) a fasting venous blood sample is taken; and 4) the subjects ingest 75 g of oral glucose or carbohydrate equivalent. In this study, Trelan-G (Shimizu Pharmaceutical, Shimizu, Japan) was used instead of glucose solution. The NDDG recommends that blood samples be taken at 0.5-h intervals up to the final sample at 2 h, whereas WHO requires only fasting and 2-h samples. In this volunteer survey, we did obtain a

Table 1—Total population, number of known diabetic subjects, and participation by age and sex

AGE-GROUP (YR)	TOTAL POPULATION	KNOWN DIABETIC	ELIGIBLE FOR OGTT	COMPLETE OGTT	%
45–54					
M	155	0	155	89	57.4
F	163	1	162	119	73.5
55–64					
M	201	5	196	149	76.0
F	260	14	246	202	82.1
65–74					
M	129	9	120	100	83.3
F	150	10	140	124	88.6
≥75					
M	48	3	45	34	75.6
F	57	10	47	47	100.0
TOTAL					
M	533	17	516	372	72.1
F	630	35	595	492	82.7
TOTAL	1163	52	1111	864	77.8

fasting and a 2-h blood sample. For international comparisons, the 1980 WHO criteria were used to determine the results of OGTTs (10).

RESULTS

Rate of participation

Of the 1111 subjects scheduled for the GTT 868 underwent the actual test. Of those, 4 suffered from diarrhea, vomiting, or were unable to ingest the entire test solution; therefore, the data of 864 subjects were used for the study.

Although the participation of men between 45 and 54 yr of age was lower, the participation was >70% in other strata. The overall rate of participation was 77.8% (Table 1). Compared with the participation rates of 78% in the Pima Indian study (7), 83% in the Nauru study (8), and 70% in the San Antonio study (9) reported for community-based OGTTs scheduled for an entire area population, our figure of 77.8% is considered generally acceptable to assess entire prevalence. The mean ± SD BMI of participants was 23.4 ± 3.4 kg/m² for men and 24.2 ± 3.5 kg/m² for women.

Prevalence

The numbers of diagnosed diabetic cases, undiagnosed diabetic cases, and cases of IGT are shown in Table 2. The prevalence of diabetes mellitus increases with age, especially between 45 and 74

Table 3—Age-standardized prevalence of diabetes and IGT in Funagata

	DIABETES (%)	IGT (%)
SEX		
M	8.8	11.9
F	14.0	16.6
TOTAL	10.4	15.3

For age-standardization by direct method, Japan Census 1985 for ages >45 was used.

yr of age, with no sex-related dominance. IGT was noted in 152 subjects, a figure ~1.5 times that of diabetes mellitus. The prevalence of IGT also increased as age increased from 45 to 74 yr, with no sex-related dominance. When diabetes mellitus and IGT were combined, the rate of glucose intolerance was 28.5% (25.2 and 30.9% among men and women, respectively). As shown in Table 3, the age- and sex-adjusted prevalence of diabetes mellitus and IGT in people >45 yr of age were assessed by direct method with the Japan Census 1985, and were 10.4 and 15.3%, respectively.

Table 2—Age- and sex-specific prevalence of diabetes and IGT in Funagata

AGE-GROUP (YR)	N	DIABETES			IGT	
		DIAGNOSED CASES	UNDIAGNOSED CASES	PREVALENCE (%)	CASES	PREVALENCE (%)
45–54						
M	92	0	3	3.3	8	8.7
F	120	1	4	4.2	15	12.5
55–64						
M	154	5	14	12.3	24	15.6
F	216	14	18	14.8	36	16.7
65–74						
M	109	9	4	11.9	18	16.5
F	134	10	9	14.2	34	25.4
≥75						
M	37	3	3	16.2	7	18.9
F	57	10	2	21.1	10	10.5
TOTAL						
M	389	17	24	10.5	57	14.7
F	527	35	33	12.9	95	18.0
TOTAL	916	52	57	11.9	152	16.6

CONCLUSIONS— Of the patients, 52 had known diabetes mellitus. The prevalence was already 4.5% before the OGTT was conducted. This figure is >2% in the total Japanese population reported by the Ministry of Health and Welfare (3), but comparable with those of reports in Japan (12–14). This relatively high prevalence is explained by the inclusion of patients diagnosed at hospitals or clinics and those diagnosed by the mass diabetes screening conducted since 1979 in this area.

As for biases, we did not conduct sampling studies or surveys by questionnaire on the population of nonparticipants; therefore, their attributes are unknown. Because the prevalence of diabetes mellitus increases with age and the rate of participation is lower in the 45- to 54-yr age-group, the actual prevalence is assumed to be slightly lower when the untested segment of the population is stratified into age levels. If the untested segment is included, the prevalence of diabetes mellitus is at least 9.4% (109 of 1163), which is still two to four times higher than the reported figures (3,12–14) of diabetes mellitus in Japan.

The prevalence of undiagnosed diabetes has been shown to be about equal to that of diagnosed diabetes in several studies (2,5,6), as also demonstrated by our survey. Mass screening by examining urinary glucose has been conducted in this area for many years, and the cases of diagnosed diabetes include not only those diagnosed at hospitals and clinics but also those detected by mass screening. In other areas of Japan where no such ongoing mass screening programs exist, the ratio of undiagnosed to diagnosed diabetes is expected to be >1.

Funagata is an agricultural community, and the inhabitants are more physically active than those in urban areas. Furthermore, the BMI, even when stratified by sex and age, is not greater than the standard for Japanese (16). In urban areas, the prevalence of diabetes mellitus is expected to be higher.

The age-related increase in prev-

alence of diabetes mellitus reported previously (2,5–9,12–14) was also the case in this study.

IGT is a relatively new clinical category, and its clinical significance is still under study (15). The prevalence of IGT in Funagata is 16.6%, compared with 11.9% for diabetes. Thus, IGT comprises 60% of all glucose intolerance, and this ratio is compatible with that of other studies (2,5,6,17). The prevalence of IGT was found to increase in people between 45 and 75 yr of age, with no sex predominance. According to the Second National Health and Nutritional Survey (2), black women >55 yr of age are most likely to develop diabetes mellitus, and they constitute the target population for the analysis of the etiological mechanism and prevention of this disease. We plan to continue the epidemiological study of diabetes mellitus and IGT in this area over an extended period. Based on our data, we believe the population group with IGT, between 45 and 64 yr of age, constitutes a suitable target population.

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