

Prevalence and Control of Diabetes and Impaired Fasting Glucose in New York City

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OBJECTIVE — To determine the prevalence of diabetes and impaired fasting glucose (IFG) and to assess clinical management indicators among adults with diabetes in a representative sample of New York City adults.

RESEARCH DESIGN AND METHODS — In 2004, New York City implemented the first community-level Health and Nutrition Examination Survey (NYC HANES), modeled after the National Health and Nutrition Examination Survey (NHANES). We used an interview to determine previously diagnosed diabetes and measured fasting plasma glucose to determine undiagnosed diabetes and IFG in a probability sample of 1,336 New York City adults. We assessed glycemic control and other clinical indicators using standardized NHANES protocols.

RESULTS — The prevalence of diabetes among New York City adults was 12.5% (95% CI 10.3–15.1): 8.7% diagnosed and 3.8% undiagnosed. Nearly one-fourth (23.5%) of adults had IFG. Asians had the highest prevalence of impaired glucose metabolism (diabetes 16.1%, IFG 32.4%) but were significantly less likely to be obese. Among adults with diagnosed diabetes, less than one-half (45%) had A1C levels <7%; one-half (50%) had elevated blood pressure measures at interview, 43% of whom were not on antihypertensive medications; nearly two-thirds (66%) had elevated LDL levels, and only 10% had their glucose, blood pressure, and cholesterol all at or below recommended levels. Most adults (84%) with diagnosed diabetes were on medication, but only 12% were receiving insulin.

CONCLUSIONS — In New York City, diabetes and IFG are widespread. Policies and structural interventions to promote physical activity and healthy eating should be prioritized. Improved disease management systems are needed for people with diabetes.

Diabetes Care 32:57–62, 2009

National surveillance has documented a sharp rise in diabetes prevalence during the past 20 years (1,2), including diabetes-related health complications and mortality (3,4). Efforts to prevent and control diabetes have been hampered by a lack of success at reducing obesity, physical inactivity, smoking, poor glycemic control, and other clinical indicators such as high blood pressure and cholesterol. Compared with the national average, urban communities typically have a larger proportion of groups at

high risk for developing diabetes, including black, Hispanic, and Asian residents and those living in poverty (5,6). Yet, efforts to monitor the diabetes epidemic in urban settings have largely been limited to analyses of mortality and hospitalization data, making it difficult to discern patterns of diabetes diagnosis, prevalence, and control, which are useful for guiding programmatic efforts to curb the epidemic.

In New York City and other cities, efforts are underway to improve diabetes monitoring by measuring prevalence

through annual population-based telephone surveys, following the model of the Behavioral Risk Factor Surveillance System (7). While self-reported diabetes status can provide an informative and ongoing measure of the local burden of diagnosed diabetes, it cannot capture the full spectrum of diabetes illness (missing undiagnosed and unreported diabetes), and it does not measure those at highest risk of developing the condition or provide accurate information on glycemic control or cardiovascular health among those with diabetes.

In this study, we report findings from the New York City Health and Nutrition Examination Survey (NYC HANES), a population-based interview and physical exam survey conducted in 2004. By adding an examination survey to existing surveillance efforts, we estimated the prevalence of diagnosed and undiagnosed diabetes, as well as impaired fasting glucose (IFG), among New York City adults. We also examined glycemic control and control of other cardiovascular risk factors to evaluate local diabetes management efforts.

RESEARCH DESIGN AND METHODS

NYC HANES was a population-based, cross-sectional examination survey of noninstitutionalized New York City residents aged 20 years or older. Modeled after the National Health and Nutrition Examination Survey (NHANES) (8), NYC HANES used a comparable three-stage probability sampling to select a representative sample of adult New Yorkers during the period from June to December 2004. All noninstitutionalized New York City residents currently living in a New York City household were eligible to participate, including non-English speakers, illiterate individuals, pregnant women, and the mentally or developmentally disabled. Survey components consisted of a physical examination, clinical and laboratory tests, a face-to-face computer-assisted personal interview, and an audio computer-assisted self-interview. Interviews were pretranslated into English and Spanish, and a translator was used for interviews conducted in other languages. Detailed information on data collection protocols and study design is published elsewhere (9).

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Received 15 April and accepted 1 August 2008.

DOI: 10.2337/dc08-0727

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See accompanying editorial, p. 204.

Participation rates

A household-based eligibility screening survey was completed for 3,388 (84%) of the 4,026 randomly selected households. Within these households, 3,047 eligible survey participants aged 20 years or older were randomly selected based on an a priori computer-generated sampling flag, 1,999 of whom completed the face-to-face interview and at least one component of the physical examination. Among these, a random sample of participants (80%) was assigned to fast for 8 h and prioritized for a morning appointment. Participants self-identifying with a history of diabetes were not required to fast. Adults not assigned to fast but who did so voluntarily ($n = 136$) were comparable with those assigned to fast in all demographic characteristics except that age and were included in the final analytic sample ($n = 1,336$). The final response rate for this analysis was 53%.

Diabetes, IFG, and glycemic control

Participants were considered to have previously diagnosed diabetes if they reported that a health care professional ever told them that they had diabetes, excluding gestational or borderline diabetes. Participants without a prior diabetes diagnosis but whose fasting plasma glucose level was ≥ 126 mg/dl were considered to have undiagnosed diabetes (10). IFG, or

pre-diabetes, was defined as a fasting plasma glucose level of 100–125 mg/dl. Glycemic control was measured by A1C, with control defined as A1C $< 7\%$ (10). Plasma glucose and A1C were tested at the University of Missouri Diabetes Diagnostic Laboratory using standardized NHANES methods (11).

Other measurements

All other measurements were taken using standardized NHANES protocols and definitions (8). For each participant, up to four systolic/diastolic blood pressure measurements were taken and the average was reported, excluding the first reading and diastolic readings of zero. Lipid profiles were analyzed at the Lipoprotein Analytical Laboratory at Johns Hopkins University Hospital. Current smoking and physical inactivity were defined using Healthy People 2010 guidelines (12).

Data analyses

Data were weighted to account for differential selection probabilities and survey nonresponse; weights were poststratified to the adult population of New York City based on age-group, sex, race/ethnicity, and borough as estimated by the 2004 American Community Survey and the 2004 March Supplement Current Population Survey. Weights for participants who voluntarily fasted ($n = 136$) were

then further adjusted for observed age differences compared with participants randomly assigned to fast. SUDAAN, version 9.0 (Research Triangle Institute, Research Triangle Park, NC) was used to obtain SE estimates by Taylor series linearization. Diabetes and IFG prevalence estimates were age adjusted to the 2000 U.S. standard population.

Diabetes (total, diagnosed, and undiagnosed), IFG, and diabetes control outcomes were estimated by sex, age, race/ethnicity, income, and nativity. Statistical significance for univariate differences in prevalence was determined using the t statistic derived from the general linear contrast procedure. Relative SEs and 95% CIs were calculated for percentages. Estimates with relative SEs of $> 30\%$ were considered unreliable (8). Two multiple logistic regression models were also constructed to characterize diabetes prevalence as well as diabetes and IFG by race/ethnicity and BMI, adjusting for sex, age, nativity, income, and physical activity. Adjusted prevalence estimates were obtained using predicted marginals.

RESULTS**Prevalence of diabetes**

The estimated total prevalence of diabetes among New Yorkers aged 20 years or older was 12.5%, representing ~696,000

Table 1—Age-adjusted prevalence of diabetes, IFG, and normal glucose levels among New Yorkers ≥ 20 years of age (2004)

	n	Diabetes		IFG		Normal Glucose	
		%	95% CI	%	95% CI	%	95% CI
Total	1,336	12.5	10.3–15.1	23.5	20.9–26.2	64.0	61.1–66.9
Sex							
Male (ref.)	561	13.4	10.0–17.7	29.6	25.2–34.3	57.1	52.2–61.8
Female	775	11.8	9.1–15.1	18.4***	15.3–22.0	69.8***	66.1–73.4
Age (years)							
20–39 (ref.)	665	2.5	1.6–4.0	14.5	11.6–17.9	83.0	79.5–86.0
40–59	504	13.3***	10.2–17.2	25.1***	21.0–29.7	61.6***	56.7–66.3
≥ 60	167	28.3***	21.4–36.4	36.2***	29.8–43.1	35.5***	28.1–43.7
Race ^a							
White, non-Hispanic (ref.)	387	10.7	7.6–15.0	21.2	17.5–25.5	68.1	63.4–72.4
Black, non-Hispanic	290	14.5	9.9–20.7	21.5	16.3–27.8	64.0	57.8–69.7
Hispanic, total	479	12.3	8.7–17.2	25.2	20.5–30.6	62.4	57.1–67.5
Asian, non-Hispanic	160	16.1	9.5–25.9	32.4*	24.8–41.2	51.5***	43.5–59.4
Income (USD) ^b							
$< \$20,000$	452	17.0**	13.3–21.5	21.6	17.8–26.0	61.4	56.8–65.8
$\geq \$20,000$ (ref.)	859	9.1	6.6–12.4	24.8	21.6–28.4	66.1	62.1–69.8
Nativity							
U.S. born (ref.)	659	12.2	9.2–15.9	20.7	17.4–24.5	67.1	63.0–70.9
Foreign born	676	12.7	10.0–16.0	26.9*	23.3–30.7	60.4*	56.3–64.4

Sample includes 131 participants with diabetes, 278 with IFG, and 927 with normal fasting glucose. ^aOther non-Hispanic ethnicities, not included due to small numbers and unreliability of estimate; total with diabetes, $n = 20$. ^bTotals do not equal 1,336 because of missing data. * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

New York City adults (Table 1). Prevalence increased with age, from 2.5% among adults aged 20–39 years to 28.3% among adults aged 60 years or older ($P < 0.001$), but did not differ significantly by sex, race/ethnicity, or nativity. Diabetes prevalence was higher among those with family incomes less than \$20,000 than among those with higher family incomes (17.0 vs. 9.1%, $P = 0.002$).

The prevalence of diagnosed diabetes was 8.7% (95% CI 6.8–11.2) and undiagnosed diabetes 3.8% (2.6–5.4), indicating that nearly one-third (30.4%) of adults with diabetes were undiagnosed (Fig. 1). Blacks and Asians had the highest prevalence of diagnosed diabetes (12.1 and 11.4%, respectively), and the rate of diagnosed diabetes was significantly higher among blacks than whites ($P = 0.04$). Adults aged 60 years or older had significantly higher rates of both diagnosed and undiagnosed diabetes than other age-groups.

IFG

The prevalence of IFG among adults was 23.5% (Table 1) and increased with age, affecting more than one-third (36.2%) of

adults aged 60 years or older. Men had higher levels of IFG than women (29.6 vs. 18.4%, $P = 0.0003$). IFG was highest in Asians (32.4%)—higher than in whites ($P = 0.02$) or blacks ($P = 0.03$). Foreign-born adults were more likely to have IFG than those born in the U.S. (26.9 vs. 20.7%, $P = 0.02$). Among foreign-born adults, IFG levels were elevated in both foreign-born Asians (32.7%, $P = 0.02$) and foreign-born Hispanics (30.3%, $P = 0.03$) compared with foreign-born whites (19.6%).

In multivariate models, there were significant differences in levels of diabetes by race and BMI (Fig. 2A). After adjusting for other factors, a higher proportion of Asians and blacks with normal weight had diabetes than whites (8.3 and 7.6% vs. 1.0%, respectively, $P < 0.05$). Age and income remained positively associated with diabetes. Low-income adults were more likely to have diabetes than higher-income adults (15.7 vs. 8.9%, $P = 0.006$). Disparities between normal-weight Asians and other races/ethnicities were even more striking (1.5–2 times higher) when modeling levels of diabetes and IFG (Fig. 2B).

Cardiovascular disease risk factors

Cardiovascular disease–related clinical indicators important for diabetes management for adults with diabetes, IFG, and normal glucose levels are presented in Table 2. More than one-half (55.1%) of adults with diagnosed diabetes had A1C $\geq 7\%$, and 17.1% had A1C $> 9\%$. A total of 12.3% of adults with diagnosed diabetes were on insulin (with or without oral agents), 71.5% were on oral agents only, and 16.1% were not taking diabetes medications. Among those with A1C levels $> 9\%$ ($n = 18$), only 15.8% were taking insulin.

More than two-thirds (69.7%) of adults with diagnosed diabetes were identified as hypertensive, and one-half (50.0%) had elevated blood pressure measures at interview. Of those with diagnosed diabetes and elevated blood pressure, 43.1% were not on antihypertensive medications and 35.4% were undiagnosed for hypertension. Similarly, nearly two-thirds of adults with diagnosed diabetes had elevated LDL levels (65.7%), of whom three-fourths (72.6%) were not taking cholesterol-lowering medications and 42.8% were undiagnosed for hypercholesterolemia. Overall,

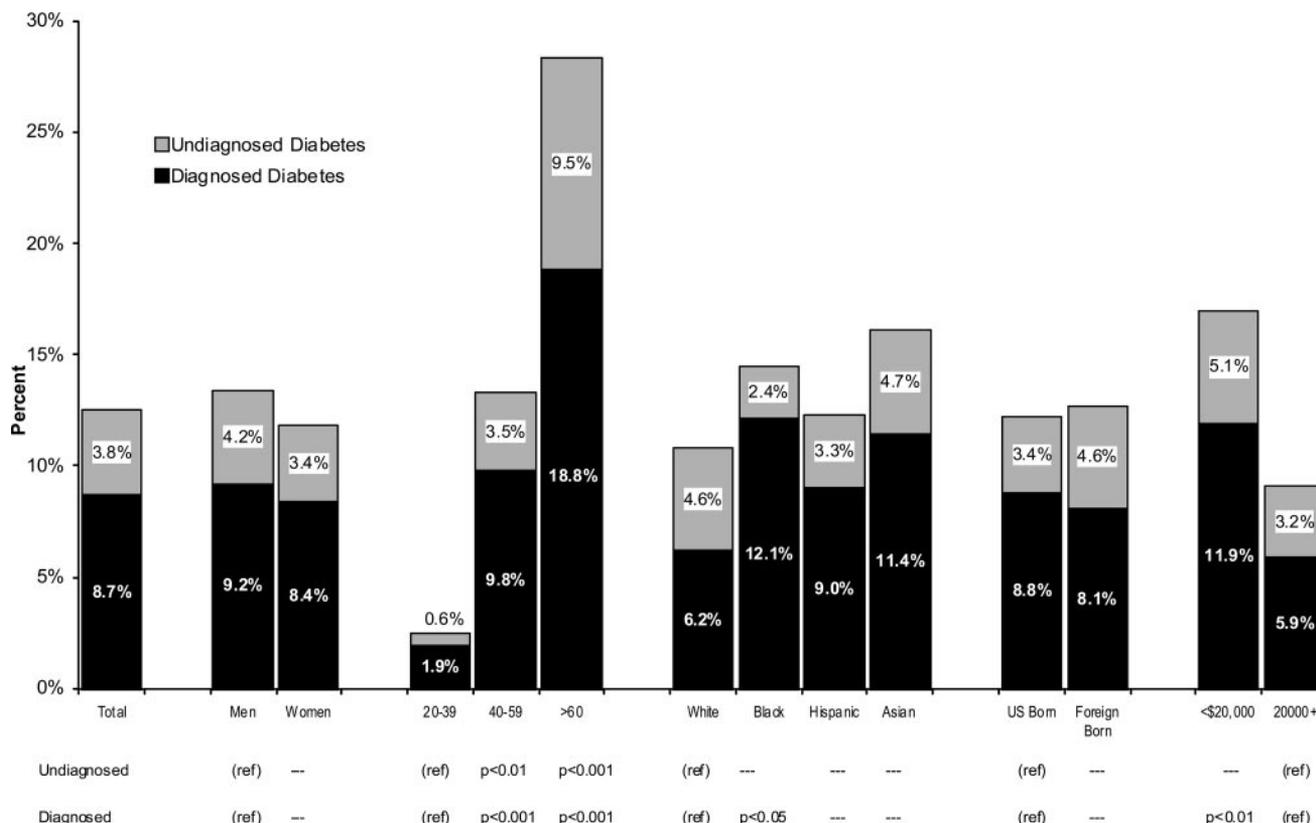


Figure 1—Prevalence of diagnosed and undiagnosed diabetes among New Yorkers aged 20 years and older: NYC HANES 2004.

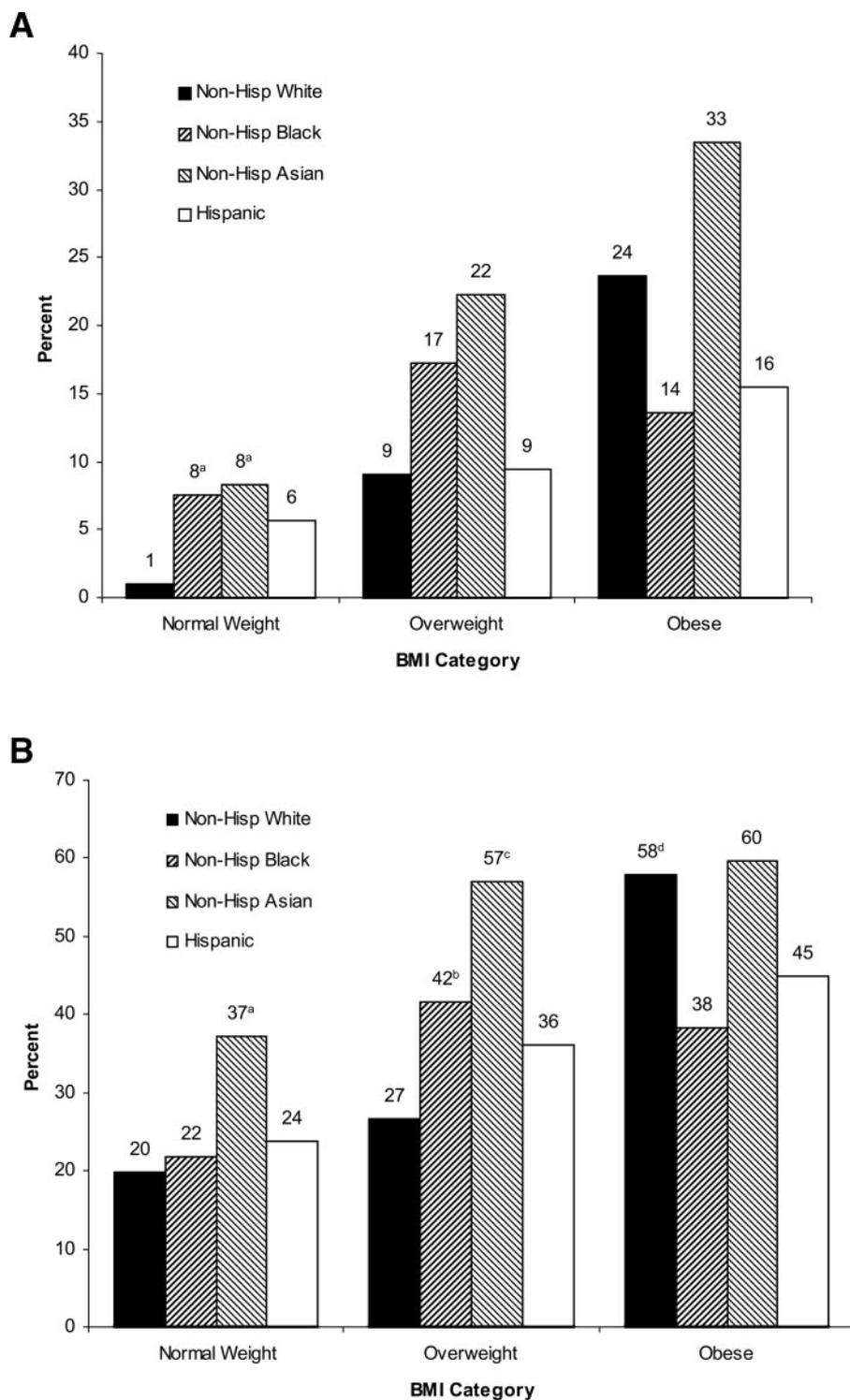


Figure 2—Adjusted prevalence (predicted marginals) for diabetes (A) and diabetes and IFG (B) by BMI category and race/ethnicity. Both models control for sex, age, place of birth, income, and physical activity. A: ^aEstimate is higher than that for whites at $P < 0.05$. B: ^aEstimate is higher than those for all other normal-weight racial/ethnic groups at $P = 0.05$. ^bEstimate is higher than that for overweight whites at $P < 0.05$. ^cEstimate is higher than that for overweight whites ($P < 0.001$) and Hispanics ($P < 0.05$). ^dEstimate is higher than that for obese blacks at $P < 0.05$. Non Hisp, non-Hispanic.

only 10.0% of adults with diagnosed diabetes had glucose, blood pressure, and cholesterol all at recommended levels.

More than one in five (22.2%) adults with diagnosed diabetes reported being a current smoker.

Adults with diagnosed diabetes were more likely to have A1C levels $\geq 7\%$ than those with undiagnosed diabetes (55.1 vs. 30.4%, $P = 0.01$). Otherwise, cardiovascular disease risk factors were similar between the two groups. Compared with adults with either IFG or normal glucose levels, adults with diagnosed diabetes had higher rates of high blood pressure.

CONCLUSIONS— This study documents a high prevalence of diabetes among New York City adults and quantifies the even larger proportion of adults with pre-diabetes. Our findings suggest that more than one-third of adult New Yorkers have abnormal glucose metabolisms, placing them at elevated risk for cardiovascular disease and death (3,13). These results underscore the need for comprehensive policies and programs to reduce obesity and diabetes. For adults with diabetes, detection of disease and control of its complications were poor. Nearly one-third of New York City adults with the disease remain unrecognized. Among those with diagnosed diabetes, widespread glucose impairment and poor control of blood pressure and cholesterol suggest pervasive failures in clinical management.

The prevalence of diabetes measured in this survey (12.5%) was significantly higher than the published national NHANES estimate of 9.3% (95% CI 8.39–10.23) from 1999 to 2002, using the same methods, labs, and standards (1). This observed difference is unlikely to be explained by subsequent increases in national prevalence through 2004; annual monitoring of self-reported diabetes among New York City residents showed a 17% increase between 2002 and 2004, whereas comparable national diabetes rates did not increase significantly (14). The high concentration of poverty and racial/ethnic diversity in New York City most likely contributes to its higher prevalence of diabetes.

An even larger group of adults in New York City had IFG, although levels were comparable with national estimates (24 vs. 26%) (1). Studies have shown that IFG increases risk of cardiovascular disease by $\sim 30\%$ (3,13) and is linked to higher all-cause and cardiovascular disease mortality (4). We found that adults with IFG had a significantly higher frequency of cardiovascular risk factors than adults with normal glucose levels. Among people at high risk for developing diabetes, disease management through lifestyle changes, such as diet and exercise, has been shown to

Table 2—Cardiovascular disease risk factors among people with diagnosed and undiagnosed diabetes, IFG, and normal glucose levels

	Diagnosed diabetes			Undiagnosed diabetes			IFG			Normal fasting glucose		
	n	%	95% CI	n	%	95% CI	n	%	95% CI	n	%	95% CI
Cardiovascular disease risk factors												
High A1C ($\geq 7\%$)	51	55.1*†	43.20–66.47	13	30.4*†	17.68–46.96	3	0.9 ^a	0.28–3.15	1	0.1 ^a	0.01–0.73
High total cholesterol (≥ 200 mg/dl)	46	47.2	35.23–59.41	18	51.1	32.72–69.24	141	53.9*	47.95–59.77	343	39.3	35.67–43.09
High LDL cholesterol (≥ 100 mg/dl)	59	65.7	52.17–77.04	22	63.6	44.20–79.36	207	78.9*	72.61–84.14	569	65.3	61.45–68.96
High blood pressure (systolic ≥ 130 or diastolic ≥ 80)	41	50.0*	38.78–61.23	18	50.9†	33.53–68.06	101	41.0*	34.53–47.73	173	22.0	18.83–25.47
Current smoker	22	22.2	14.78–32.02	15	32.3	18.22–50.59	72	23.0	18.34–28.40	234	24.8	21.47–28.47

Impaired fasting glucose is defined as a fasting plasma glucose level between 100 and 125 mg/dl. ^aStatistically unstable population estimate. Using normal glucose as the referent group: * $P < 0.001$, † $P < 0.01$. Using impaired fasting glucose as the referent group: † $P < 0.001$.

effectively prevent progression to disease (15).

The pervasiveness of elevated glucose levels suggests that policies aimed at changing the built and food environments are needed to make it easier for people to be more physically active and to eat smaller, healthier amounts. In local jurisdictions, such changes might include decreasing the price of fruits and vegetables or expanding sales outlets, reducing the availability of calorie-dense snack foods, developing bicycle paths or jogging trails, or increasing safety protection on streets, parks, and playgrounds. Without a national commitment to change the built and food environments, however, the impact of such local initiatives is limited.

Unlike its national counterpart (NHANES), NYC HANES included enough Asians to estimate diabetes and IFG levels in this group. In doing so, we found that they had the highest levels of glucose impairment of any race/ethnicity, with nearly one-half having glucose levels above the normal range. Among those in the normal-weight range, Asians had higher levels of diabetes even after adjusting for other demographic factors. These findings support previous studies that identified higher diabetes risk in Asians at lower BMI levels than whites, particularly among South Asians (16,17). Despite lower BMIs, Asians are almost twice as likely to have diabetes as whites (17), resulting in higher rates of cardiovascular disease and death (18,19). While obesity is an important screening marker for most racial/ethnic groups, lower BMI cutoffs for assessing risk have been recommended for Asian patients (16).

Over one-half of New Yorkers with diagnosed diabetes had poorly controlled blood glucose levels, suggesting inadequate disease management and lack of aggressive medication therapy. The proportion of New York City adults with diagnosed diabetes not taking any medications was similar to national rates, but the proportion taking insulin was strikingly low (12%): only half as frequent as among adults with diabetes nationally (23%) (20). Among those at highest risk for complications (adults with A1C $> 9\%$) most were not taking insulin. Traditional approaches to diabetes treatment have followed a stepwise introduction of non-pharmacologic approaches, followed by oral agents and, finally, insulin. More recent recommendations are that oral agents should be started in conjunction with lifestyle modification as first-line treatment, rather than waiting for non-pharmacologic approaches to take effect, and that insulin therapy should be started early in patients not meeting target glycemic goals (21). Our findings suggest that providers in New York City should consider insulin therapy earlier in the course of their patients' disease.

Among those with diagnosed diabetes, most had elevated blood pressure and LDL cholesterol levels, and medication use was far from optimal. Given that heart disease and stroke account for the majority of diabetes-related deaths, a greater focus on improving the routine use of these medications is critical. Disease management programs that monitor treatment indicators and patient adherence to medication and improve access to low-cost medications can improve treatment rates (22).

More than 80% of New Yorkers diagnosed with diabetes were overweight or obese, and one-third reported no leisure-time physical activity, both of which are far below current recommendations (23). Both weight reduction and physical activity are strongly associated with preventing and mitigating the effects of diabetes, hypertension, and hypercholesterolemia (15). Similarly, these data suggest that smoking prevalence is high among adults with both diagnosed and undiagnosed diabetes. Programs designed to address these behaviors will not only have a positive effect on overall health status of adults with diabetes but also a preventive impact among those at risk for developing the disease.

In New York City, recent efforts to improve diabetes management include improved public health surveillance, as well as patient, provider, and public education. In 2006, the New York City Department of Health and Mental Hygiene implemented the New York City A1C Registry. The registry is a combined surveillance system and intervention in which clinical labs report A1C test results electronically. The information is used to create decision-support tools and resources for providers and their patients to improve awareness and glycemic control.

NYC HANES data are subject to several limitations, including recall bias and measurement error in the examination components, but the study strictly adhered to widely accepted quality-assurance procedures from NHANES protocols. Also, the small sample size limited more detailed analyses that might have resulted in a better understanding of diabetes in specific sub-

groups. While the overall response rate of 55% was suboptimal, post-stratification weighting based on age-group, sex, race/ethnicity, and borough was applied to minimize the impact of nonresponse bias.

Nationally and in New York City, a disturbing proportion of adults with diabetes are unaware of their condition and/or are undertreated for it, increasing the risk of serious health complications. The levels of documented comorbid conditions also remain alarmingly high, despite being amenable to public health interventions. The large reservoir of New Yorkers with IFG suggests that diabetes prevalence will continue to grow in the years to come, amplifying these current problems even further. Effective programs to prevent progression to diabetes should be expanded.

Acknowledgments— No potential conflicts of interest relevant to this article were reported.

Early diabetes prevalence findings from this article were presented at the Forum on Diabetes Policy for New York City at Hunter College, New York City, 17 January 2006.

The authors thank Thomas Farley, Bonnie Kerker, Mary Bassett, and Lynn Silver for their valuable comments on this manuscript and Thomas Matte and Elizabeth Waddell for suggestions on the analysis. We gratefully acknowledge the NYC HANES participants and staff who made this study possible.

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