Finally, analysis of organizational performance could be substantially improved if data on the process indicators of the dental care delivery system were available. Future research should collect work-sampling data through direct observations of dental practice so that the measurement of production (for example, the visit) can be refined by considering the amount of time and quality of care rendered to patients.

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The Control of Hypertension in Persons with Diabetes: a Public Health Approach

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Synopsis

Coexistent diabetes and hypertension affect an estimated 2.5 million persons in the United States. Hypertension occurs approximately twice as frequently in persons with diabetes as without and contributes to most of the chronic complications of diabetes, including coronary artery disease, stroke, lower extremity amputations, renal failure and, perhaps, to diabetic retinopathy and blindness. The proportions of complications in the diabetic population attributable to hypertension range from 35 to 75 percent. Hypertension in the diabetic population increases with age and is particularly associated with obesity and nephropathy. Limited data suggest the control of hypertension in the diabetic population may be better than in the general population, perhaps due to greater contact that persons with diabetes have with the health care system. Yet, in approximately half, hypertension is not controlled.

Control strategies for hypertension in the diabetic population must take into account the higher frequency of hypertension, increased risks for adverse sequelae from the coexistent conditions, more complicated clinical management, and the greater contact with the health care system experienced by persons with diabetes. Community programs to improve hypertension control in the diabetic population may target a subset of the diabetic population and should tailor strategies to meet the needs of the target population. Hypertension control in the diabetic population must be addressed at multiple levels in the health care system, including improved detection, evaluation,

and treatment of hypertension; improved adherence to antihypertensive therapy and long-term followup; provision of quality professional education and patient education and support; and systematic health care monitoring and program evaluation. Hypertension control should be emphasized in all comprehensive diabetes control programs. The treatment and control of hypertension may significantly reduce morbidity and mortality in the diabetic population.

DIABETES MELLITUS AND SYSTEMIC arterial hypertension are both common, chronic conditions that frequently coexist. In combination they produce an important impact on the health care needs and clinical outcomes of affected individuals. This paper will review the types and magnitude of hypertension-associated morbidity in the diabetic population, the factors which contribute to morbidity, and interventions to improve hypertension control at the community level.

Epidemiology

Impact of hypertension in the diabetic population. An estimated 2.5 million persons in the United States have coexistent diabetes and hypertension. Hypertension is approximately twice as common in persons with diabetes as in persons without diabetes (*1*).

Hypertension contributes to the leading causes of morbidity and mortality in the diabetic population: coronary heart disease, stroke, peripheral vascular disease and lower extremity amputations, nephropathy and end-stage renal disease and, perhaps, diabetic retinopathy and blindness (*2–4*). The frequency of these complications in persons with diabetes is shown in table 1. The mortality rate for persons with both hypertension and diabetes may be increased fourfold to fivefold over that for persons without either condition (*5,6*). Cardiovascular and renal disease account for the majority of deaths in the diabetic population; three-fourths of the deaths in a large cohort of persons with diabetes at the Joslin Clinic resulted from these causes (*2*). More recent data from death certificates for the U.S. population confirm this finding (*7*).

Risk factors for hypertension. At least 90 percent of hypertension in the general population is essential hypertension; that is, the etiology is unknown (*8*). Essential hypertension also accounts for most of the cases in the diabetic population, although precise prevalence estimates are not available. Risk factors for essential hypertension include age, race, sex, family history, dietary factors (especially sodium intake), and obesity. It is assumed that risk factors for hypertension in the general population also apply to the diabetic population. The prevalence of hypertension in the diabetic population also varies with type and duration of diabetes and the presence of complications of diabetes, especially nephropathy.

The prevalence of hypertension increases with age in both the diabetic and the general population and is higher in persons with diabetes than in persons without diabetes at all ages. However, the differential between persons with and without diabetes is greatest in younger age groups. Age-specific rates of self-reported hypertension from the 1976 National Health Interview Survey for the diabetic and the nondiabetic populations of the United States are shown in the figure. Among persons ages 20–44, the prevalence is 3.8 times greater in persons with diabetes than without; among persons ages 45–64, the prevalence is 2.2 times greater; and among persons ages 65 and older, the prevalence is 1.6 times greater (*9*).

In the general population hypertension is more common in men than women before the sixth decade and more common in women than men in later years (*10*). A similar pattern has been found in the diabetic population, except that the prevalence of hypertension in women exceeds that of men at a somewhat younger age—in the fifth decade (*2,11,12*).

Both hypertension and diabetes occur more frequently in blacks than whites. Overall, hypertension is 33 percent more common (*10*) and diabetes is 35 percent more common (*13*) in blacks than whites. The prevalence of the coexistent conditions is almost twice as great in blacks as in whites (National Center for Health Statistics, National Health and Nutrition Examination Survey II, unpublished data, 1980). Both conditions are also more common among lower socioeconomic groups (*14,15*).

Hypertension in the general population has been noted to aggregate in families, but the relative contributions of genetics and the environment are unclear (*8*). The existence or importance of a familial tendency toward hypertension in the dia-

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Table 1. Annual incidence and total prevalence of complications of diabetes, United States, 1984

Complication	Incidence	Prevalence
Stroke	27,000	392,000
Coronary artery disease	101,000	781,000
Peripheral vascular disease	50,000	573,000
Blindness	6,900	47,000
End-stage renal disease	5,900	13,000
Amputation	47,000	86,000

SOURCE: Unpublished, updated data based on reference 9.

betic population has not been given much attention.

Differences in the epidemiology (and pathophysiology) of hypertension in persons with insulin-dependent or type I diabetes compared with noninsulin-dependent or type II diabetes may largely be accounted for by differences in age, duration of diabetes, and diabetic complications between the two groups. Diabetic nephropathy, which develops in a greater proportion of persons with type I diabetes than with type II diabetes (*16*) and is strongly associated with hypertension, may account for the high age-specific prevalence of hypertension in the younger diabetic population compared with the general population (*9,11*).

Proteinuria, a clinical marker for nephropathy, develops in 18–30 percent of persons who have had type I or type II diabetes for 15–19 years (*16*). After persons with type I diabetes develop proteinuria, blood pressure may rise at an accelerated rate. Systolic pressure has been reported to rise almost 1 mm Hg per month in these patients (*17*). The prevalence of hypertension in persons with type I diabetes and no nephropathy quadruples to approximately 65 percent at the time persistent proteinuria develops, and the prevalence increases to 92 percent when serum creatinine becomes elevated (*18*). Virtually all patients with end-stage renal disease have hypertension.

Current status of treatment and control. Treatment and control of hypertension in the general U.S. population have improved in the past two decades. In national surveys, the prevalence of "never diagnosed" hypertension (systolic pressure greater than 160 mm Hg or diastolic pressure greater than 95 mm Hg or both) decreased from 51 percent in 1960–62 to 27 percent in 1976–80, and the prevalence of controlled hypertension increased from 16 percent to 34 percent (*19*). Control was defined as hypertension under treatment and blood pressure below 160/95 mm Hg.

Currently, hypertension treatment and control in the diabetic population may be better than in the general population (*6*). In a 1980 survey of persons with diabetes in Michigan, 76 percent of those with coexistent hypertension were receiving treatment for hypertension (*20*). This proportion compares with 37 percent of persons with hypertension in the general population in the 1976–80 National Health and Nutrition Examination Survey II (NHANES II). Similar definitions of hypertension were used in both populations (blood pressure > 140/90 mm Hg for those under age 65 in both populations and > 160/90 mm Hg and > 160/95 mm Hg for persons in Michigan and NHANES II, respectively, for those age 65 and older). In a 1980 survey of persons with diabetes in southern Wisconsin, a similarly higher proportion of persons with coexistent hypertension were on antihypertensive therapy than were persons with hypertension in the general population in NHANES II (*10*). In the Michigan survey of persons with diabetes, 48 percent of persons with coexistent hypertension had controlled hypertension (*20*), compared with only 17 percent in the NHANES II population (*11*), again using similar definitions of control.

Community Intervention

Goals and methods of control programs. The goals of a hypertension control program are timely detection, evaluation, and long-term treatment and control of hypertension. The tasks of public health programs are (*a*) to help ensure that patients and providers are knowledgeable about hypertension; (*b*) to help ensure that hypertension is being

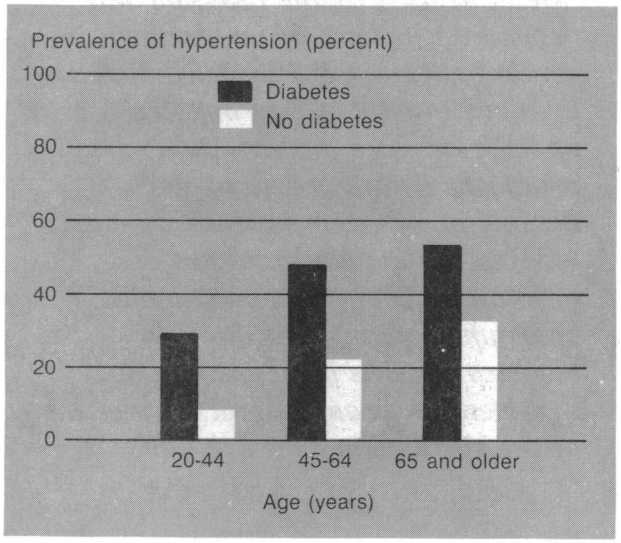
detected, evaluated, and treated and that patients are being followed; and (*c*) to monitor and evaluate health care practices and outcomes. These efforts may be targeted at subsets of the population at highest risk, as dictated by the needs and resources of the community. Hypertension control should be a part of all comprehensive diabetes control programs.

Hypertension control in the diabetic population is a new direction for public health programs. Separate diabetes and hypertension control programs, such as those conducted by local health departments, may be quite disparate in the composition of their advisory groups, patient populations served, methods, and administration. Hypertension control programs for the general population have worked by improving community awareness of and screening and referral for hypertension; more recently these programs have emphasized targeting high-risk groups, including persons with diabetes. Diabetes control programs, on the other hand, have focused on persons with known diabetes and in the health care setting. They emphasize the prevention of diabetic complications by improving health care services and educating patients and providers. Improvement in hypertension control for the diabetic population involves more than the simple linking of these two programs; rather it involves the incorporation of a hypertension control program within the diabetes program.

Hypertension control in the diabetic population may be improved by ensuring state-of-the-art health care practice. Guidelines and standards for medical care must be promoted by groups in the medical and scientific communities such as the guidelines of the 1984 Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (*21*). Guidelines for the treatment of hypertension in persons with diabetes have also recently been developed (*22*). The impetus for the working group that developed the latter set of guidelines was generated by a need perceived in the medical community and in several State public health programs.

The experiences of almost 10 years of State-based diabetes control programs have taught that recommendations and comments from community and scientific groups must be solicited and encouraged at each phase of the program, from planning through implementation and evaluation. Building a consensus increases the value and acceptance of interventions. Feedback to the medical community ensures continued participation in and scientific validity of program activities.

Prevalence of self-reported hypertension by self-reported diabetic status and age, United States, 1976



SOURCE: Reference 9.

Table 2. Relative risks and attributable risks for hypertension for complications in the general population and the diabetic population

Complication	Relative risk	Attributable risks (percent)	
		General population	Diabetic population
Coronary artery disease.....	2	20	35
Stroke.....	7	60	75
Lower extremity amputation ...	2	20	35
End-stage renal disease	...	25	50
Retinopathy.....	2	...	35

SOURCES: References *4, 9, 39, 40.*

Potential impact. Hypertension control has been shown to reduce morbidity and mortality from cardiovascular disease in the general population, including stroke, congestive heart failure, and coronary artery disease (*23–26*), and to slow the decline in renal function in patients with diabetes and nephropathy (*27,28*). It has been suggested that improved hypertension control has contributed to the one-third reduction in mortality from coronary artery disease in the general population over the past 25 years (*29*). There are no data to suggest that persons with diabetes have not similarly benefited. Improved hypertension control in the diabetic population may also delay retinopathy (*30*). Because the latency period between the detection of hypertension and the development of these complications is long (several years to decades), the impact of hypertension control in a population will not be evident for at least 5 years.

Table 2 shows the approximate proportions of

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each of the major morbid outcomes that may be attributed to hypertension in the general and diabetic populations, termed attributable risk (AR). The AR may be derived from the risk ratio and the prevalence of the risk factor in the population, using the formula

$$AR = b(RR - 1) \div [b(RR - 1) + 1]$$

where b is the prevalence of hypertension and RR is the relative risk of the outcome (risk among those with hypertension ÷ risk among those without hypertension) (*31*). Table 2 provides approximate measures of the impact of hypertension and hypertension control in absolute and relative terms. The relative risks were derived from a limited number of studies, mostly conducted in the general population. Factors such as varying definitions of hypertension and age, race, and sex, which influence hypertension prevalence, are not addressed. An estimate of the relative risk of hypertension for development of end-stage renal disease is not available; however, recent intervention studies among persons with diabetes suggest that control of hypertension may reduce the rate of decline in renal function by 50 percent (*27,28*).

There is no estimate in table 2 for the AR for retinopathy in the general population because it is assumed that this condition is unique to persons with diabetes. It is also assumed that hypertension contributes to the development of retinopathy, although scientific evidence of this relationship is only suggestive. Because the prevalence of hypertension in the diabetic population is higher than in the general population, hypertension may be estimated to be responsible for higher proportions of these outcomes than in the general population. Rates of control of hypertension are probably also higher; approximately half of persons with hypertension in the diabetic population may have controlled it (*20*). Therefore, the absolute impact resulting from improvement in hypertension control will be somewhat less than that suggested by the ARs in table 2.

Targeting high-risk groups. The impact of hypertension control in a diabetic population and the specific interventions necessary to improve hypertension control will depend on the group targeted. Which group a program chooses to target will depend on the needs and resources of the community that the program serves. Examples of potential target groups and the rationale for intervention follow.

- All persons with diabetes are at high risk (more than 50 percent) of developing hypertension during their lifetimes. Focusing a hypertension control program on all persons with diabetes would provide an opportunity for earliest intervention. The program should address both persons with diabetes who are at risk of developing hypertension and those who already have hypertension. The emphasis should be on education regarding the risk of developing hypertension; the importance of checking blood pressure regularly; reduction of concomitant risk factors, such as obesity; and clinical aspects of hypertension and hypertension control.
- Elderly persons who have had type II diabetes and persons who have had type I diabetes for more than 10 years have the highest rates of hypertension and are at particularly high risk for morbid complications. A hypertension control program for this group should emphasize appropriate therapies and followup, patient and provider education, and monitoring of disease outcomes.
- Persons with type I diabetes and proteinuria comprise a group at particularly high risk for accelerated increases in blood pressure and declining renal function. Screening for microalbuminuria, an early indicator of nephropathy, may enable these persons to be detected and targeted for intensive preventive strategies at an early stage. Program activities for this group should emphasize identification of those at high risk; intensive blood pressure monitoring and control; hypertension detection, treatment, control, and followup; patient and provider education; and monitoring of disease outcomes.

• Other high-risk groups include those with inadequate access to health care, such as low-income groups. Program emphasis should be on increasing both access to health care and ensuring followup.

Current program opportunities. The epidemiology of hypertension in the diabetic population reveals which persons are at highest risk of hypertension and complications. Limited data available on current state-of-care practices suggest that opportunities to improve hypertension control in the diabetic population are not concentrated at one level in the health care system from initial detection of hypertension through long-term followup. Rather, problems and opportunities for improvement exist in many places throughout the health care system for persons with diabetes.

Levels of intervention in the health care system. As a group, persons with diabetes have a relatively high degree of contact with the health care system. This circumstance must influence the approach taken by a hypertension control program. Methods used by the program will depend on its level of involvement in actual patient care. Programs directly involved in patient care must ensure appropriate care through policy and protocols. Those programs not directly involved in patient care must educate health care providers and promote patient tracking systems. Finally, programs offering education to diabetes patients must ensure that hypertension is an integral component of the curriculum.

Detection. Lack of awareness among persons with diabetes does not appear to represent a significant gap in control of hypertension at the population level. In the 1980 Michigan survey, 85 percent of the persons with diabetes and hypertension were aware that they had hypertension (*20*). It must be ensured, however, that detection of hypertension continues at a high level.

Evaluation and therapy. The proportion of persons with hypertension who are receiving treatment has been found to be greater in the diabetic population than in the general population (*11,20*). This difference may result from the greater degree of contact that persons with diabetes have with the health care system.

The approach to the clinical management of hypertension advocated by the Joint National Committee on the Detection, Evaluation, and Treatment of High Blood Pressure (*21*) may generally be applied to persons with diabetes. There are, however, unique aspects to clinical evaluation and treatment of hypertension in persons with diabetes compared with those without diabetes. Clinical evaluation must consider obesity, nephropathy, and cardiovascular disease, which are frequent in persons with diabetes. There is increased potential for adverse side effects from antihypertensive drug therapy, including worsening of glycemic control and prolonging recovery from hypoglycemia (*22*). Antihypertensive therapy may be initiated at lower levels of blood pressure elevation, and the goals of therapy may be more stringent because of the increased potential for complications of uncontrolled hypertension. Controversy exists in most of these areas. The reader is referred to the recent report on hypertension in diabetics for specific guidelines on evaluation and treatment of hypertension in diabetics (*22*).

Adherence and followup. Lack of adherence to prescribed therapy is usually cited as the major barrier to hypertension control (*21*). In general, it is estimated that only one-third of patients may be expected to comply fully with prescribed therapies (*32*). Among persons with diabetes, it is estimated that only about half follow their diet prescriptions (*33*). Adherence to recommended antihypertensive therapy may be improved if the provider

• Simplifies the regimen,
• Gives written and oral information on medication dose, side effects, and therapeutic goals,
• Discusses goals on each visit,
• Addresses the psychosocial factors that contribute to the patient's perceptions, beliefs, and practices regarding illness and health care, including cultural or ethnic norms and specific life experiences,
• Tailors the regimen to fit the person's needs and lifestyle,
• Involves the patient's support system (for example, spouse or other family members) in treatment and monitoring,
• Uses the services of nurses, dieticians, pharmacists, and family members in a team care approach, and
• Provides a long-term, supportive therapeutic environment.

These and other guidelines are delineated in several sources (*21,22,34*). Despite cross-sectional data that suggest persons with diabetes see physicians two to three times as frequently as those without diabetes (*35,36*), the proportion who con-

'All persons with diabetes should be educated about the risks of developing hypertension; the adverse health effects of hypertension; and the types, benefits, and side effects of antihypertensive therapies.'

tinue followup and the regularity and duration of followup are unknown. A program may facilitate followup by emphasizing the importance of followup in patient education programs and through monitoring and tracking systems, such as those used in hypertension programs (*37*).

Patient and provider education. All persons with diabetes should be educated about the risks of developing hypertension; the adverse health effects of hypertension; and the types, benefits, and side effects of antihypertensive therapies. Diabetes patient education should go beyond the traditional diabetes-specific curriculum to include topics related to generic hypertension risk factors, such as obesity and sodium restriction, and beyond the traditional provider-patient setting to offer ongoing support groups and lifestyle change programs, such as weight control, smoking cessation, and exercise programs.

Educating providers about the control of hypertension in persons with diabetes should begin in schools for health professionals and continue throughout each provider's career. Such a program should include both the clinical principles of prevention and treatment and the public health principles of community-oriented primary care (*38*)—the epidemiology of relevant diseases, characteristics of the community served, the services necessary for primary care practice in the community, and accessibility of care. Provider education programs should be conducted by or in conjunction with professional organizations.

Monitoring and Evaluation

Health care monitoring and program evaluation are important for public health programs to ensure that the program accomplishes its objectives and goals. The types of data needed will depend on characteristics of individual programs, but generally include the following information:

- Estimate of the total number of persons in the target population (those the program intends to reach), including the number with diabetes and hypertension;
- Demographic characteristics of the target population;
- The presence of factors that affect hypertension, such as obesity, dietary factors, and other medical conditions;
- Types and use of nonpharmacologic and pharmacologic therapies;
- Information on patient care, such as frequency of visits, types of health care personnel involved in care, and costs; and
- Prevalence of hypertension and levels of blood pressure.

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