Moving Diabetes Care from Science to Practice: The Evolution of the National Diabetes Prevention and Control Program

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The National Diabetes Prevention and Control Program has a dynamic and evolving scientific foundation. This article describes this program and how seminal research studies provide an impetus for its public health policy and programs. The charge and challenges of integrating science into past, current, and future program designs are detailed, as are the program's accomplishments. Areas requiring new science are explored, including better research to translate new findings into clinical and public health practice and models to evaluate the effect of public health on improved outcomes. The epidemic of diabetes and its increasing burden on public health demands a better understanding of existing science and its limitations and informed public dialogue and policy responses.

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In 1975, the congressionally appointed National Commission on Diabetes recommended that the Centers for Disease Control and Prevention (CDC) establish a program for diabetes education and control (1). This recommendation resulted in the establishment of the National Diabetes Prevention and Control Program (NDPCP), whose goal was to reduce diabetes-related complications through dissemination of research-based knowledge. In the ensuing decades, the science underlying the initial purpose and interventions of the program has evolved.

In 1981, researchers established that photocoagulation treatment can prevent blindness in persons with diabetes (2). Twelve years later, the results of the landmark Diabetes Control and Complications Trial established that intensive control of blood glucose greatly reduces microvascular complications in persons with type 1 diabetes (3). In 1998, the United Kingdom Prospective Diabetes Study demonstrated similar benefits in persons with type 2 diabetes and equally compelling benefits for control of blood pressure (4, 5). More recently, the Diabetes Prevention Program released findings in 2002 demonstrating that lifestyle changes and medications can prevent diabetes in persons with impaired glucose tolerance (6). With each new scientific breakthrough comes an ethical responsibility and obligation to ensure that programs and people benefit as quickly as possible from new knowledge by ensuring that programs are funded and redirected accordingly (7, 8).

The CDC’s National Diabetes Prevention and Control Program (NDPCP) plays a major role in fulfilling the public obligation to move science into practice. We seek to demonstrate how clinical research has guided decision making in development of the NDPCP; clarify the expectations of this program for clinicians, policymakers, and public health practitioners; and describe the interdependent relationships between specific public health actions and health care systems and providers.

**Moving from Science to Practice**

Randomized, controlled clinical trials have generated the science on which the NDPCP is based. These studies provide a starting point for new knowledge, but moderating factors, such as settings, population characteristics and behaviors, and qualifications of intervention staff, often compromise efforts to implement these findings (8, 9). If ignored, these real-world situations can render interventions ineffective. Usually, program planners must look outside clinical trials for guidance on these matters, which contribute to the continuing gap between research and practice (10).

While the NDPCP’s public health role in moving from science to practice has evolved over time, the goal of involvement of public health agencies has been to facilitate and support improvements in health at the population level. The role of agencies is evident in maintenance of state- and national-level surveillance systems to monitor health and risk status of the population, tracking and monitoring of population-level prevention practices, and establishment of collaborations with provider groups to perform pilot tests of promising interventions (11). The underlying premise of the NDPCP is that no single agency, group, or organization can achieve the goals of moving from science to practice.

**The Program**

The NDPCP began as a small demonstration project in 1975 and continues to develop as new science and resources become available. Primary grantees are state and territorial health departments, to which funds are given for implementation of public health–focused interventions that are intended to reduce the burden of diabetes. These grantees are awarded funds through a competitive process and submit applications that respond to a program announcement describing the public health approach and the allowable use of funds. Funds are awarded yearly on the basis of the quality of the application and past performance. The public health approach adopted by the NDPCP and implemented by these grantees has evolved through 3 distinct historical phases. Each phase developed in response to new knowledge and built on the efforts of the previous
phase while also responding to resource constraints and refining the public health focus for interventions.

**Phase 1: Building a Foundation**

In 1977, the CDC funded 7 state health departments to establish diabetes programs (12). At that time, the organizational capacity and infrastructure of state and national public health efforts to prevent diabetes or chronic disease were minimal. Initial attention and resources were directed to building and maintaining a stable organizational capacity. The overarching goal was to develop effective strategies for diabetes control at the community level (13). State grantees were charged to use basic epidemiologic principles and methods to identify and implement appropriate interventions in order to reduce diabetes-related morbidity and mortality (14).

During this phase, interventions typically involved patient and professional education. Educational interventions were designed and implemented at the state level. The expected effect of the program was reduction of diabetes-related complications through improved availability of and reimbursement for diabetes education services. The logic behind the program was that if providers and persons with diabetes were appropriately educated about proper management of this disease, appropriate changes in behavior would follow. This proved to be a necessary but incomplete strategy for most providers and persons with diabetes (15, 16).

However, this effort resulted in institutionalization of state health department–sponsored diabetes education programs in many states, which meets an important need. For example, several programs currently focus on increasing the number of education programs recognized by the American Diabetes Association and patient support groups in communities with a high prevalence of diabetes.

Overall, the above approach recognized the important function of the federal government to ensure that state and local agencies had sufficient people, money, equipment, research capacity, and organization to develop state-level programs (17). An underlying assumption was that infrastructure provided a means to leverage resources, making it a worthwhile and beneficial public investment.

**Phase 2: Finding a Niche**

In 1981, photocoagulation therapy in the setting of regular eye examinations was found to prevent blindness in persons with diabetes (2). This research, and the fact that diabetes-related eye disease is frequently asymptomatic in its early stages, caused the CDC to focus efforts on screening for diabetic complications. This second program phase, which began in 1985, focused on screening uninsured persons with diabetes. Diverse partnerships and coalitions were developed between state programs and community and provider groups to initiate recommended care for uninsured persons (18). For the next 9 years, the program continued to focus on patient and provider education and selective screening.

The objective of the program was early detection and treatment of diabetes complications in underserved populations through program-supported screening activities. Emphasis was placed on tracking screened persons to ensure that they received recommended treatment. State public health programs were encouraged to establish partnerships with providers and negotiate gratis or reduced rates for specific treatment on behalf of these persons. Treatment tended to have an identifiable start and completion date and did not commit the provider to long-term care of an uninsured person. This labor-intensive approach focused primarily on persons directly served by the program. The goal during this phase was secondary and tertiary prevention of diabetic complications in targeted vulnerable persons.

For example, the Rhode Island Diabetes Control Program directed efforts toward reducing barriers to care and providing eye examinations for persons with diabetes, in particular those with low income and without health insurance. Program activities included distribution of education materials to target sites (for example, primary care providers, emergency departments, hospitals, worksites, pharmacies, and Lions clubs) that promote annual eye examinations among persons with diabetes; dissemination of national standards for eye care through the mail, presentations, and publication of articles; and screening services through neighborhood health centers associated with the Providence Ambulatory Health Care Foundation (19).

During phase 2, states developed a great ability to partner with health care providers, community organizations, and others. Resource limitations underscored the need to identify uninsured persons and negotiate arrangements with providers to treat them. Although screening activities, particularly those occurring in nonmedical settings, are not a dominant feature of current program interventions, a heavy focus on partnering continues.

**Phase 3: Mainstreaming Diabetes Care through Models of Influence**

The changes that took place during phase 3 led to the current design of the NDPCP. These changes began in 1993, when the Diabetes Control and Complications Trial established that intensive control of blood glucose greatly reduces microvascular complications (3). Publication of the findings of this trial resulted in intensive discussion and debate in the clinical and public health communities (20). The two major program implications of this study were that the findings needed to be translated to all persons with diabetes and that the screening and follow-up approach used in phase 2 of the NDPCP was not the most efficient method of widely translating these findings. Extensive dialogue with the public took place on health care reform and its potential to cover prevention and treatment for the growing number of uninsured and high-risk persons in the United States (21).

Ultimately, the health care community understood
that improved glycemic control could be achieved in persons with diabetes if health care providers adopted policies that supported and were congruent with the findings of the Diabetes Complications and Control Trial. This approach could also maximize the potential of the NDPCP to prevent complications in persons with diabetes. Therefore, in 1994, NDPCP concentrated its efforts on establishment of population-level interventions, elimination of individual screening activities (because they have limited effect at the population level), and patient and provider education and its role in the management of diabetes.

Using this framework, the Minnesota Diabetes Control Program and Health Partners, a large managed care organization, improved diabetes care by identifying and implementing systems changes within primary care clinics. During the pilot stage of this effort, the frequency of eye examinations, foot examinations, and microalbumin testing increased substantially among clinic attendees. These results were replicated in the intervention phase. In 2 years, the average hemoglobin A1c values in participants decreased from 9.2% at baseline to 7.7%. Other effects of this program included ongoing recognition of diabetes as a priority for medical staff leadership, increased devotion of resources and time to improving diabetes outcomes, and increased recognition among patients and the community that program-supported clinics provide high-quality diabetes care (22, 23).

The Figure shows the developmental phases of the NDPCP. Science has provided the catalyst for the evolution of this program and will probably continue to do so.
However, the program will probably also draw from different scientific disciplines and heuristic frameworks.

**Current Status**

The NDPCP currently funds health departments in 50 U.S. states, the District of Columbia, and 8 U.S. jurisdictions. In 2004, the budget for state and jurisdictional program activities totaled $29 million, with annual funding ranging from $100,000 in less populated jurisdictions to approximately $1 million in the most populated states.

At the start of the 21st century, the program model of the NDPCP continued to become more oriented to community-level, system-based interventions and less focused on direct clinical services to individual patients with diabetes. Two significant enhancements to the program have been introduced since 1995. First, the central idea of models of influence has been elaborated as 3 “levers for change”: community interventions (such as community mobilization training [24]), health communications (such as national influenza campaigns [25]), and health systems change (such as managed care collaborations). Because few programs have sufficient resources to implement all 3 efforts simultaneously, growth has been slow and gradual. Resource limitations have necessitated the expansion of partnership programs, with the aim of achieving synergism across agencies and organizations in order to effect change in community and health systems.

Second, in 1999, the NDPCP adopted a set of national program objectives, primarily to help guide a new emphasis on program evaluation. The objectives of the NDPCP supported those of the Healthy People 2010 effort (18, 26). It was believed that alignment of these objectives would help create the synergy needed to achieve these important national goals.

Currently, objectives of the national program focus on increasing population-level rates of eye examinations, foot examinations, vaccinations, and hemoglobin A1c testing. These objectives were adapted from Healthy People 2010 and provide common measures of population improvement for public health and health care systems. Although the selective objectives do not cover all of the important areas in diabetes prevention and control, they provide a reference point in the program’s design. In addition, they should be viewed as having a critical role in achieving desired program outcomes (Table 1).

Clinical trials have shown that regular eye examinations and ophthalmologic consultation can prevent vision loss by as much as 50% (28). Despite the known benefit of eye examinations, a substantial proportion of persons with diabetes do not receive them. For example, in a 2002 study from the CDC, 63.3% of persons with diabetes had had a dilated eye examination during the previous year (29). Therefore, increasing the number of patients who undergo eye examinations is a critical initial step in reducing diabetes-related blindness.

### Table 1. National Objectives of the National Diabetes Prevention and Control Program*

<table>
<thead>
<tr>
<th>Objective</th>
<th>Target Year</th>
<th>Description</th>
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<tbody>
<tr>
<td>By 2008, demonstrate an increase in the percentage of people who receive the recommended number of eye examinations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 2008, demonstrate an increase in the percentage of people who receive the recommended number of foot examinations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>By 2008, demonstrate an increase in the percentage of people who receive recommended vaccinations</td>
<td></td>
<td></td>
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<tr>
<td>By 2008, demonstrate an increase in the percentage of people who receive the recommended hemoglobin A1c tests</td>
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* Reproduced from Centers for Disease Control and Prevention (27).

Diabetes accounts for about 60% of all nontraumatic amputations in the United States (30). Amputations are costly in both economic and emotional terms and can negatively affect quality of life (31). Amputees are also at high risk for secondary amputations. Self-reported preventive practices have been linked with decreased risk for lower-extremity amputations (28). The benefit of good foot care, including periodic foot examinations, is well documented. Therefore, it is reasonable to expect reductions in population-level risk for amputation if population-level improvements in foot examinations are achieved. The expected outcome of this objective is a reduction in amputations.

Regardless of race, sex, or socioeconomic status, persons 25 to 64 years of age with diabetes are 4 times more likely than comparable persons without diabetes to die with pneumonia or influenza (33, 34). The Advisory Committee on Immunization Practices recommends that all persons with diabetes be vaccinated against pneumonia and influenza (35, 36), yet a large gap remains between recommendations and practice. The CDC has demonstrated that among diabetic persons 18 to 44 years of age, 27.7% reported receiving influenza vaccination in the 12 months before the study questionnaire and 11% reported ever receiving pneumococcal vaccination (33). The gap between racial and ethnic groups was larger, with differences as large as 27% between non-Hispanic white persons and Hispanic persons. The compelling evidence of the benefit of vaccinations and the historical role of public health in providing immunization services underscore this as a relevant program objective.

The hemoglobin A1c level has been shown to predict risk for many chronic complications of diabetes, and maintenance of normal or near-normal levels dramatically reduces the incidence and progression of complications (2). The American Diabetes Association considers glycemic testing to be a cornerstone of good-quality diabetes care and recommends measurement of hemoglobin A1c at least twice yearly (37). Twenty-five percent of persons who had seen a physician within a 1-year period reported undergoing hemoglobin A1c testing (29). The potential to reduce preventable complications will be limited without glycemic
control. Therefore, increasing the use of hemoglobin A1c testing is a critical starting point in closing the gap between practice and recommended care.

Recent national data show that preventive care practices have improved, but they remain lower than recommended (38). In the future, the national program must emphasize the necessity of continued improvement in selective practices and adoption of new measures, such as primary prevention and cardiovascular disease. Such measures are needed to achieve long-term reductions in rates of morbidity and mortality due to diabetes.

**Current and Future Challenges**

The major challenges facing the NDPCP are significant and include the need to address external expectations, program evaluation, and primary prevention. All of these matters warrant attention and may stimulate a program phase 4.

**External Expectations**

As a federally funded entity, the NDPCP is accountable to diverse constituents, including the U.S. Congress; the President’s Office of Management and Budget; health care providers; national, state, and local health agencies; and a wide range of public and private sector stakeholders. Each constituent appropriately brings different expectations of program interventions and time horizons for desired changes. The complicated progression from healthy status to risk status, disease, and ultimately death is not always understood or agreed on from a population perspective. Therefore, program planners for national efforts such as the NDPCP need decision support tools to help them not only make but also explain their selection of interventions to external stakeholders. These tools should explain the relationship between intermediate outcome measures (for example, eye or foot examinations) and desired reductions in morbidity and mortality in measurable terms that have a defined time frame.

**Program Evaluation**

As the focus of the NDPCP changed, so have its measures of success. The NDPCP has adopted an evaluation strategy that includes assessment of its ability to prevent diabetes-related complications at the population level. Outcomes measurement in this instance is hampered by the fact that interventions have varying degrees of effect. For example, whereas hemoglobin A1c testing and glycemic control may affect both eye disease and amputation of lower extremities, eye examinations affect eye disease alone. This variability adds complexity to the evaluation of diabetes intervention strategies and hinders demonstration of a direct relationship between the program and the effects of its activities. Models are needed to evaluate preventive interventions and their varying effects at the population level.

The NDPCP acknowledges that no single program can accomplish national goals (18). Therefore, the program has emphasized facilitation of prevention-related activities in health and social systems that are coordinated by many external partners (39). This approach can be loosely termed an influence model and is viewed as an appropriate and important role for government (18, 40). A challenge in evaluation is the lack of an appropriate effect metric for an influence model.

**Primary Prevention**

The alarming increase in rates of obesity in the United States (41, 42) raises the specter of a national diabetes epidemic. If current trends continue, persons will develop type 2 diabetes and related complications at younger ages. However, the high-risk approaches used in clinical trials such as the Diabetes Prevention Program were conducted in resource-intensive clinical settings that focused exclusively on persons at highest risk for diseases such as diabetes. Conversely, community-based approaches that attempt to reduce risk factors for or causes of diseases at a population level are also important (43). Current program efforts focus on high-risk approaches that aim to identify people with prediabetes and engage them in preventive strategies in community settings; however, effective translation of the findings of the Diabetes Prevention Program into practice will probably require both high-risk and community-based approaches (44, 45).

The appropriate balance of resources among primary, secondary, and tertiary prevention requires an ongoing dialogue within and beyond the public health community (46). In addition, primary prevention efforts are challenged by a health system that is overwhelmingly focused on acute care (47). The NDPCP is exploring how best to facilitate effective and efficient program interventions to address these challenges.

In conclusion, the scientific foundation of the NDPCP is dynamic and challenging. Randomized, controlled clinical trials have provided direction and focus for planning and decision making at national, state, and local levels. These studies have shown that blindness can be prevented in persons with diabetes, diabetic eye disease can be delayed, intensive control of blood glucose can prevent microvascular complications, and type 2 diabetes can be prevented or delayed. However, more information is needed on how to implement recommendations in typical settings and those that serve low-income, rural, or minority groups, who encounter health disparities (48).

The public health response of the NDPCP to these and other scientific issues has included assessment activities to monitor changes in and barriers to implementation of new scientific findings and the resulting public health burden. These efforts show that progress has been made in developing strong national and state public health capacities to implement and evaluate effective prevention and control interventions. Examples include the following: a national surveillance system and epidemiologic studies measure the burden of diabetes and track effective practices.
Table 2. Response of the National Diabetes Prevention and Control Program to Scientific Findings

<table>
<thead>
<tr>
<th>Phase</th>
<th>Scientific Finding</th>
<th>Context for Translation</th>
<th>Response</th>
<th>Intended Effects</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Education on diabetes management can lead to sustained changes in behavior</td>
<td>No public health infrastructure for prevention of chronic disease</td>
<td>Funds to build state program infrastructure; guidelines for educational interventions</td>
<td>At local level, develop and maintain resources to implement effective diabetes control strategies in patient and professional education</td>
<td>Development of 5 state programs and early partnerships for education</td>
</tr>
<tr>
<td>2</td>
<td>Diabetic Retinopathy Study: Photocoagulation treatment can prevent blindness, and regular screening examinations can identify persons in need of treatment</td>
<td>Symptomless disease; large disparities in access to insurance and care among high-risk groups</td>
<td>Screening, referral, and follow-up services targeted to vulnerable uninsured persons</td>
<td>Reduce morbidity and mortality by direct delivery services to vulnerable uninsured persons</td>
<td>Development of partnerships for service delivery with health professionals and community-based organizations</td>
</tr>
<tr>
<td>3</td>
<td>Diabetes Control and Complications Trial: Control of blood glucose can reduce eye, kidney, and foot disease</td>
<td>National health care reform; changing role of public health from care delivery to influence</td>
<td>Population-based interventions; systems change through models of influence; national objectives for key preventive services</td>
<td>Increase access to care by providing diabetes care in mainstream health care systems; reduce morbidity and mortality by changing environment, policy, and systems</td>
<td>Establishment of 59 grant programs and of national objectives; identification of 3 methods of influence; development of partnerships for system, policy, and environment change</td>
</tr>
<tr>
<td>4</td>
<td>Diabetes Prevention Program: Primary prevention works</td>
<td>Reduced resources; varied levels of access to health care; racial and ethnic disparities in health care</td>
<td>Awareness messages and tools; pilot projects; system links to support lifestyle change</td>
<td>Increase awareness; identify barriers and opportunities</td>
<td>Change of program name; development of public health model for primary prevention of diabetes</td>
</tr>
</tbody>
</table>

in diabetes prevention; strategic national and state organizational partnerships mobilize and promote changes to community and health systems; tested models of effective strategies to improve community and health systems show measurable improvement in prevention services; and a growing public health work force has become skilled in surveillance and evaluation of chronic disease, changes in health systems, and building community coalitions. Table 2 summarizes the response of the NDPCP to the findings of scientific research.

As the number of persons with diabetes grows and resources remain limited, the future challenge is to continue to effect changes and improvements in diabetes prevention and control through mobilization and influence of diverse stakeholders who share common goals and can take complementary approaches. Slowing the epidemic of this complex and devastating chronic disease will continue to require synergistic action between public and private health systems and communities.

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