

# Primary prevention of type 2 diabetes: integrative public health and primary care opportunities, challenges and strategies

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Type 2 diabetes imposes a large and growing burden on the public's health. This burden, combined with the growing evidence for primary prevention from randomized controlled trials of structured lifestyle programs leads to recommendations to include caloric reduction, increased physical activity and specific assistance to patients in problem solving to achieve modest weight loss as well as pharmacotherapy. These recommendations demand exploration of new ways to implement such primary prevention strategies through more integrated community organization, medical practice and policy. The US experience with control of tobacco use and high blood pressure offers valuable lessons for policy, such as taxation on products, and for practice in a variety of settings, such as coordination of referrals for lifestyle supports. We acknowledge also some notable exceptions to their generalizability. This paper presents possible actions proposed by an expert panel, summarized in Table 1 as recommendations for immediate action, strategic action and research. The collaboration of primary care and public health systems will be required to make many of these recommendations a reality. This paper also provides information on the progress made in recent years by the Division of Diabetes Translation at the US Centers for Disease Control and Prevention (CDC) to implement or facilitate such integration of primary care and public health for primary prevention.

**Keywords.** Behavior, community, diabetes, lifestyle, primary care, primary prevention.

## Diabetes epidemic

Diabetes has emerged as a major public health problem in the 21st century. In the USA, an estimated 26 million people (8% of the entire population) have diabetes; 7 million of them are not even aware that they have the disease.<sup>1</sup> Over the last several decades, diabetes prevalence has increased 5- to 7-fold in the USA. In the USA, ~1.9 million new cases were diagnosed in adults in 2010.<sup>1</sup> For Americans born in the year 2000, the lifetime risk of developing diabetes is ~40% among females and 30% among males.<sup>2</sup> Diabetes is a major cause of blindness, kidney failure, cardiovascular disease, reductions in quality of life and premature death. In addition to causing much human suffering, it imparts major economic burdens, costing an estimated annual \$174 billion in the USA alone, and an increasing burden on medical care systems and resources everywhere.<sup>1</sup>

## Why primary prevention and integration of primary care with public health?

Effective management is essential for reducing morbidity and premature mortality related to diabetes and the tools for treating diabetes are stronger than ever before.<sup>3–6</sup> Primary prevention, however, is highly attractive as a complementary and integrated strategy for Type 2 diabetes for several reasons (Fig. 1). Firstly, the immense public health burden imposed by diabetes justifies action at the population level. Secondly, currently available treatments, while valuable, are costly, convey risks of harmful side effects (e.g. hypoglycemia), still have limited efficacy and are less likely to be effective for persons who have problems accessing medical care or adhering to self-care regimens. Thirdly, prevention of Type 2 diabetes by lifestyle modification is likely to produce beneficial other effects (e.g. reduction in risk of hypertension,

TABLE 1 *Proposed action items*

Setting	Immediate action	Strategic action	Research
Health care system	Measures Define uniform diagnostic criteria, high-risk state, outcome targets Screening, diagnosis and referral	Financing Support reimbursement for proven prevention programs Policy	Technology Identify affordable technologies for measuring glycemia Promote studies that link different clinical and community environments Research mobile technologies that help increase reach of proven prevention programs Assessment, evaluation and surveillance
	Assess risk and discuss risk status with patients	Identify policies that support sustainability and reach of proven prevention programs	Research mobile technologies that help increase reach of proven prevention programs
	Conduct prediabetes diagnostic test, as appropriate	Advocate for insurers and Medicare/Medicaid to pay for proven prevention programs	Assessment, evaluation and surveillance
	Refer patients with prediabetes to proven prevention program	Involve CMS to identify codes and reimbursement policies for diabetes prevention	Support national surveillance system for prediabetes
	Intervention delivery	Partnerships	Evaluate strategies to increase identification of those at high risk and participation in proven prevention programs
	Determine role of drugs/medications	Support the National Diabetes Prevention Program	Intervention delivery
	Support the National Diabetes Prevention Program	Establish multi-sectorial partnerships to advocate policy and environmental change and its evaluation	Research ways to increase sustainability and reach of effective prevention programs
	Support delivery of proven prevention programs in convenient locations	Encourage companies that advertise products that support unhealthy eating and sedentary behaviors to change products to healthier options	Research effective prevention strategies for those at lower risk (do not yet have prediabetes)
	Educate primary health providers about proven prevention strategies		Support natural experiments and opportunistic evaluations of policy and environmental changes, especially those that include the clinical sector
	Monitor glycemic status and cardiovascular risk factors in high-risk patients		Research pharmaceutical agents that are currently under investigation for prevention efficacy
Public health	Demonstration of best practices Lead by example Encourage institutions to adopt a 'healthy environment' (e.g. no convenience machines, provide activity breaks, encourage walking, integrate health clinics with gyms and fitness centers) Facilitate linkages between sectors that influence behavior and risk Provide feedback to primary health provider and medical records Support effective interactive technologies, e.g. websites) to provide support for lifestyle improvements		
	Intervention delivery Support implementation of the National Diabetes Prevention Program Support delivery of proven prevention programs in convenient locations	Policy Identify policies that support sustainability and reach of proven prevention programs Explore life and health insurance incentives for healthy lifestyle and prevention	Technology Promote studies that link different clinical and community environments Research mobile technologies that help increase reach of proven prevention programs

TABLE 1 *Continued*

Setting	Immediate action	Strategic action	Research
	Support training of workforce to deliver proven prevention programs	Organize local, statewide and Federal multi-agency task forces to identify and prioritize actions government can take to contribute to diabetes prevention, healthy eating and physical activity	Assessment, evaluation and surveillance
	Conduct quality assurance of prevention programs—certification program	Identify policies that improve worksite, school and community environments to support healthy lifestyles	Conduct national surveillance system for prediabetes
	Health communication	Explore strategies to eliminate ads for calorie-dense foods aimed at children and decrease screen time	Evaluate marketing strategies for healthy eating and physical activity that have been used effectively for tobacco control
	Provide messages and tools to increase knowledge of diabetes risk	Partnerships	Conduct opinion polling about potential policy changes to encourage healthy eating and physical activity
	Provide messages to high-risk population and health care professionals to increase uptake of proven prevention programs	Develop collaborative relationships and partnership among federal, state, local and private institutions to facilitate implementation of proven prevention programs for those at high risk and population-wide health promotion strategies	Evaluate ways to diffuse effective health promotion interventions for adults and youth
	Partnerships		Intervention delivery
	Develop collaborative relationships and partnership among federal, state, local and private institutions to facilitate implementation of proven prevention programs for those at high risk and population-wide health promotion strategies		Research ways to increase sustainability and reach of effective prevention programs
			Support natural experiments and opportunistic evaluations of policy and environmental changes
			Conduct economic studies of proposed intervention programs and policies
			Systematic review of neighborhood and environmental studies and their impact on diabetes and other health-related outcomes

hyperlipidemia, heart disease and certain cancers). Fourthly, most of the determinants of caloric intake, weight management and physical activity are beyond the reach or influence of medical care practitioners by themselves and are likely to be more amenable to public health efforts. Fifthly, since racial/ethnic and socio-economic disparities are the result of several factors, it is logical to suggest that integration of primary care and public health interventions will be needed to address these disparities.<sup>7</sup> Finally, a variety of primary prevention strategies, including both lifestyle modification and pharmacotherapy for those at high risk, have been rigorously tested in randomized controlled trials (RCTs) and proven efficacious.<sup>8</sup> Translation studies have been conducted in a variety of settings to provide guidance on cost-effective implementation of proven interventions.<sup>9,10</sup> However, these interventions need to

be implemented on a large scale if they are to reduce the growing incidence of Type 2 diabetes. Although less easily tested in controlled trials, public health strategies that produce mutually supportive changes in behavior, policies and environments at the community level may be more cost-effective with greater reach for mass intervention and can create synergy with structured lifestyle and pharmacotherapy interventions tailored to high-risk individuals.<sup>11</sup>

For these reasons, primary care medicine needs the support of public health or community interventions for primary prevention. Public health also needs the support of the medical care system. Assessing risk status, discussing risk and referring to a proven community-based prevention program is a critical role for the primary care practitioner. For many people, specific

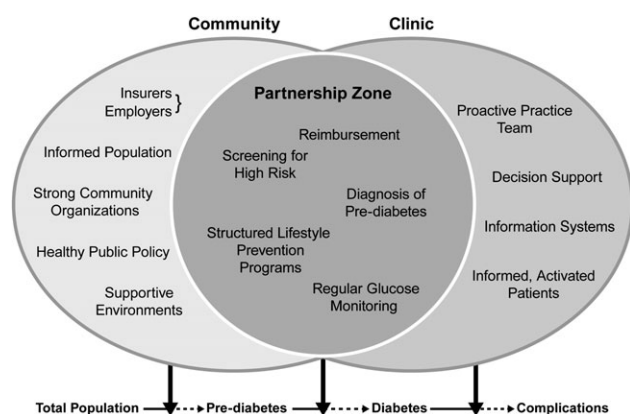


FIGURE 1 Prevention of Type 2 diabetes: The community-clinic partnership model; provided by Centers for Disease Control and Prevention, Division of Diabetes Translation. Elements in the clinical component are adapted from the Chronic Care Model, MacColl Institute for Health care Innovation. The elements listed in this figure are not intended to be all-inclusive but to provide information on the kinds of elements contributed by each sector and shared across sectors

encouragement by their health care practitioner is a key factor in taking action to improve their health.<sup>12</sup>

## Evidence for prevention from efficacy trials

RCTs of structured lifestyle modification have consistently demonstrated that caloric reduction plus increased physical activity leading to modest weight loss reduces the risk of incident Type 2 diabetes in adults at high risk by 50–70%.<sup>13</sup> Most relevant for the US population, but generalizable to other countries, is the Diabetes Prevention Program (DPP) research trial led by the US National Institutes of Health (NIH).<sup>8</sup> DPP recruited 3234 middle-aged overweight or obese adults with impaired glucose tolerance, a high-risk state for Type 2 diabetes. Participants were randomly assigned to one of three conditions: (i) a lifestyle intervention that employed behavioral counseling to promote caloric reduction and physical activity; (ii) metformin, a widely used anti-diabetic medication known to improve insulin sensitivity and (iii) a placebo for metformin (i.e. a control group). The DPP lifestyle intervention produced an initial weight loss of ~6% of body weight after 12 months, diminishing to ~4% after 3 years. The intervention also significantly increased self-reported physical activity (equivalent to brisk walking) from 100 to 190 minutes per week. The effect on diabetes incidence was impressive: compared to their counterparts in the placebo group, DPP participants in the lifestyle intervention group enjoyed a 58% reduction in incident diabetes over 4 years. This benefit was highly robust; it was observed in men and women across race and ethnic groups and it was even stronger at older ages.

RCTs have also generally shown pharmacotherapy to be effective for the primary prevention of Type 2 diabetes in high-risk adults, although few of those agents currently available on the market have been the subject of more than one trial. The DPP proved that metformin was safe and effective for primary prevention, producing a 31% reduction in diabetes risk. Protective effects of similar magnitude in adults with impaired glucose tolerance have been observed for acarbose<sup>14</sup> and orlistat<sup>15</sup>—oral agents not absorbed from the gastrointestinal tract that inhibit absorption of carbohydrates and fats, respectively. Stronger effects have been observed for troglitazone, the first of the thiazolidenediones, or TZDs, a class of insulin-sensitizing agents.<sup>16</sup> However, troglitazone was pulled from the market because of hepatotoxicity. Newer TZDs with little hepatotoxicity are available but have not been as rigorously tested for primary prevention. Most recently, pioglitazone reduced the risk of conversion of impaired glucose tolerance to Type 2 diabetes mellitus by 72% but was associated with significant weight gain and edema.<sup>17</sup>

## Lessons from blood pressure control

Hypertension is well established as a risk factor for heart disease, stroke, kidney failure and a wide array of other vascular diseases. In turn, obesity and sodium intake are major modifiable risk factors for high blood pressure. In lean economically isolated (Yanomamo and Xingu Indians of Brazil and rural populations in Kenya and Papua New Guinea) populations who consume fresh foods because there are few processed foods, high blood pressure is uncommon, and the age-related rise in blood pressure so common in the industrialized world is absent.<sup>18</sup> In the 1970s and 1980s, evidence from RCTs began to accumulate, indicating that pharmacotherapy agents could prevent vascular complications in hypertensive adults but that their effectiveness depended on detection of elevated blood pressures, behavioral changes and maintenance over time, much as with diabetes. Since the early 1970s and in recent years, trials have proved the efficacy of lifestyle modification to reduce blood pressure and prevent hypertension in adults at high risk.<sup>19</sup> In combination with increased community detection programs and compelling epidemiologic data, these trials of primary and secondary prevention led to a series of strong national recommendations for the prevention, detection and treatment of high blood pressure in the USA to enhance the National High Blood Pressure Education Program.<sup>20</sup> Coincident with these developments, many countries enjoyed historical declines in cardiovascular mortality. However, despite the impressive evidence base, the availability of a large pharmacologic armamentarium and a formidable degree of scientific consensus, prevention, detection and treatment of high blood pressure remains suboptimal.

This story holds several possible lessons for public health strategies aimed at primary prevention of Type 2 diabetes. Firstly, mere dissemination of knowledge about health benefits of lifestyle change is not sufficient: salt intake grew despite warnings that it contributed to hypertension risk. Secondly, drug therapy can play a major role if the drugs are strong and safe, if wedded to a campaign of awareness and detection and if accompanied by systematic interventions to ensure access and adherence to prescribed regimens. Thirdly, limited long-term data on lifestyle modification has contributed to challenges in achieving policy change. Finally, while the food industry responded with some low-sodium food options, these have thus far been insufficient to promote change in overall salt intake. Although the 2005 Dietary Guidelines for Americans urged reduced sodium in the diet, it was not until 2010 that the Dietary Guidelines featured substantially reduced sodium intake as a priority over dietary fat or trans-fat reduction.

## Lessons from tobacco control

Heart disease-, cancer-, stroke- and chronic lung disease-related deaths have been declining thanks to a combination of medical and public health developments in the last third of the 20th century.<sup>21</sup> On the medical side, developments in pharmaceutical agents and other improved treatments have been notable, as described for hypertension above. Among the most notable developments on the public health side have been the acceleration of reductions in tobacco consumption and exposure of non-smokers to secondhand smoke following the implementation of statewide tobacco control programs and policies in California, Massachusetts, Florida, Arizona, Oregon and Mississippi.<sup>22</sup> The prevalence of smoking declined for most age groups and all race/ethnicity groups in California and both youth smoking and aggregate cigarette sales have declined significantly and independently in proportion to tobacco control program expenditures in states that followed California's lead.<sup>23–25</sup> Cardiovascular disease rates improved swiftly after smoking prevalence declined and rebounded when the California program support was cut back.<sup>26</sup> Rates of chronic lung disease and bronchial cancer responded as well, although with greater lag times. These improvements were especially noticeable in California, with lung cancer rate declines four times greater than in the rest of the USA.<sup>27</sup>

The tobacco control story conveys several possible lessons. Firstly, success in health behavior change was achieved largely by coordinated public health policy, regulatory, mass media and environmental control means. Although individually tailored programs of behavior change and pharmacotherapy to reduce nicotine dependence were certainly available, their reach

and efficiency were far less than policies that prevented initiation of smoking and prevented smoking in public places.<sup>28</sup> The strategies that appear to have been most effective related to the intermediate targets of (i) changing social norms of public behavior, (ii) restraining the advertising by industries that market tobacco products and (iii) increasing the cost of the behavior through pricing strategies. Secondly, the public health approach generally produced successful behavior change across boundaries of age, sex, race and ethnicity (the per cent decline in smoking among African-American and Hispanic males and females were greater in California between 1990 and 2005 than in non-Hispanic Whites),<sup>29</sup> although many disparities in smoking prevalence persist across strata of socioeconomic status. Thirdly, it demonstrates the potential that lies outside the health care system for empowering individuals, organizations and communities to self-manage behavior change.<sup>30–35</sup> Fourthly, strength of infrastructure—including number and training of personnel, level of funding and presence of coalitions—was directly related to policy change and reductions in smoking rates.<sup>35</sup> Finally, the tobacco control story highlights the role of communities and states as laboratories for innovating and evaluating policy change.<sup>36</sup>

Although these 'lessons' have served as guides, if not inspiration, in other public health initiatives, their generalizations to physical activity and nutrition must acknowledge that the issues in changing these more pervasive behaviors and associated lifestyles, commercial interest, environmental and media influences will bring other, often more complex, issues into play.<sup>30–34</sup> Indeed, with cutbacks in the state funding of their comprehensive tobacco control programs and relative magnitude of tobacco industry spending, there are no guarantees that the advances in tobacco control can be sustained.

## Proposed actions to help translate diabetes prevention into practice

A multidisciplinary panel of US experts selected by Centers for Disease Control and Prevention (CDC) leadership at the time reviewed various issues related to diabetes prevention in a 2-day meeting. An international group selected and convened by their Dutch hosts at the Heelsum symposium in 2010 further examined the comparative issues of primary care and community collaboration on weight management across various nations. Both groups represented those disciplines and professions seen by their organizers as having leadership roles in primary prevention of Type 2 diabetes, especially weight management, in various sectors and populations. The first panel enumerated specific action items to help speed translation of proven diabetes prevention strategies into practice. The panel avoided



explicit prioritization since the expert consensus was that priorities would differ across settings. Rather, the goal was to offer a comprehensive menu of possibilities that cut across disciplines and settings. The possible array of action items is summarized in Table 1. For ease of presentation, the action items in Table 1 were grouped into a  $2 \times 3$  classification scheme based on primary locus of action (Health Care System versus Public Health Settings) and type of action (Immediate Action versus Strategic Action versus Research). These classifications, however, are not to imply choices that need to be made between the categories. They should be approached as potentially synergistic or at least additive, interventions and policies.

In the health care system, 'immediate actions' might be designed to enhance risk identification and stratification, counseling on risk reduction, referral to proven community-based prevention programs and pharmacotherapy. Such improvements might be accelerated by better adherence to practice guidelines, changes in reimbursement for preventive services and promotion of continuing medical education related to diabetes prevention. 'Strategic action' might include greater changes in reimbursement for preventive services such as reimbursement to medical practitioners for referral and reimbursement to a community-based organization and encouraging state governments to undertake and evaluate broadly based model prevention programs for whole populations as 'natural experiments'. 'Research' might focus on information technology designed to detect individuals at risk, facilitate behavioral counseling and cost-effectiveness evaluations and better link clinics to community settings.

In public health settings, immediate actions might include public dissemination of prevention messages via the mass media, Internet and care providers as well as policies to fund implementation of evidence-based programs and regulations in schools, worksites, community organizations and health care settings.<sup>37,38</sup> Strategic action might promote new partnerships to guide interventions to improve physical activity and/or diet, to facilitate sustainable funding for evidence-based lifestyle programs and to create health-promoting after-school environments for young people and health-promoting work environments for adults. Research might focus on improved diabetes surveillance, Internet-based structured lifestyle programs and interventions aimed at youth at home and at school.

The scale of the diabetes epidemic and the contribution of common risk factors to other chronic diseases will require interventions to address environmental and policy determinants of physical activity and diet such as community design, transportation policy, park and recreation policy and funding, school physical education laws and availability and cost of healthful foods.<sup>39–41</sup> Strategic action might include the establishment of multi-sector partnerships to advocate policy and

environmental change and their evaluation. Research in this area might include opinion polling about support for potential policy changes among policy makers and the public, systematic evaluation of community interventions, cost-effectiveness studies and natural experiments to identify the most practicable areas of policy and environmental change for intervention. This research requires interdisciplinary collaboration with epidemiologists, urban planners, social scientists, policy experts and others.

The panel recognized that this classification scheme in Table 1 was in some ways artificial: many of the action items spanned horizontally, linking the health care system with the public health setting, as suggested by Figure 1; others spanned vertically, incorporating ongoing research into clinical and public health action. Recognizing the importance of such cross-cutting themes, in the following paragraphs, the authors highlight a few.

## Quality of care/quality improvement

Although we know the general principles that guide primary prevention of Type 2 diabetes from the DPP research trial and obesity trials, knowledge alone will not translate into improved care. The Institute of Medicine's landmark report on *Crossing the Quality Chasm* demonstrated that the quality of care will not improve from information alone.<sup>42</sup>

Efforts to improve quality of care in various jurisdictions have emphasized the measurement of evidence-based processes of care and outcomes as the first step in both internally and externally driven quality improvement efforts.<sup>43</sup> For the health care organization and provider, such data allow self-assessment and direct attention to areas that need quality improvement. Externally, such data have been used for public reporting, which in theory can improve care by allowing health care purchasers and consumers to choose high-quality providers and provide an incentive for providers to improve their care. In addition, growing efforts by private payers in the USA—and, more recently, the US Centers for Medicare and Medicaid Services (CMS)—to reward high-quality care with increased reimbursement—so-called 'pay for performance'—provides an additional financial incentive.

Thus, prevention and control of conditions like Type 2 diabetes seems to call for incorporating process-of-care and outcome-performance measures into both governmental quality improvement efforts to measure quality of care and private efforts such as the US National Committee on Quality Assurance's HEDIS measures that assess the quality of care in managed care organizations. The first line of assessment would logically relate to patient screening and counseling on risk factors predicting subsequent development of diabetes.

Persons from minority groups are at higher risk for diabetes and have sometimes received inferior care and had worse outcomes.<sup>7</sup> Therefore, quality improvement efforts will need to take special care to ensure that no incentives exist for unintended consequences. For example, reforms should not pay less to organizations providing care for particularly challenging patients, such as those with advanced disease or multiple co-morbidities.

## Issues related to youth

American estimates of diagnosed diabetes prevalence for people <20 years from the SEARCH for Diabetes in Youth Study were 0.26%.<sup>44</sup> A consensus panel convened by the American Diabetes Association and the American Academy of Pediatrics recommended that testing for Type 2 diabetes be performed every 2 years in the context of a health care visit for overweight or obese children aged 10 years and older in the presence of other risk factors.<sup>45,46</sup>

With regard to primary prevention, most experts agree that clinicians should prescribe and support lifestyle (diet and activity) modification for the entire family as well as for the patient, in an age-appropriate manner and as the prerequisite for all overweight and obesity treatments for children and adolescents. One study showed the long-term benefits of family-based lifestyle interventions in the clinical setting on weight and risk factors in obese youth.<sup>47</sup> However, few clinics have the resources or expertise to offer evidence-based lifestyle interventions, so funding and training are needed, in addition to greater collaboration, referral and integration with community and public health resources.

While some school-based interventions have produced sustained improvements in physical activity or diet,<sup>48</sup> most have focused on one element of lifestyle change and offer little evidence of having substantially improved body mass index (BMI) or other diabetes-related outcomes.<sup>49</sup> The HEALTHY study (part of the STOPP-T2D study funded by the NIH) reduced the per cent of middle-school students with BMI >95th percentile (obese) but did not show a significant effect on reducing the percentage of >85th percentile (overweight and obesity combined).<sup>50</sup> Other benefits of the trial were observed, including reduced fasting insulin levels and waist circumference. Community-based interventions are proliferating, although there is little consistency in the data on outcomes.<sup>51,52</sup> As we await further public health interventions, with more consistent outcome data, interventions delivered in child care, preschools, schools, communities, medical settings, etc. should continue to focus on improving energy balance in youth.

### *Translating diabetes prevention to the public health sector*

The very promising but intensive and costly lifestyle intervention of the DPP research trial was designed

for efficacy and not for sustainable delivery by a community organization.<sup>8,53,54</sup> The design of effective 'real world' models for implementing the DPP lifestyle intervention requires a collaborative effort that balances fidelity to the DPP design with additional incentives, communications and organizational elements that predispose, enable and reinforce behavioral changes in both practitioners and patients and that optimize reach, adoption and implementation and effectiveness, minimize cost and improve sustainability for capable community partners.<sup>55–61</sup>

Two major barriers that have prevented translation of DPP findings to the growing population of people who might benefit are the cost and the one-on-one intervention format.<sup>62</sup> For the DPP to extend into the public health sector, it is necessary to demonstrate effective strategies to: (i) identify persons in community or clinical settings with risk characteristics similar to the DPP study population and (ii) optimize referral and participation in lifestyle interventions modeled after the DPP but adapted for broad-scale delivery in community settings.

Several translation studies and demonstration projects have been conducted to address these issues. These studies illustrate the bridge we seek to build between more strictly clinical, RCT-based interventions and the community-level interventions required to achieve greater reach and cost-effectiveness.<sup>9,10,63</sup> For example, two studies supported by the NIH evaluated the feasibility and effectiveness of training Y (formerly called YMCA) wellness instructors to deliver a group-based adaptation of the DPP lifestyle intervention in Y facilities.<sup>9,64</sup> The first of these studies used a social marketing approach to recruit persons with diabetes risk factors within the communities served by specific Y facilities to a free screening event in which each individual's risk status is ascertained using a combination of the American Diabetes Association risk assessment tool and capillary glucose values.<sup>9</sup> Persons identified as having increased risk for abnormal glucose metabolism were offered access free of charge to the adapted DPP lifestyle intervention at the Y and were followed prospectively to determine the effectiveness of the new program to achieve the meaningful changes in weight and cardiovascular risk-factor levels that translated into improved health outcomes in the DPP clinical trial. This study showed a 6% weight loss over 1 year which is in line with the weight loss achieved in the DPP research trial.

The second study focused on the feasibility and effectiveness of a clinic-based strategy to identify, counsel and refer patients for participation in a community-based lifestyle intervention.<sup>64</sup> Practices in this study are using a two-stage screening procedure in which adult patients with two or more diabetes risk factors are encouraged to attend a formal prediabetes-test visit that involves both fasting and 2-hour post-challenge glucose

tests using a capillary blood sample. This approach was chosen because capillary samples offer reasonable sensitivity and specificity for discriminating normal from impaired glucose tolerance (i.e. the primary DPP risk characteristic),<sup>65,66</sup> are considerably more feasible to perform at a high volume in busy primary care settings and offer the advantage of immediate feedback to patients about their risk levels. This study is evaluating not only the feasibility of this overall screening approach but also different strategies to optimize participation by high-risk patients, who are offered brief advice followed by referral to a community-based DPP lifestyle intervention at either a nearby Y facility or a DPP study research site.<sup>64</sup>

Economic modeling studies suggest that, even if these adapted interventions proved only half as effective as the original DPP approach, they are still likely to be cost-effective and could be financed in a way that achieves short-term return on investment for a private health insurer offering the program.<sup>67</sup> Moreover, the studies illustrated the kind of novel partnerships among a health system, an academic institution and a community-based organization that are especially appealing for translation.

Based on its own examination of these experiments and other pilot work they conducted, the CDC's Division of Diabetes Translation (CDC/DDT) began plans to carry out the National Diabetes Prevention Program in 2009 and was authorized in the 2010 Affordable Care Act to oversee and manage this program. CDC/DDT is taking a strategic approach to creating the National Diabetes Prevention Program. This approach includes the core elements of: (i) Training—helping train the workforce that can implement the program cost effectively. To do this, CDC/DDT has established the Diabetes Training and Technical Assistance Center at Emory University. (ii) Program Recognition—setting standards that will help assure program quality and consistency which are necessary components for effectiveness and reimbursement. (iii) Intervention sites—supporting the start-up of sites easily accessible in the community that will deliver the intervention and working with third-party payers to initiate and sustain intervention funding. (iv) Health Marketing—raising awareness among both health care providers and high-risk populations to increase referral and use of the program.<sup>68</sup> The inaugural participating organizations working with CDC/DDT in the National Diabetes Prevention Program are the Y's delivering the 16-session core and monthly post-core sessions (total 1-year program) and United Health Group which includes United Health Care, a third-party payer, that is providing payment for the intervention on a pay for performance basis. As the CDC program recognition is implemented, more organizations will be involved in delivering the intervention and additional third-party payers will participate.

A promising model is being tested by Finland for nationwide dissemination of a highly beneficial and

cost-effective approach to diabetes prevention.<sup>54–56</sup> Other European models are being tested. In Germany, an implementation process is underway that includes the pay for performance medical care concept and clear implications for quality management with incentives for patient coordination, patient education, referral, plus structural and public health integration.<sup>57</sup>

## Creating and funding an infrastructure for promoting healthful eating and active living

Although some evidence has accrued about effective interventions to improve physical activity and eating behaviors,<sup>49</sup> there is limited infrastructure or funding in place to apply this knowledge by widely implementing evidence-based interventions or to generate more practice-based evidence from innovations in the absence of much controlled-trial evidence of what works. Because of extensive promotion of foods of low nutritional quality and products like cars, television programs and computer games that enable people to be sedentary, a major counterforce may be needed to promote healthful habits. There are models for multi-sectoral physical activity and/or nutrition coalitions led by governments of other countries, notably Australia,<sup>34</sup> and in the Healthy Eating-Active Living Convergence Partnership in the USA, which includes the Robert Wood Johnson Foundation, the WK Kellogg Foundation, Kaiser-Permanente, CDC, the California Endowment and Nemours Health and Prevention Services ([www.rwjf.org](http://www.rwjf.org)). The US National Physical Activity Plan which is a multi-sector plan developed with input from several groups serves as a useful guide for improving physical activity.<sup>69</sup> Partnerships and collaborations could be expanded.<sup>33,70–73</sup> The largest efforts of this type are CDC's Communities Putting Prevention to Work, which is supporting 39 communities to implement policy, environmental and system changes to prevent obesity and address tobacco use<sup>74</sup> and Community Transformation grants to reduce chronic diseases, promote healthy lifestyles, reduce disparities and control health care spending.<sup>75</sup> Evaluations are underway to document lessons from these experiences. Multi-sectoral coalitions are prioritizing promising interventions guided by available research, advocating for changes in policies and participating in surveillance to evaluate effects. Such groups are promoting improved interventions across a variety of settings, including health care, private industry, multiple government agencies and education.

Tobacco taxes and legal settlements with the tobacco industry have provided financing for tobacco control activities in a few states, but few comparable funding sources have been mobilized for promoting physical activity and healthful eating. New taxes on foods and beverages



have been proposed, but public support is uncertain. Parking fines have been dedicated in part to support mass transit in some cities. Willingness-to-pay studies and public opinion polling will be needed to identify acceptable funding options that might include a combination of dedicated taxes and fees, government support from general funds, voluntary contributions from industries and philanthropic contributions. The 2010 Affordable Care Act's health promotion and prevention fund that will support obesity prevention through 'community transformation grants' on an ongoing basis.<sup>75</sup> This funding source should allow community initiatives to gain strength and innovations to be demonstrated and evaluated.

Finally, the worksite promises to be a cost-effective settings and infrastructures for community-clinical interface, insofar as employers are often engaged both in the insuring of clinical care and in the promotion and protection of health in the employee population and environments.<sup>76–78</sup> This and other community settings offer opportunities for the generation of practice-based evidence to complement and extend the necessarily limited evidence-based practices from controlled trials.<sup>46</sup>

## Conclusions

The growing epidemics of overweight, obesity and Type 2 diabetes demand urgent and coordinated attention. Primary prevention of Type 2 diabetes is a logical strategy in light of the scale and the cost of ongoing medical treatment for the diabetes epidemic and the inevitable increases in diabetes incidence with the overweight and obesity epidemics. Behavioral strategies tailored to high-risk individuals have proven effective in RCTs. Adaptation of these evidence-based strategies for use in community settings has been under investigation with promising results now being taken to scale and evaluated by CDC/DDT and partners. Given the size of the diabetes epidemic and the number of people at high risk approaches aimed exclusively at individual behavior change in clinical settings will likely prove inadequate for diabetes control at the population level. Improvements in policy and the environmental factors summarized in Table 1 would predispose, enable and reinforce more healthful diets and more active lifestyles for widespread and sustained behavior changes. These will require development of infrastructure, environmental and policy changes and ongoing funding of a multilevel, multidisciplinary approach and an experimental attitude at the state and local levels to allow public health researchers to evaluate the ingredients of successful innovations that constitute natural experiments in diabetes prevention.

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