Models for collaboration: how system dynamics helped a community organize cost-effective care for chronic illness

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Abstract

Chronic illness is a large and growing problem throughout the world. Experts agree that the U.S. health care system is poorly organized to care for chronic illnesses and, as a result, is wasteful and unresponsive to the needs of patients. This article describes a program to improve chronic care in a county of Washington State, and how system dynamics models focusing on diabetes and heart failure supported the planning of that program. The models project the program's costs and benefits over 20 years and have given its leadership the ability to do resource planning, set realistic expectations, determine critical success factors, and evaluate the differential impacts on affected parties. Relying upon model projections, the leadership is seeking ways to address concerns about financial "winners" and "losers" so that all parties are willing to participate in and support the program. Copyright © 2004 John Wiley & Sons, Ltd.

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Magnitude of chronic illness as a problem

Chronic illness—that which lasts more than three months and is not self-limiting in nature—is a huge and growing problem in the U.S.A. and throughout the world. Chronic illnesses are the leading cause of illness, disability, and death and are responsible for at least 70% of all health care expenditures in the U.S.A. (Hoffman *et al.* 1996; Institute for Health and Aging 1996). More than half of the adult population in the U.S.A. has at least one chronic illness and the number of the chronically ill is expected to grow from 125 million in 2000 to 157 million by 2020. About half of those with a chronic illness have more than one such affliction, and are responsible for the great majority of the total cost of chronic illness. The aging of the population will drive growth in the prevalence of chronic illness, as one third of the chronically ill are over 65. People over 65 currently make up 13 per cent of the population, but that segment will reach 20 per cent by 2030 after the entire "baby boom" population has reached age 65. Chronic illness is much more prevalent among the older population, as is the likelihood of having two or more chronic conditions, and will grow in importance and cost as the population ages (IoM 2001; Partnership for Solutions 2004).

A recent report by the Institute of Medicine of the National Academy of Sciences (IoM 2001) suggests that the health care system in the U.S.A. is not up

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to the challenge posed by chronic illness, describing it as "poorly organized". It states that, "The prevailing model of health care delivery is complicated, comprising layers of processes and handoffs that patients and families find bewildering and clinicians view as wasteful." Involvement of patients and their families in care is especially important in chronic illness where they can provide much of the care and make a difference between good outcomes and deteriorating health. The report indicates that fundamental change is needed to effectively deal with chronic illness.

systems, and development of interactive learning environments for helping managers and providers better understand those systems.

Mary Minniti has worked in the health care quality improvement profession for the last eight years, and is Project Manager for the Pursuing Perfection Project of Whatcom County in Washington State. She is a Certified Professional in Healthcare Quality, with a BS in sociology from the University of Oregon. She has worked for over 20 years in the social service field, promoting and initiating innovative community programs for improving education and employment opportunities for at-risk populations, and coordinating the involvement of a wide variety of organizations to ensure that the programs benefit all stakeholders.

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The Pursuing Perfection Program

This article describes a program to improve the care of chronic illness in Whatcom County, Washington, and the role played by a pair of system dynamics models in support of that program. The county is semi-rural and its largest town is Bellingham, about two hours north of Seattle. It has a population of 171 thousand with 14 per cent living below the poverty line. The program is a collaborative effort of healthcare providers in Whatcom County and includes two of the leading insurers active there and a primary Medicaid (government-funded coverage for people with low income) insurer that has recently joined the effort. The program has received $1.9 million in funding from the Robert Wood Johnson Foundation (RWJF) as one of seven sites in a larger program called Pursuing Perfection ("P2") that is designed to improve the care of chronic illness (Pursuing Perfection Learning Network 2004). Whatcom County's P2 program built on a foundation of cooperation that had already been established in the county.

Pursuing Perfection in Whatcom County is focused on the following problems:

- *Poor cooperation among organizations*. More competition between organizations than cooperation on behalf of patients.
- *Poor patient care*. Care is often unsafe, unscientific, filled with delays and inefficiencies, not seamless, not transparent, broken up into silos of care, and delivered inequitably.
- *Lack of focus on chronic care*. Although chronic care is responsible for the majority of healthcare utilization and costs, the current system is designed more around acute care than chronic care.
- Consequently, *chronically ill patients carry the burden* of an inadequate health care system.

In line with the Institute of Medicine's recommendations, the mission of the Whatcom County P2 program is to create a community-based system of chronic care that it is patient-centered, evidence-based, effective, safe, timely, and equitable (Patient Powered 2004).

systems to improve health care quality in Whatcom County. He is a long-standing member of the executive team at Whatcom County's St. Joseph Hospital, and Project Executive for the Pursuing Perfection Project. He has also led the implementation of a community-wide clinical information network and medical record availability securely across the community.

The program is initially concentrating on two chronic illnesses as prototypes for improved care: Type 2 diabetes and heart failure. Both of these illnesses affect a great many people in the U.S.A. and other countries. About 17 million people have Type 2 diabetes (NIDDK 2004a) and nearly 5 million have heart failure in the U.S.A. alone (AHA 2000). Total costs of diabetes in the U.S.A. in 2002 were estimated to be $132 billion, with $92 billion of that in direct medical expenditures and the other $40 billion in indirect costs due to disability and premature mortality (NIDDK 2004a). Heart failure was estimated to cost $38 billion in 1991 in health care costs alone (O'Connell and Bristow 1993). The prevalence of both diseases is growing rapidly as the population ages and the number of people above age 65 increases. Obesity, the prevalence of which has more than doubled in the past 20 years in the U.S.A. (Flegal *et al.* 2002), has also contributed to the growth of diabetes prevalence and heart disease, as well as being a risk factor for several other chronic diseases (NIDDK 2004b). The following sections describe how the disease processes of diabetes and heart failure were modeled, with special attention to diabetes, and how the results were used to further the goals of the P2 program.

Role of system dynamics in Pursuing Perfection

The Whatcom County P2 program had two critical needs for making decisions about potential interventions for improving the care of chronic illnesses such as diabetes and heart failure:

- Getting a sense of the overall impact of these interventions on incidence and prevalence of diabetes and heart failure, health care utilization and cost, and mortality and disability rates in the community.
- Understanding the impact of the various interventions on individual health care providers in the community and on those who pay for care—insurers, employers, and individuals. There was a concern that the costs and benefits of the program be shared equitably and that providers who helped produce savings not be overly penalized by a loss of revenue that might result.

These needs could not be met with common quantitative tools such as spreadsheet models that project impacts in a simple, linear fashion. Interventions in chronic illness do not have simple direct impacts. The aging of the population, incidence of new cases and progression of disease, deaths, and the interventions themselves all create a constantly changing situation. For example, interventions ideally reduce mortality rates, leaving more people with the disease alive and requiring care at a later point in time. Similarly, people prevented from advancing to a more serious stage of the illness will have fewer health care requirements at a later point in time.

People kept from developing the disease altogether have even fewer needs and better prognoses. What mix of preventive programs and more active treatment of those who already have the disease yields the best results for the community? How might screening programs that identify these illnesses at an earlier stage improve outcomes? To fully evaluate these interventions, it is necessary to be able to track the effects of interventions over time.

The stock-and-flow structure of system dynamics models is ideal for this purpose. The models that were developed for diabetes and heart failure track flows of patients across several stages of severity of illness, calculating health care requirements and mortality and disability rates for patients at each stage. Interventions slow the rates of progression across these stages as well as preventing the disease in the first place.

The models offered additional capabilities that would help to advance the goals of Pursuing Perfection:

- They would support sensitivity analyses to help deal with uncertainty in the available data. With the models, we could create a range of projections to illustrate possible impacts, from worst-case to best-case scenarios. Conservative (worst-case) scenarios would be helpful for for those reluctant to take risks who worried that certain benefits of the programs might not materialize.
- The models would also provide a framework in which to assess controversial issues and get a better understanding of them in the context of the larger system. For example, the literature on both diabetes and heart failure contains an active debate about the value of screening at-risk patients to find those who are at an early, asymptomatic stage of the disease. Both models would provide a framework for testing different screening strategies and understanding their costs and benefits.
- It would also be possible to compare different implementation paths and understand their consequences for resource requirements and impacts. Providers and insurers initially involved in P2 represented only a fraction of the community's health care system. The manner in which others were assumed to get involved or whether they got involved at all would have a major impact on the magnitude and timing of the project's benefit to the community.

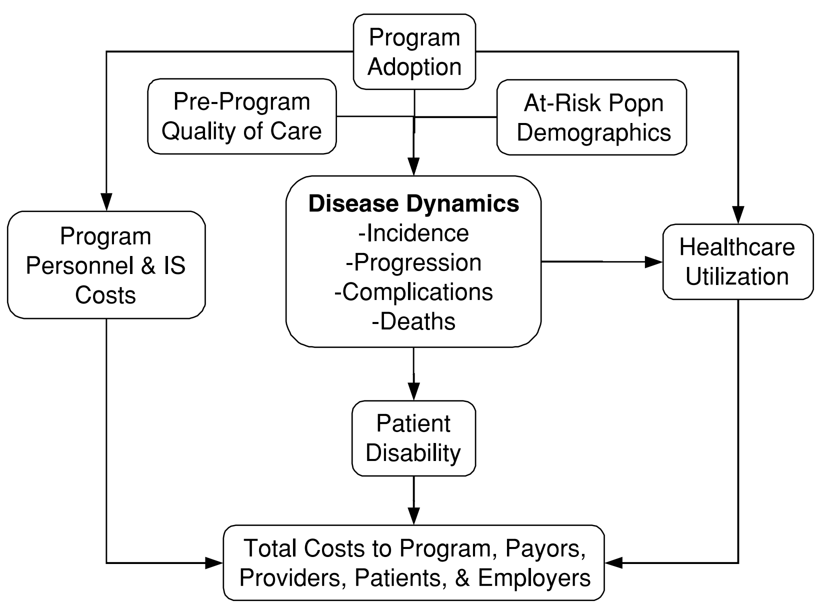
Modeling of chronic illness in this project draws on an extensive body of system dynamics work on specific chronic illnesses such as cardiovascular disease (Luginbuhl *et al.* 1981; Hirsch and Wils 1984), on dental care and oral health (Hirsch and Killingsworth 1975), and on a microworld dealing with community health status in which chronic illness is a central focus (Hirsch and Immediato 1998; 1999).

The community will eventually want to do model-based analyses for all of the other major chronic illnesses. Diabetes and heart failure are a starting point and serve as prototypes. Expanding the range of chronic illnesses will eventually let us model the synergies of treating risk factors that lead to multiple chronic illnesses and the downstream benefits of treating one such as diabetes that can be a risk factor for others such as heart failure. The models will eventually be able to show how creating a treatment and prevention infrastructure to do this will have beneficial effects on multiple illnesses.

A modeling framework

Pictured in Figure 1 is the conceptual framework we used for modeling the costs and benefits of a program to address any particular chronic illness. Program adoption by providers of care occurs against a backdrop of the community's demographics, prevalence of the disease, and the prevailing approach to caring for the disease. The program may have significant infrastructure costs, including costs of program personnel (administrators, consultants, clinical care specialists) and the costs of information systems that allow providers and patients to record and share data electronically. Adoption of the program leads to a shift in care patterns, typically toward greater intensity of planned, non-urgent, care, which, in turn, directly affects health care costs. This shift in care is intended to reduce the incidence and progression of disease and consequent complications and deaths. Reductions in the health care costs associated with diseases, as well as productivity losses due to disability, ideally would offset the added costs of infrastructure and greater intensity of planned care, resulting in a net savings for the community as well as improving outcomes for patients.

Fig. 1. A framework for modeling chronic illness program impacts



Applying the modeling framework to diabetes

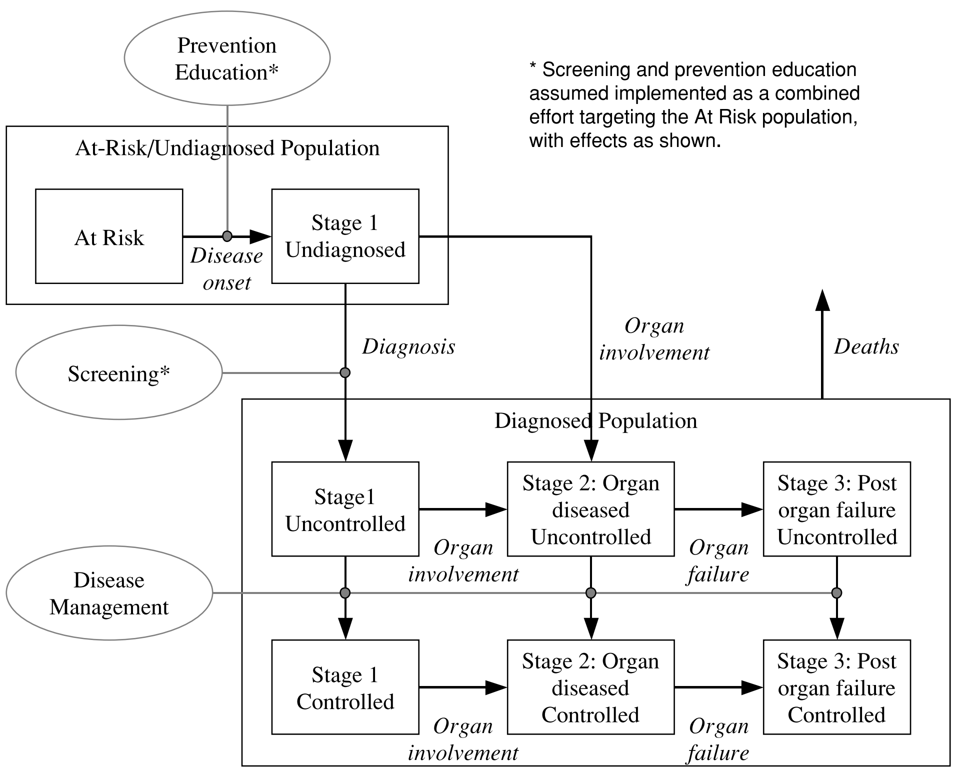
Application of the modeling framework to a specific chronic illness and intervention program requires the specification of four things:

- the patient stock-and-flow structure for the illness and its calibration to reflect data for a typical patient population;
- the types, amounts, and unit costs of healthcare utilization associated with the patient stock-and-flow structure;
- how the program would affect patient flows;
- how the program would directly affect infrastructure and health care costs.

In the remainder of this article examples of model structure and behavior will be presented for Type 2 diabetes. Space constraints here do not allow for a similar presentation of heart failure, which may, however, be found in a previous version of this article (Homer *et al.* 2003).

Figure 2 presents a somewhat simplified view of the stock-and-flow structure used in modeling Type 2 diabetes. The actual model has two separate

Fig. 2. Diabetes stages and intervention points



structures like those shown in Figure 2, one for the 18-to-64 age group and one for the 65-and-older age group, which are linked by flows of patients turning 65. The model also calculates an inflow of population turning 18, death outflows from each stock based on patient age and stage of illness, and flows of migration into and out of the county. The three stages of diabetes portrayed in this figure were identified through discussions with clinicians in Whatcom County.

About 30 per cent of the general population is at risk for developing diabetes primarily by virtue of being overweight and physically inactive, or having a family history of diabetes. Diabetes develops through several stages. Increased sugar in the blood of a pre-diabetic leads to changes that weaken the body's ability to maintain blood sugar control, and take a patient from pre-diabetic to Stage 1 diabetes, unless treated with oral medications and/or changes in diet and activity. Most Stage 1 diabetics, up to two-thirds of all diabetics, have no outward symptoms, and more than half are undiagnosed.

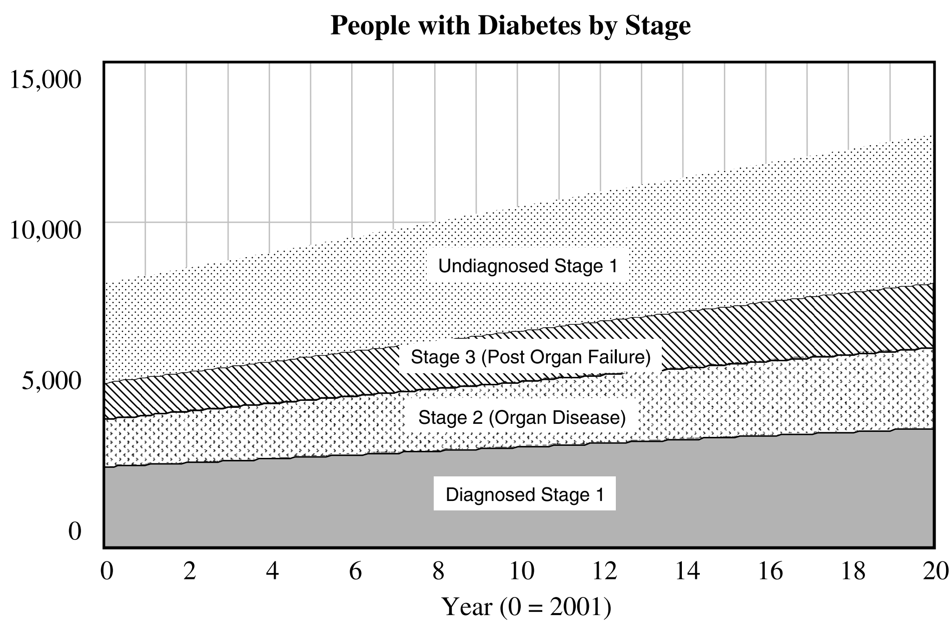
If Stage 1 diabetics go untreated, most will eventually progress to Stage 2, marked by organ disease. In Stage 2 diabetes (about 18 per cent of diabetics in Whatcom County), blood flow disturbances impair the functioning of organ systems and potentially lead to heart attack, stroke, kidney disease, peripheral vascular disease, loss of sensation in the extremities, or eye disease (retinopathy, glaucoma, cataracts). At this stage it is still possible to reduce complications through glycemic and blood pressure control. A patient who has suffered irreversible organ damage, or organ failure, is said to be in Stage 3 (about 14 per cent of diabetics in Whatcom County); this would include patients post-heart attack, post-stroke, post-amputation, with end-stage renal disease, or with blindness. These patients are at the greatest risk of further complications leading to death. Despite the advanced state of their disease, even Stage 3 diabetics may benefit from glycemic and blood pressure control.

Several studies have demonstrated that the incidence, progression, and complications of diabetes can be reduced significantly through concerted intervention (Wagner *et al.* 2001; ADA/NIDDK 2002). As indicated in Figure 2, primary prevention would consist of efforts to screen the at-risk population and educate pre-diabetics about the lifelong diet and activity changes they need to prevent progression to diabetes. Intensive preventive programs for pre-diabetics can reduce the incidence of diabetes by 50–60 per cent. For confirmed diabetics, a comprehensive disease management approach, such as that employed by the P2 program, can increase the fraction of patients under control from the 40 per cent typically seen without a program up to nearly 100 per cent for those patients who make the required lifestyle changes and take the required medications. (We have estimated more conservatively, based on conversations with providers, that a maximum of 80 per cent of known diabetics could be brought under control under P2.) The benefits of control are substantial: disease progression is reduced by perhaps two-thirds, and the hospitalization rate at each stage of the disease cut by about half.

The diabetes model was implemented in Vensim,[1] using its array capability to replicate the structure shown in Figure 2 for the 18–65 and over-65 age groups, several different primary care providers participating in P2, and for patients covered by a number of different insurers. As indicated earlier, this disaggregation was important for being able to see how the costs and benefits of P2 would fall on different health providers and insurers. The model also includes an extensive set of calculations of health care utilization and costs for each of the subgroups defined by this array structure.

Figure 3 presents a 20-year *status quo* projection of diabetes prevalence by stage in Whatcom County, which assumes no intervention program. The total number of diabetics grows from about 8,000 in 2001 to nearly 13,000 in 2021, an average growth rate of 2.2 per cent per year. During this same period the total county 18-and-over population grows by only 1.5 per cent per year. As a result, diabetics increase from 6.5 per cent of the population to 7.5 per cent over the 20 years. The reason for this growth of diabetes, more rapid than that of the overall population, is that the prevalence of diabetes is much greater among the faster-growing elderly population (with about 17 per cent prevalence of diabetes) than among the slower-growing non-elderly (less than 5 per cent prevalence of diabetes). Note in Figure 3 that the distribution of diabetics by stages remains about the same throughout the simulation. This reflects an assumption that there are no significant advances in diabetes diagnosis and care, such as those contemplated by P2, and no further increases in the fraction

Fig. 3. *Status quo* projection of diabetes in Whatcom County, 2001–2021



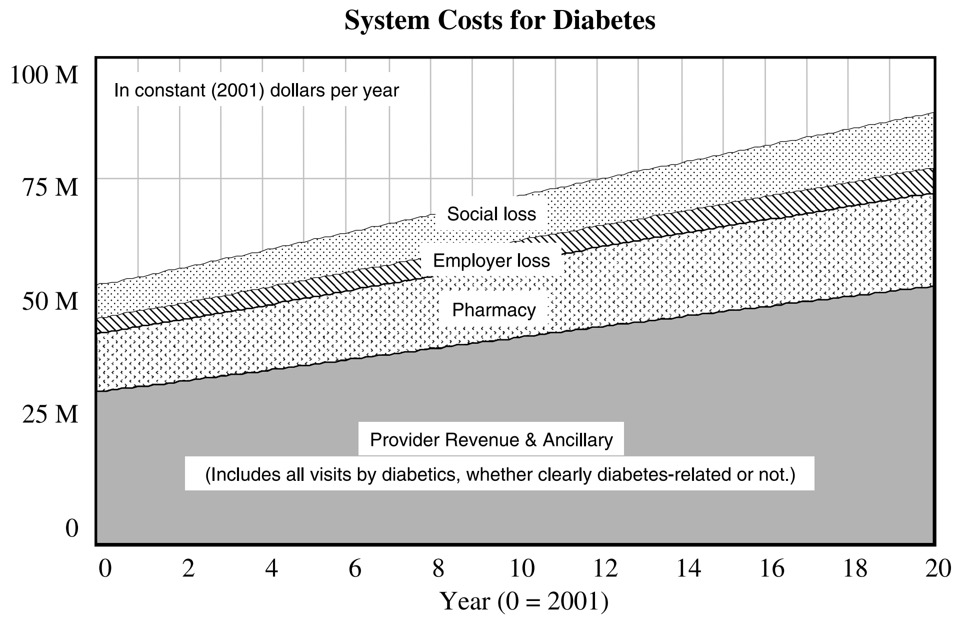


Fig. 4. *Status quo* projection of diabetes-related costs in Whatcom County, 2001–2021

of the population at risk for diabetes. (This may be a conservative assumption in view of recent data on the growing prevalence of obesity in the US.)

Figure 4 presents a *status quo* projection of diabetes-related costs, broken into four major categories. These costs are presented in constant 2001-dollar terms, excluding inflation in the general economy and in healthcare *per se*. The observed growth in costs is a direct reflection of the growth in the diabetic patient population, and especially growth in the number of the Stage 2 and 3 patients, who generate most of the costs. The largest cost category is Provider Revenue and Ancillary. Within this category, hospital costs account for 74 per cent of the total, ancillary costs (e.g., for laboratory tests) for 14 per cent, specialist MD visits for less than 10 per cent, and primary care physician (PCP) visits for less than 3 per cent. Pharmacy is the cost of all drugs used by diabetics. Somewhat less tangible but no less important for the community are the losses of productivity due to disability, shown in Figure 4 as Employer loss (value of the employee's productivity to the employer) and Social loss (loss of income to the employee and the value of having that person participate in the economy). (Testa and Simonson 1998 describe how these costs are distinguished.)

Calibration of the diabetes and heart failure (HF) models was made possible by diverse sources of data. These include:

- county population projections from the Washington State Office of Fiscal Management;

- illness prevalence by age from the National Center for Health Statistics (diabetes) and the literature (HF), which were in close agreement with member data from Group Health Cooperative (GHC), a major payor in the area offering both commercial and government plans;
- distribution of illness by stage from GHC based on diagnostic codes (diabetes) and the literature (HF);
- in-control/out-of-control fractions (diabetes) from laboratory data provided by the Family Care Network (FCN) primary care group;
- hospital utilization and financial data from St. Joseph Hospital;
- PCP utilization and financial data from PCPs currently participating in P2 (FCN, SeaMar, and CSH);
- specialist utilization and financial data from GHC (diabetes) and the North Cascade Cardiology group (HF);
- pharmacy costs from GHC;
- effect of control (diabetes) and ideal care (HF) on utilization and costs from the medical literature and expert judgment of clinicians in the community.

Small focus groups, made up of a cross-section of physicians, nurses, other health providers, and a patient representative were invaluable in helping to develop parameters for which numerical data were not available. They gave generously of their time and drew heavily on many years of experience with diabetes and heart failure patients to help estimate important model parameters.

Representing program impacts with the diabetes and heart failure models

The basic clinical intervention components of the P2 program in Whatcom County include screening and prevention education for diabetes, risk management for heart failure, and disease management for both. The models reflect detailed information on the personnel, information systems, and healthcare costs that the P2 interventions are expected to entail. The models also describe how the clinical interventions would affect patients flows (as illustrated for diabetes in Figure 2), and specify two possible factors that could mitigate the ability of the program to bring patients successfully under control (diabetes) or ideal care (heart failure) via disease management. The first of these issues is drug affordability, particularly for elderly patients who lack sufficient drug coverage under Medicare. (Medicare is the government-sponsored insurance plan for people over age 65 in the US.) The second issue is the possible insufficiency of clinical care specialists (CCSs) to keep up with the demand for their services.

Figure 5 illustrates the causal structure used in the diabetes model to model the movement of patients from uncontrolled to controlled status, for any given stage in the three-stage chain of diagnosed diabetics shown in Figure 2. (An

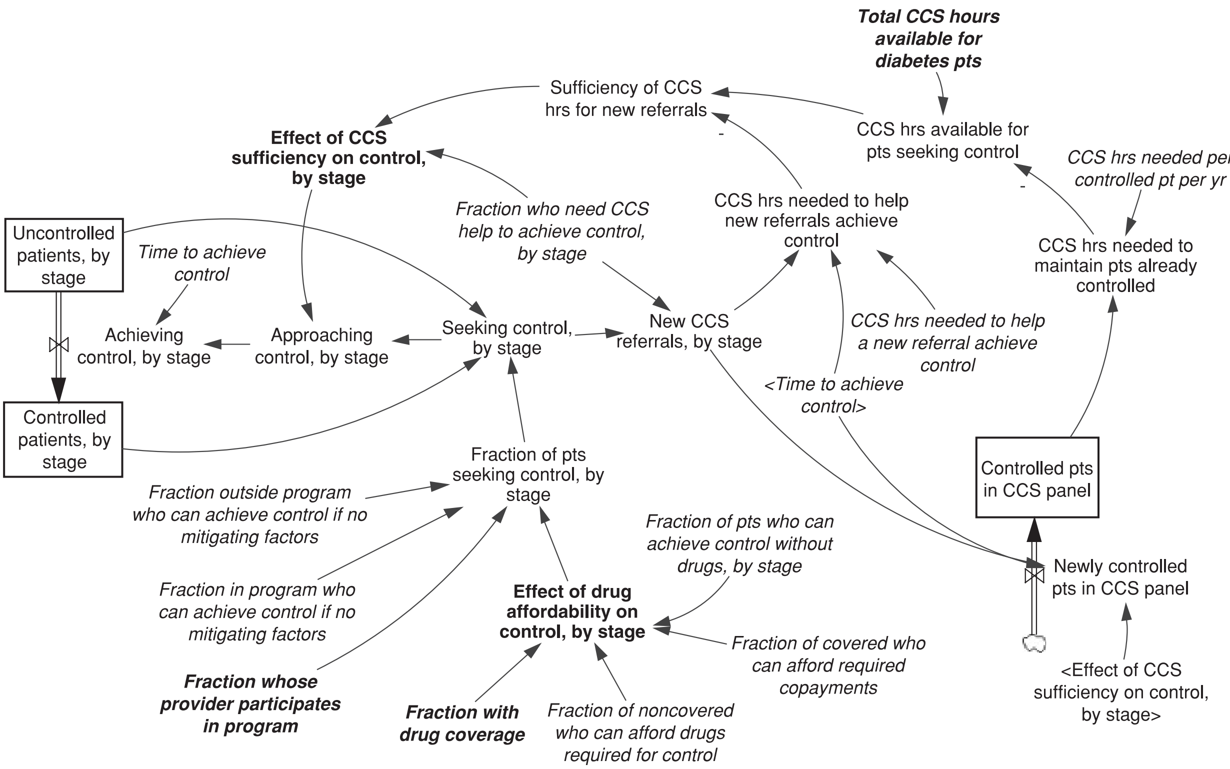


Fig. 5. Causal structure describing control of diabetes, with drug affordability and clinical care specialist (CCS) sufficiency as potential mitigating factors

identical structure is used in the heart failure model to model the movement of patients from usual care into ideal care.) The P2 program raises the fraction of patients who will achieve control, absent any problems with drug affordability or CCS sufficiency.

As shown in Figure 5, four key factors combine directly to determine the effect of drug affordability, namely, the fractions of:

- patients with drug coverage;
- those without coverage who can afford to self-pay for the additional drugs required for disease management;
- patients with coverage for drugs who can afford the co-payments for these drugs required by most U.S. plans (for example, \$10 per prescription);
- patients in the given disease stage who can achieve control without the need for additional drugs but rather through diet and exercise alone. (This last fraction becomes smaller as one progresses to more advanced stages of disease.)

Unlike the structurally straightforward effect of drug affordability seen in Figure 5, the structure for the effect of CCS sufficiency on control involves some interesting dynamic complexity. In particular, CCS hours available to assist diabetes patients are increasingly siphoned off to meet the maintenance demand of a growing panel of clients already under control, leaving fewer hours available to new referrals. These maintenance demands are relatively minor on a per-patient basis—only about 1½ hours per patient per year on the average, compared with about 6 hours required to help bring new referrals under control over the course of a few months. However, these maintenance demands can accumulate, within just a few years' time of program initiation, to double and then triple in aggregate the number of hours needed for bringing new referrals under control, according to our simulations. In addition to the time requirements just mentioned, there are two other key factors affecting CCS sufficiency:

- the fraction of patients in a particular stage who need CCS help to achieve control (which becomes larger as one progresses to more advanced stages of disease);
- total CCS hours available for diabetes patients—which, in turn, are determined by the number of clinical care specialists. The number of CCSs should be expected to grow over time to accommodate demand and is treated in the model as an exogenous decision variable.

Table 1 presents a group of scenarios for evaluating program impacts for diabetes and heart failure. These scenarios, and several others not seen here, were presented to program participants and other community stakeholders

Table 1. Selected Scenarios Tested with Diabetes and Heart Failure Models

Status quo
- No program implementation, costs or benefits

Full program adoption
- Administrative costs incurred starting Year 0 (2001)
- PCP & specialist adoption grows to 100% during Years 1 to 4 (2002–2005):
  - (Yr 1) 2 FCN sites, SeaMar, and CSH; (Yr 2) Other 6 FCN sites;
  - (Yr 3) Half of other PCPs; (Yr 4) All remaining PCPs
  - Specialists: Ramp-up in parallel with PCP adoption
- Clinical care specialists hired to meet demand as projected by model
  - Start with 2 CCSs, grow to 7 by Year 4, up to 10 by Year 18
- Program components included:
  - Diabetes: Community-based screening and prevention education for At-Risks (with referral to PCP if test positive), and disease management for known diseased
  - Heart Failure: Risk management for At-Risks, and disease management for known diseased, but no additional screening of At-Risks beyond what MDs do already (mostly post-infarction)

Disease management only
- Diabetes: No screening or prevention education of At-Risk beyond *status quo* amount
- Heart failure: No risk management beyond *status quo* amount

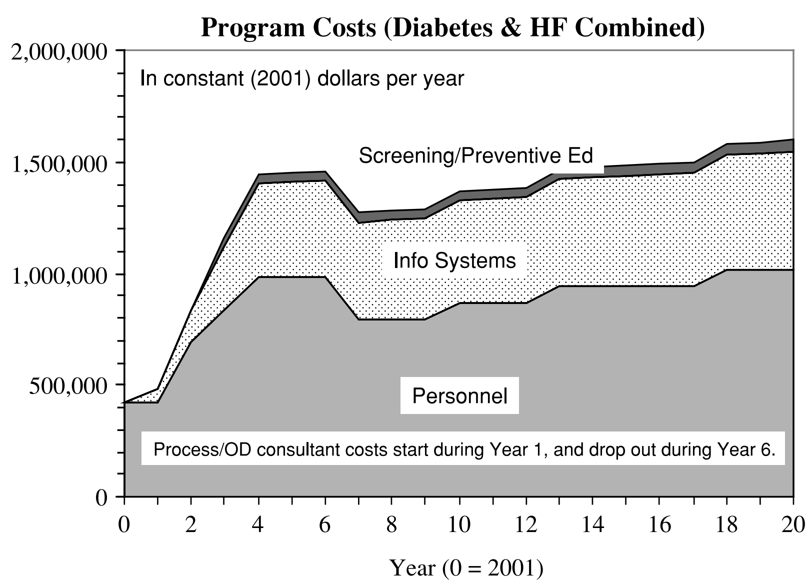
Full program plus comprehensive Medicare drug coverage (for people over age 65)

as part of the P2 planning process. The key scenario for comparison with the *status quo* is "Full program adoption." This scenario, which represents the fully realized vision of P2, assumes that all of the county's office-based physicians will participate in the program by 2005. It also assumes comprehensive disease management for both diabetes and heart failure, similarly rigorous risk management for heart failure, and a community-based mass screening and preventive education program for diabetes. Finally, it assumes a ramping up of the number of CCSs sufficient to meet the demand for their services projected by the model.

Figure 6 shows the growth of direct program costs (in constant 2001 dollars) under all scenarios in which there is full adoption of the program by physicians, and CCS growth to meet the corresponding demand. (These conditions apply to all scenarios in Table 1 other than *status quo*.) The largest category is personnel costs, which include administrative, process and organizational development consultants for redesigning office practices, and the CCSs. The consultants drop out during Year 6 (2007), after they have completed their final office practice redesign and implementation. There are seven CCSs by Year 4, growing to ten by Year 18, at an annual cost of $74,000 each. The information systems cost about $1,500 per physician per year, leading by Year 4 to an annual cost of over $400,000 county-wide.

The direct cost of the diabetes mass screening and prevention effort is tiny in comparison, involving about 5,000 subjects per year at a cost of only about eight dollars per person. We assume that half of the county's at-risk population of 30,000 will be screened in this way, once every three years as recommended

Fig. 6. Program costs under full adoption scenarios

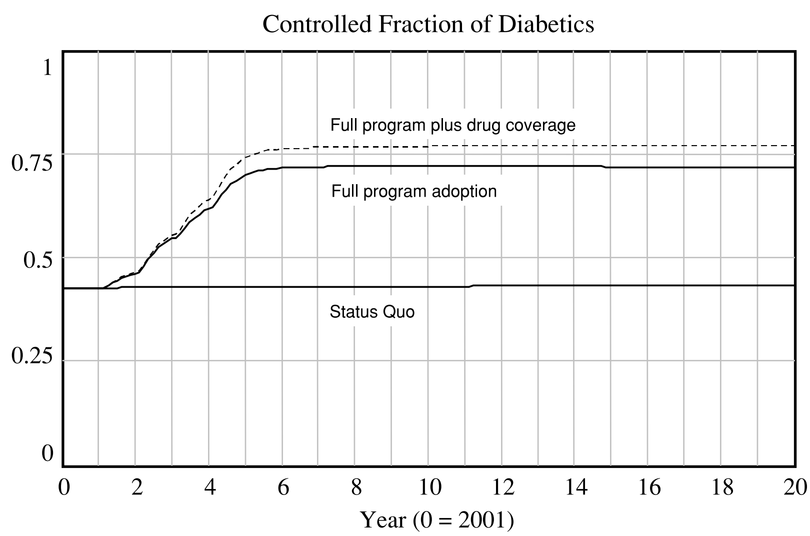


by guidelines. A quarter of those tested will get a positive reading for diabetes or prediabetes (impaired glucose tolerance), and will be referred to their physician for additional testing and counseling.

Simulated Results of Alternative Program Scenarios

Figures 7 to 10 present graphical output from the diabetes model allowing comparison of the four scenarios described in Table 2 over the full 20-year time horizon. (Similar graphs from the heart failure model are presented in Homer *et al.* 2003.) The following is a summary of these results.

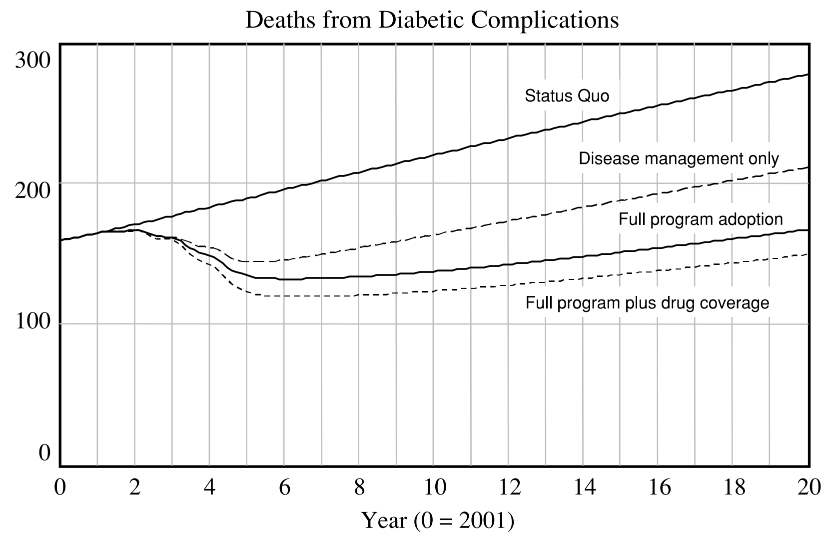
Fig. 7. Program impact on fraction of diabetics under control



Fraction of diabetes patients under control (figure 7). The fraction of known diabetics under control starts at a *status quo* value of 43 per cent. It is assumed that 80 per cent of known diabetics could be brought under control if they could afford the drugs and there were sufficient CCS support. With full program adoption, the fraction under control is increased to 72 per cent, and with adoption plus full Medicare drug coverage it is raised to 77 per cent. This final value is short of 80 per cent not because of any mitigating factors, but because there is a steady influx of newly diagnosed diabetics who require some months to achieve control.

Deaths from diabetes complications (figure 8). Under the *status quo*, the number of diabetes-related deaths grows continuously along with the size of the diabetic population. Full program adoption reduces these deaths by 40 per cent, and adoption plus drug coverage by 54 per cent, in line with the greater

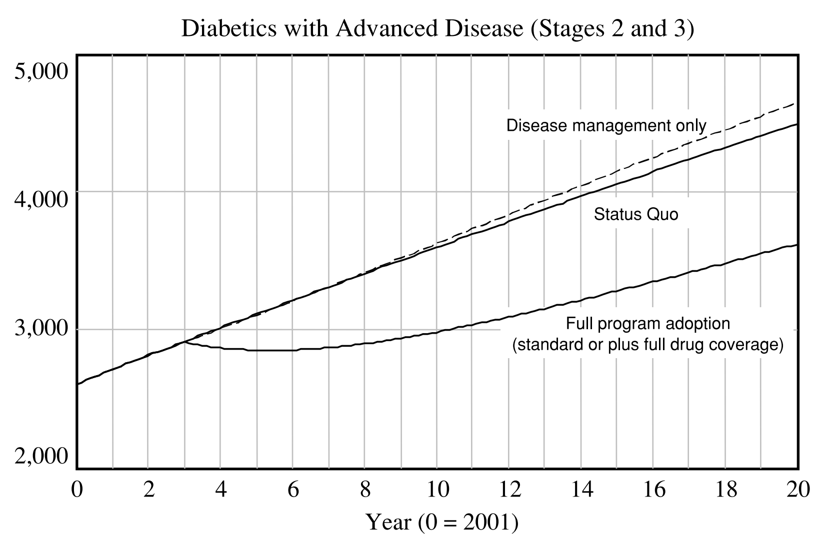
Fig. 8. Program impact on deaths from diabetic complications



fractions of diabetics being brought under control. A program with disease management only (no screening and prevention component) is effective at reducing deaths early on, but becomes less and less effective as time progresses.

PATIENTS WITH ADVANCED DIABETES (FIGURE 9). Under the *status quo*, the number of patients with later stage (Stage 2 or 3) diabetes grows continuously at an average rate of 2.7 per cent per year. The full program—with or without drug coverage—ends up reducing the number of later stage diabetics by about 20 per cent relative

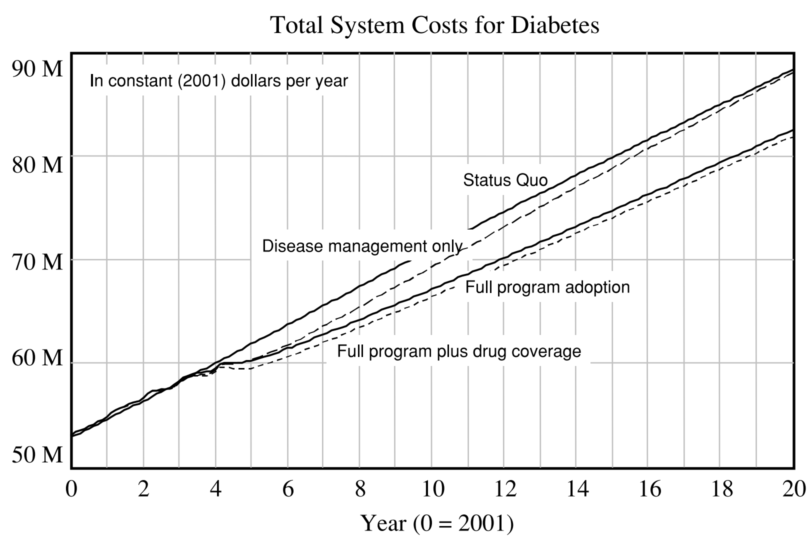
Fig. 9. Program impact on prevalence of advanced diabetes (Stages 2 and 3)



to the *status quo*. These two scenarios share the same screening and prevention component, a component that markedly reduces the incidence and progression of diabetes to later stages. A program with disease management only actually leads to an increase in later stage diabetics relative to the *status quo*, because (lacking a screening component) it does more to keep later stage diabetics alive longer than it does to reduce the progression from Stage 1 to Stage 2.

TOTAL SYSTEM COSTS (FIGURE 10). A breakdown of total system costs for the *status quo*, including disability losses to employers and society-at-large, was previously shown in Figure 4. In the scenarios with full program adoption and full adoption plus drug coverage, net savings are achieved by Year 3, only two years after the program is launched. By Year 5, drug coverage generates further reductions in disability beyond those provided by the program alone. The scenario with disease management only, in contrast, achieves total net savings initially, but gives back most or all of these savings by the end of 20 years. By the end of 20 years, the full adoption approach results in a net savings of $6 million per year, or 7 per cent of the *status quo* costs, including a $4 million per year reduction in disability losses.

Fig. 10. Program impact on total system costs of diabetes (including disability costs)



There was naturally concern that the numbers used in the models were subject to some uncertainty and that this might affect the conclusions one might draw. In addition to reviewing many of the model's parameters with providers in the community, we performed sensitivity analyses to examine the effect of varying key parameters on the models' results. These used best-case and worst-case assumptions for the impact of P2 on disease progression and rates of complications from disease. These simulations suggest that, while there is some uncertainty about the exact magnitude of impact, P2 is likely to result in significant health benefits at acceptable cost, even with worst-case assumptions. However, the crossover point for net savings does not occur as soon as it does in the mid-range or best-case simulations.

The P2 program planners and stakeholders in Whatcom County appreciated the long-term view afforded by the preceding graphs, but also required a more detailed sense of the program's impacts over the shorter term. Table 2 presents numbers covering the period 2003–2008 (model Years 2–7) that describe the impact of the full program adoption scenario relative to the *status quo* for diabetes and heart failure combined. A table like this one but with somewhat more detail has served in Whatcom County as a tool for identifying likely "winners" and "losers" over the next several years. It has also helped with developing ideas for program funding and mechanisms for the redistribution of savings so that all stakeholders might have a financial interest in program participation.

The table has also helped to convince stakeholders that the cost of the program is worthwhile, even if one ignores disability savings and longer-term benefits. The final section at the bottom of Table 2 suggests that over the 2003–2008 time period program-related outlays (program and payor costs) will generate health benefits that rival or beat those of other accepted health interventions on the basis of cost–benefit ratio. The model suggests that the P2 program will result in an average outlay per life-year saved of less than $30,000 over the 2003–2008 period, an amount that compares very favorably with accepted medical technologies. This cost-benefit ratio turns negative by 2010, signifying a net saving from that year onward for diabetes and heart failure combined.

Using model results to reach a common understanding

The work described here began in July of 2002. It started with a series of community meetings designed to help P2 participants better understand the process and objectives of modeling and begin to create an approach to model diabetes, the first of the two illnesses to be modeled. Results of the pilot effort at diabetes modeling done a year earlier were shared to help participants visualize the projections and insights that would be available at the end of the current effort in the Spring of 2003. The meetings were also valuable for providing input to the design of the two models and critique as they developed.

As indicated earlier, focus groups of clinicians helped us define the flow of patients through the stages of the two illnesses being modeled and changes in care that could result in improved outcomes. Community meetings provided participants with the first set of critical insights from the modeling work. These were about the overall impact of P2 on the community and were essential for helping to build commitment to continue with the program. Key insights included:

Table 2. Six-year program impacts on diabetes and heart failure combined, comparing full program adoption scenario to *status quo*

As of start of year:	2003	2004	2005	2006	2007	2008	Total
1. Health impacts							
1.1 Disability days avoided	2,781	10,201	24,134	41,400	48,688	52,976	180,180
1.2 Inpatient days avoided	214	781	1,637	2,806	3,251	3,517	12,205
1.3 Deaths avoided (life-years saved)	6	22	54	89	104	114	388
Financials below are in constant 2001 dollars.Values are the result of subtracting status quo projections from full-program projections. Parentheses indicates decrease relative to status quo; no parentheses indicates increase.							
2. Program costs ($000)							
2.1 Personnel and operations	689	878	1,025	1,026	1,026	835	5,479
2.2 Info systems paid for by MDs	147	279	416	423	431	438	2,134
2.3 Total	836	1,157	1,442	1,449	1,457	1,273	7,613
3. Impact on provider net income ($000)							
3.1 Primary care MDs	(65)	(111)	(118)	(54)	(44)	(37)	(428)
3.2 Specialist MDs	(71)	(174)	(291)	(343)	(375)	(394)	(1,647)
3.3 Hospital	(123)	(495)	(1,039)	(1,758)	(2,052)	(2,231)	(7,697)
4. Impact on supplier revenue ($000)							
4.1 Pharmaceuticals	513	1,716	3,794	6,128	6,519	6,591	25,261
4.2 Implanted devices	(19)	(103)	(346)	(701)	(891)	(1,020)	(3,079)
5. Impact on payor costs ($000)							
5.1 Commercial plan reimbursements	77	222	428	575	391	190	1,883
5.2 Medicaid reimbursements	59	121	474	862	883	843	3,241
5.3 Medicare reimbursements	(154)	(607)	(1,531)	(2,995)	(3,753)	(4,204)	(13,245)
5.4 Patient out-of-pocket payments	206	674	1,574	2,609	2,787	2,838	10,688
5.5 Total	189	410	945	1,050	307	(334)	2,567
6. Impact on disability losses ($000)							
6.1 Employer loss	(116)	(478)	(1,016)	(1,641)	(1,904)	(2,062)	(7,217)
6.2 Social loss	(246)	(922)	(2,142)	(3,638)	(4,269)	(4,642)	(15,859)
6.3 Total	(362)	(1,400)	(3,158)	(5,278)	(6,174)	(6,704)	(23,076)
7. Impact on combined costs ($000)							
7.1 Outlay (program+payor)	1,025	1,566	2,387	2,500	1,764	938	10,180
7.2 Total (program+payor+disability)	663	166	(771)	(2,779)	(4,409)	(5,765)	(12,896)
8. Cost-benefit ratios ($)							**Average**
8.1 Outlay per disability day avoided	369	154	99	60	36	18	56
8.2 Outlay per inpatient day avoided	4,800	2,006	1,458	891	543	267	834
8.3 Outlay per life-year saved	173,479	70,491	44,370	28,155	16,954	8,263	26,216

- Complete implementation of P2 involving all providers in the community would produce more extensive benefits than partial implementation involving only those providers already participating.
- Knowing the magnitude and growth of P2 costs over time enabled participants to budget for their shares of those costs.

- Total system costs for the P2 program are less than *status quo* costs without P2 even though reduced mortality rates keep more people alive. Some health care payors have expressed concern that improved care for older people will lead to higher costs because they will be kept alive longer and continue to require care. However, the P2 program produced a net reduction in cost in the simulations by keeping people in the less severe stages of the diseases for a longer period of time and reducing the complications of these diseases that require expensive hospitalizations. Given the sensitivity of payors who were already bearing high costs, this was an important insight to help motivate their continued participation.

In addition to these overall results, the impacts on particular providers and those paying for care yielded additional insights that were important to these conversations:

- Benefits of P2 in terms of savings are likely to fall unevenly among those paying for care for at least the first several years of the program. Medicare is likely to be the biggest "winner" from the start; see Table 2. Commercial insurers, on the other hand, would actually pay out more under P2 relative to the *status quo* through 2008, after which time they too start to realize net savings due to the accumulated achievements of primary prevention under the program. Medicare patients are older and are, on the average, at more severe stages of the two diseases. As a result, they have higher rates of acute complications and hospitalizations that can be prevented by the more rigorous care available under P2. For these patients, it is possible to achieve immediate and substantial savings despite higher costs for prescription drugs and primary care. Commercial insurers cover younger patients whose disease is not typically as advanced and who are therefore less likely to have acute complications and require hospitalization. Savings from reduced hospitalization are not enough to offset higher costs of care under P2 and prescription drug costs for the first six years of the program. Medicare, in fact, benefits from the investment made by these commercial insurers that helps keep patients healthier when they are younger and require less care once Medicare becomes responsible for them. This insight highlighted the importance of "bringing Medicare to the table" to help pay part of the increased costs of P2 since it would be the biggest recipient of the savings generated for payors.
- Employers in the community and the community at large are also winners in terms of the reduction of disability losses resulting from diabetes and heart failure. Employers may be willing to fund some of the additional costs created by P2, so that they might reap the bulk of this loss reduction. For example, employers may be willing to pay higher premiums to commercial insurers to help cover P2, so that these insurers will have a greater financial interest in supporting the program.

- The other big winner is the pharmaceutical industry; see Table 2. This windfall for the pharmaceutical industry suggested that the drug companies be brought to the table and asked to help fund P2.
- The hospital and physicians (particularly specialists) are likely to see reductions in their net income as a result of P2, as seen in Table 2. This reduction is, of course, a concern to those providers. The hospital depends on "bread and butter" chronic illnesses to generate income that helps to subsidize other services such as mental health that are poorly covered by insurers. The good news is that hospital income contributions from diabetes and heart failure under P2 are not projected to fall below their 2001 values at any time, even though these contributions are lower than they would have been without P2. Reductions in hospital utilization from diabetes and heart failure are also not bad news in the sense that the community has undergone consolidation of its hospitals and can use the excess capacity to provide services that might otherwise be lacking as the population ages and requires more care. This is also true of a perceived physician shortage the community is experiencing. Having less severe chronic illness with fewer complications means that the limited number of physicians can spend more time keeping patients healthier.
- The model also provided a framework in which to examine mechanisms for redressing any perceived inequities in the distribution of program costs and benefits. One of these might be a payment scheme in which the hospital's payments from insurers are kept relatively constant despite reductions in the number of admissions. This might be justified by the need to support the broader role that the hospital plays in the community's health care system and the fact that some services subsidize others. One approach would be to have Medicare, the largest insurer and also the largest beneficiary of program-generated savings, pay a fixed annual amount per patient with a chronic illness (regardless of hospital use) rather than on a per-admission basis. Tests of the diabetes model demonstrated the feasibility of using such a severity-adjusted per-capita payment mechanism for leveling hospital revenues. The model demonstrates that the mechanism would effectively shift some of the windfall Medicare stands to receive under the program in order to "make the hospital whole", but without causing a net increase in Medicare payments relative to the *status quo* projection. The ability to use the model to do such testing permitted differences of opinion about equity to be pursued constructively rather than becoming stumbling blocks for the program.

From common understanding to collaboration

The Whatcom County P2 Leadership Board met on March 17–18, 2003, to learn about model-based findings and to discuss next steps for the program. The members of this board are leaders of the P2 participant organizations, representing the hospital, primary and specialist care providers, and major local insurers, plus a patient representative (also involved in all of our community meetings) who has both diabetes and heart failure. Much of the day's discussion focused on financial support for P2, and model findings proved helpful in this regard.

Financial support during transition period

A key concern addressed at the meeting was how the P2 program in Whatcom County would be supported during the nine-month period after the RWJF funding was due to run out and before other anticipated sources of funds could take over. Much of the discussion about this was purely practical: how much money was required to continue making progress during the transition period, and how much each of the participants could contribute. In this regard, the model contributed in two ways:

- The model helped the insurer, GHC, see that it could have a direct return from P2 during and soon after the nine-month transition period as a result of savings from the care of its older, sicker patients. While the program might cause GHC to pay more than it would have otherwise for its younger, non-Medicare patients, savings on the Medicare patients it manages would outweigh these higher costs and result in a net savings. After showing GHC what these net savings were projected to be through 2004, they agreed to contribute more for the interim funding than they had offered earlier in the discussion.
- The model also helped participants understand the value of preventive care and risk management in controlling the long-term cost and health impacts of the two diseases. The long-term nature of the impacts of these activities and the short-term financial needs might have made it tempting to postpone any spending on prevention until after long-term funding was assured. However, based on insights from the model, a community-based screening program for diabetes was retained in the program budget, and the importance of getting ideal care to hypertensives and hyperlipidemics at risk for heart failure was underscored.

Identification of other funding sources

While some additional funding might still come from RWJF starting mid-2004, it was clear that P2 had to develop other sources of outside funding. As indicated earlier, the model showed that employers in the community would enjoy a substantial reduction in cost due to disability from these two diseases among people who were still working. Pharmaceutical companies would benefit from substantial increases in the volumes of drugs prescribed. Other insurers in the community who managed programs for Medicare patients as GHC does would also benefit from significant savings. These insights helped shape the strategy for pursuing additional funding sources. The discussion also identified additional potential sources such as disability insurance carriers.

Going public, going forward

Following soon after the Leadership Board meeting in March 2003, meetings outside of Whatcom County have taken place that illustrate what it will take, and what questions must be answered, in order to spread the Whatcom County P2 approach to other communities and gain needed support from government and other major institutions.

- On April 14, a "Policy Summit" organized by the P2 staff and Leadership Board was held in Seattle. This was a well-publicized, all-day event, attended by some 200 representatives from government, foundations, and industry and community organizations. Morning presentations described Whatcom County's success in forging agreement around P2, early successes of the program, and an overview of the system dynamics approach and findings. Facilitated small group discussions in the afternoon generated further ideas on cost-effective improvements in health care, as well as support for taking the P2 approach beyond Whatcom County.
- On April 28–29, we discussed the use of system dynamics in Whatcom County at a meeting of the Pursuing Perfection Partners, hosted by the Institute for Healthcare Improvement, and attended by representatives of all seven of the RWJF P2 grantee institutions in the U.S.A., as well as groups from England, the Netherlands, and Sweden. One question raised in discussion was about whether and how easily the models might be adapted to other communities and other countries. Another question was about what greater benefits and cost savings one might expect to see as a one- or two-illness P2 approach is expanded ultimately to include all of the major chronic illnesses, and about how one might model these multi-illness synergies. Interest was also expressed in modeling the impacts of a program like P2 on patient access to caregivers and the dynamics of physician supply in a community.
- On May 9, we presented the P2 modeling work to the team from the American Hospital Association responsible for developing policy positions used in lobbying for or against proposed legislation on behalf of hospitals nationwide. Much of the discussion revolved around what the models might say about different approaches to Medicare reform being discussed in Congress. On one side of the debate was a proposal to provide expanded drug benefits to seniors under privately run disease management programs. On the other side was a more ambitious (and initially more costly) "case management" approach bearing a likeness to P2, involving not only drug benefits but also multi-disciplinary provider teams.

Every audience we have presented to has agreed that there is a role for modeling in support of program planning and policy evaluation in the complex area of chronic illness care. The leaders of P2 in Whatcom County are convinced that the models have given them the ability to do resource planning, set realistic expectations, determine critical success factors, and evaluate the differential impacts on affected parties. They feel that the models have led them to conclusions and decisions they likely would not have reached otherwise. They are now seeking ways to address concerns about financial winners and losers so that all parties are willing to participate and support the P2 program.

Note

1. The models contain proprietary financial information and are not available to the public.

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