

# **Models for Collaboration: How System Dynamics Helped a Community Organize Cost-Effective Care for Chronic Illness**

## **Jack Homer**

Homer Consulting  
3618 Avalon Court, Voorhees NJ 08043 USA  
856-810-7673  
[jack@homerconsulting.com](mailto:jack@homerconsulting.com)

## **Gary Hirsch**

Creator of Learning Environments  
7 Highgate Road, Wayland MA 01778 USA  
508-653-0161  
[gbhirsch@attbi.com](mailto:gbhirsch@attbi.com)

## **Mary Minniti**

Pursuing Perfection Project Manager  
PeaceHealth – Healthcare Improvement Division  
800 E. Chestnut Avenue, Bellingham WA 98225 USA  
360-756-6885  
[mminniti@peacehealth.org](mailto:mminniti@peacehealth.org)

## **Marc Pierson**

Pursuing Perfection Project Executive  
PeaceHealth/St. Joseph Hospital  
2901 Squalicum Parkway, Bellingham WA 98225 USA  
360-738-6709  
[mpierson@peacehealth.org](mailto:mpierson@peacehealth.org)

*Chronic illness is a large and growing problem throughout the world, and is responsible for at least 70 percent of total healthcare spending in the U.S. Experts agree that the U.S. healthcare system is poorly organized to care for chronic illnesses and, as a result, wasteful and unresponsive to the needs of patients. This paper 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. The leadership is now seeking ways to address concerns about financial "winners" and "losers" so that all parties are willing to participate and support the program.*

## **Magnitude of Chronic Illness as a Problem**

Chronic illness is a huge and growing problem in the U.S. and throughout the world. Chronic illnesses are those that last more than three months and are not self-limiting in nature. According to the Robert Wood Johnson Foundation, chronic illnesses are the leading cause of illness, disability, and death and, in the U.S. alone, affect almost half the adult population or about 100 million people. That number is expected to grow to 134 million by 2020. 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 percent of the population, but that segment will reach 20 percent by 2030 after the entire “baby boom” population has reached age 65. Chronic illness is much more prevalent among the older population and will grow in importance and cost as the population ages.

About 1 in 6 Americans are limited in their daily activities by a chronic condition. In 1990, direct medical costs for chronic illness were \$425 billion, representing nearly 70 percent of all personal health care expenditures. Lost productivity due to premature death or inability to work added another \$234 billion to this figure. A more recent study places chronic care at 78% of total U.S. healthcare spending, and forecasts chronic care treatment costs of over a trillion dollars per year by 2020. While concentrated in the industrialized world, chronic illness is an expanding problem in the developing world as people get access to better health care, nutrition, and sanitation and live longer.

A recent report by the Institute of Medicine (IoM 2001) of the National Academy of Sciences suggests that the health care system in the U.S. is not up 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. It quotes Dr. Edward Wagner of the MacColl Institute for Healthcare Innovation (a unit of the Seattle-based Group Health Cooperative) on five elements needed to improve outcomes for the chronically ill:

- Evidence-based planned care consistent with well-established guidelines for common chronic problems.
- Reorganization of practices to meet the needs of patients who require more time, a broad array of resources, and closer follow-up. Such reorganization generally involves multi-disciplinary teams and ongoing management of patient contact.
- Systematic attention to patients' needs for information and behavioral change.
- Ready access to necessary clinical expertise.
- Supportive information systems.

The IoM report also describes the additional difficulties for dealing with chronic illness created by the misalignment between payment policies and the type of care that is required. Payment mechanisms are called “perverse” in that they inhibit the provision of quality care that can also

help to save money. Payment mechanisms tend to encourage fragmented piecemeal care that is not helpful in dealing with complex chronic illnesses.

### **The Pursuing Perfection Program**

This paper 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 170,850 with 14% living below the poverty line. The program is a collaborative effort of health care providers in Whatcom County including St. Joseph Hospital in Bellingham, Family Care Network (a multi-site primary care group), SeaMar Community Health Centers, the Center for Senior Health operated by the hospital, and North Cascade Cardiology (a specialty group). It also includes two of the leading insurers active there, Group Health Cooperative (GHC) and Regence BlueShield. A primary Medicaid insurer Community Health Plans of Washington 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. The program is operating under the direction of the Institute for Healthcare Improvement in Boston. This \$20.9-million initiative of the RWJF is intended to help hospitals and physician organizations dramatically improve patient outcomes by pursuing perfection in all of their major care processes. Whatcom County was selected from among 228 original applicants and is the only one of the seven sites selected where a community rather than a specific health provider is the grant recipient. Local participating organizations will contribute additional resources equivalent to \$4 million over the two year life of the grant.

Whatcom County's P2 program built on a foundation of cooperation that had already been established in the county. For example, a health care information network called HInet had been created a number of years earlier to facilitate communications among the county's health care providers. The Community Health Improvement Consortium (CHIC) was formed in 1996 and served as a framework for collaboration in areas such as data sharing, data analysis, process design, system design, quality improvement education, and other community-wide healthcare improvements. CHIC became the vehicle for mobilizing the healthcare community to apply for a P2 planning grant in 2001. This planning grant led to a successful two-year implementation grant award beginning in 2002.

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.
- ***Healthcare isn't designed for chronic care***—The current system is designed for acute care even though chronic care requires more than 70% of the nation's healthcare dollars.
- Therefore, ***patients carry the burden*** of a broken healthcare system.

The program's mission is to create a community-based system of chronic care that is patient-centered, evidence-based, effective, safe, timely, and equitable; in other words, "quality healthcare for all, based on the best we know." The program has these elements:

- Care organized by multi-disciplinary care teams that include patients, physicians and clinical care specialists. Clinical care specialists are nurses, hired by the program, to whom physicians may refer patients for counseling, education, and navigation through the health care system.
- Care coordination advanced through chronic disease protocols that are evidence-based and incorporated into a shared care plan located on a secured website, and accessible to all team members, especially patients.
- Healthcare information to support clinical decision-making and patient self-management. This includes use of electronic medical records and automated tools to support disease management and associated workflows.
- Redesigned primary care practice sites with improved access, patient self-management support, and improved patient flow within and between providers.
- Development of new reimbursement models to support patient-centered care.
- Patient and staff measurement tools to plan interventions in pilot sites.

The program is initially concentrating on two chronic illnesses as prototypes for improved care. These are Type 2 diabetes (sometimes called adult onset diabetes to distinguish it from the inherited form called juvenile or insulin-dependent or Type 1 diabetes) and heart failure (or congestive heart failure, an older and less accurate term which refers to the pulmonary congestion that many but by no means all heart failure patients have.) Both of these illnesses affect a great many people in the U.S. and other countries. About 13 million people have Type 2 diabetes and 6 million have heart failure in the U.S. alone. Total costs of diabetes in the U.S. 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. Treatment of heart failure is estimated to cost \$30 billion or more per year in health care costs alone. The prevalence of both diseases is growing rapidly as the population ages and numbers of people above age 65 increase. In addition, the emergence of "adult onset" diabetes among teenagers caused by overeating and lack of exercise is alarming clinicians. The following sections describe how these two disease processes were modeled 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:

- 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. Which alternative interventions would yield the greatest savings? The greatest improvement in health status? What are the tradeoffs? How sensitive are overall results to changes in particular features that might be implemented? How long will it take for the interventions to begin producing net savings? Anticipating savings from interventions would

also help the community estimate what additional amounts could be invested in further improvements in care without raising overall costs. Answers to these questions would also help make the case to providers and payors not initially participating in the P2 program and hopefully get them to join.

- 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 would not be overly penalized by a loss of revenue that might result. Some providers were worried that a loss of revenue might prevent them from offering certain services that currently were subsidized by revenues from chronic illness care. Understanding impacts on individual providers and payors was also necessary for creating mechanisms for redistributing these costs and benefits among the program's participants. Establishing this sense of equity was a key requirement for gaining and maintaining collaboration among the community's providers and those who pay for care. The models were essential for understanding the differential impacts and assessing payment and other mechanisms for redistributing costs and benefits of interventions in care delivery for chronic illness.

These needs could not be met with common quantitative tools such as spreadsheet models that project impacts in a simple, linear fashion. It is difficult to anticipate how each intervention will affect a population with chronic illness. Interventions in chronic illness don't have simple direct impacts. The aging of 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 yield 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.

There were other benefits to System Dynamics modeling. Traditional cost-benefit analysis tends to focus on single interventions at a time. But in the case of chronic illness, it was understood that multi-pronged interventions would be most effective. The P2 project needed a framework in which several types of intervention could be evaluated together. For example, so-called disease management programs reduce the severity of illness and frequency of acute complications of chronic illness, but the cost of these depend on how many patients develop the disease which, in turn, can be affected by preventive programs. Costs and benefits of both types of programs are interdependent. A System Dynamics model would reflect these interdependencies.

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 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.

The community will eventually want to do these kinds of 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 healthcare costs. This shift in care is intended to reduce the incidence and progression of disease and consequent complications and deaths. Reductions in the healthcare 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.

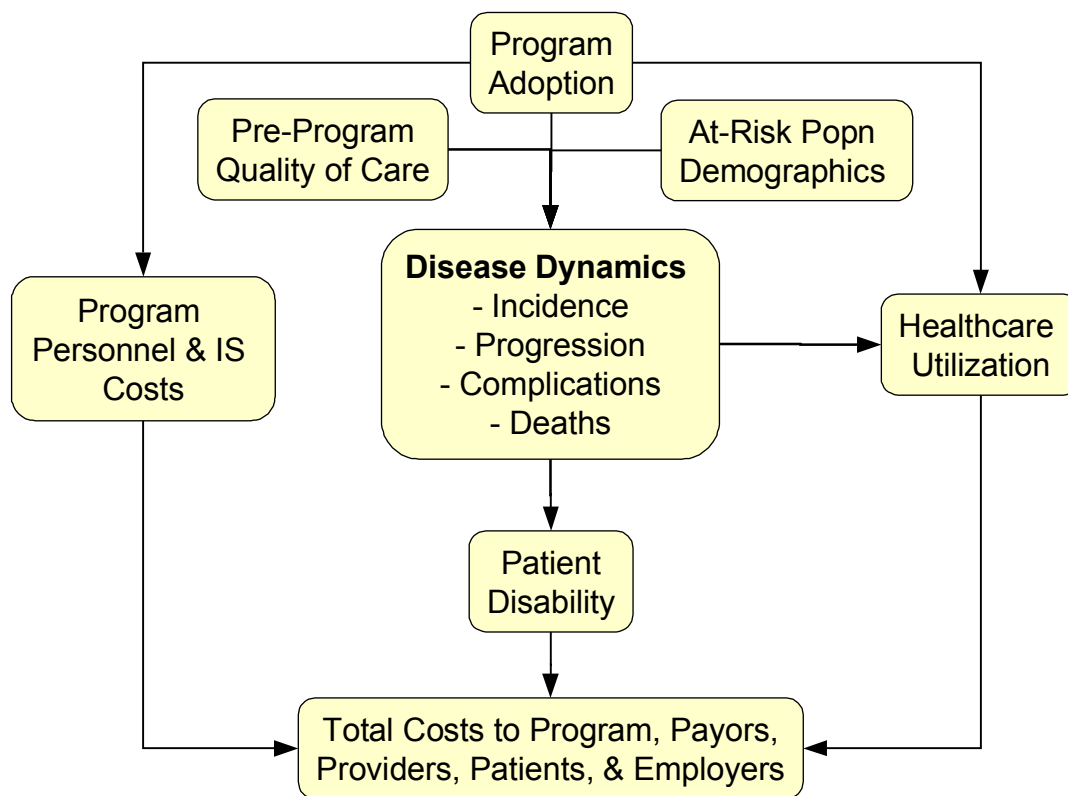


Figure 1. A Framework for Modeling Chronic Illness Program Impacts

Even if the program results in such net savings for the community as a whole, some members of the community may benefit more than others, and some may actually lose financially while others win, absent any cross-subsidies or redistribution of funds. Our models specify the expected financial impacts on primary care physicians, specialists, the hospital, providers of other services (hospice, home care, exercise rehab, etc.), drug and device manufacturers, payors (commercial plans, Medicaid, Medicare), patients, and employers, as well as others in society who are affected when a patient is unable to perform his or her daily activities due to illness.

### Dealing with Illness Interactions in a Single-Illness Framework

Our modeling framework examines program costs and benefits for one illness type at a time. However, because of the synergies and downstream effects described above that connect certain chronic illnesses and their risk factors, it is important to ask how our “one model, one illness” framework may still provide useful results. An example will illustrate how we have addressed that question.

Figure 2 illustrates the interconnections that exist among illnesses within the broad arena of cardiovascular disease, an arena that includes both diabetes and heart failure. Some of the leading complications of diabetes come from its contribution to atherosclerotic disease, which can damage heart, brain, kidney, and peripheral blood vessels. When these complications are heart-related, they may in turn lead, eventually, to heart failure. Thus, if a chronic illness program addresses both diabetes and heart failure, the diabetes part of the program should, if successful, indirectly reduce the risk of heart failure, thereby affecting the incremental benefit of the heart failure part of the program. If diabetes were a leading risk factor for heart failure, one would thus need to be careful to reflect in the heart failure model the fact that the population at-risk for heart failure should be expected to grow less quickly due to the beneficial impact of the diabetes program. (In fact, however, the contribution of diabetes to heart failure is relatively minor: Hypertension is by far the leading cause of heart failure, followed by high cholesterol or hyperlipidemia, with diabetes a distant third.)

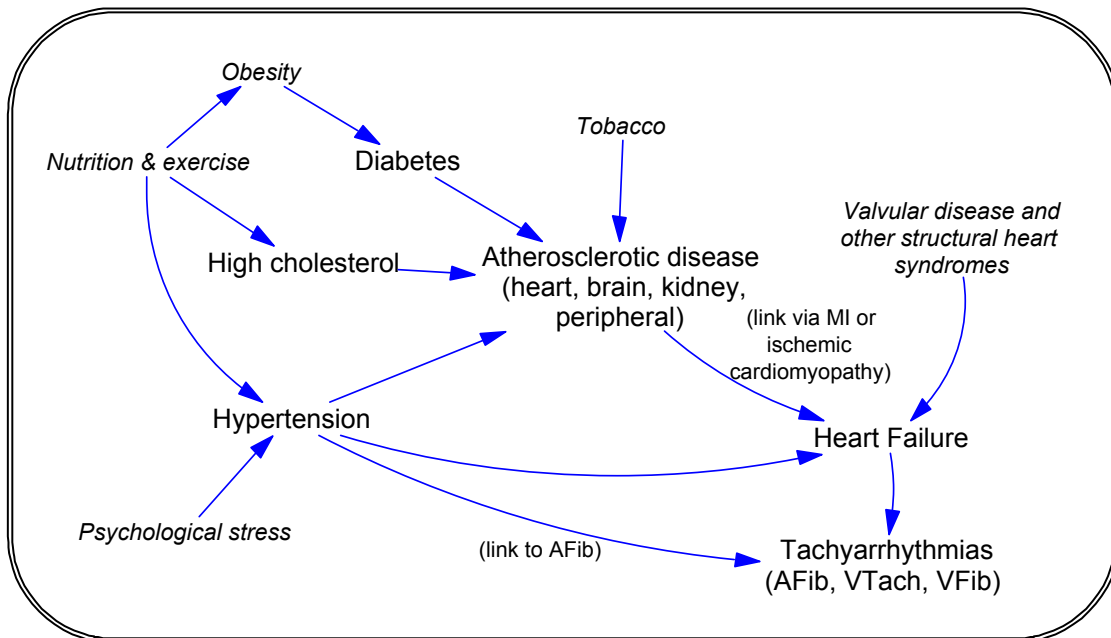


Figure 2. Pathways of Cardiovascular Disease

Another type of interconnection about which one must be careful when using a “one model, one illness” approach is illustrated by the fact that hypertension, a risk factor for heart failure, is also a risk factor for other chronic illnesses, including atherosclerotic diseases and tachyarrhythmias (abnormally fast or fast-and-irregular heart rhythms). Thus, if a program includes a preventive component for hypertension management, then that preventive component will have benefits that lie outside the scope of a model focusing only on heart failure. Our approach to dealing with such multi-illness benefits, short of building separate models of the other illnesses affected, has been to assign a fraction of the total cost of hypertension management to heart failure, a fraction based on an estimate of the fraction of total benefit from hypertension management accruing to heart failure specifically.



The solutions just described for addressing interconnections and synergies are probably satisfactory in many cases, for example when the two target illnesses are not closely linked, or when one can develop a defensible estimate of the fraction of total savings from risk-factor control accruing to the specific illness in question. We believe that is the situation in our current modeling of diabetes and heart failure. Admittedly, perhaps the only way to prove that this assertion is true is by building the necessary additional single-illness models and appropriately linking the output of one to the input of others, or by building a comprehensive model of cardiovascular disease that effectively (and perhaps more elegantly) does the same thing. But that is for another time.

### **Applying the Modeling Framework to Diabetes and Heart Failure**

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

- (1) the patient stock-and-flow structure for the illness and its calibration,
- (2) the types, amounts, and unit costs of healthcare utilization associated with the patient stock-and-flow structure,
- (3) how the program would affect patient flows, and
- (4) how the program would directly affect infrastructure and healthcare costs.

Figure 3 presents a somewhat simplified view of the stock-and-flow structure used in modeling Type 2 diabetes. (The actual model has two separate structures like those shown in Figure 3, 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 illness (after at-risk) portrayed in this figure were identified through discussions with clinicians in Whatcom County.

About 30% 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. As diabetes develops, increased sugar in the blood leads to microvascular changes that weaken the body's ability to maintain blood sugar control, and take a patient from pre-diabetic to Stage 1 diabetes, where the blood glucose (HbA1c) level remains above 7 mcg/dl unless treated with oral medications and/or changes in diet and activity. Most Stage 1 diabetics, who account for about two-thirds of all diabetics, have no outward symptoms, and more than half are undiagnosed, though the screening test is a simple one. If Stage 1 diabetics go untreated, with their blood glucose (and in many cases high blood pressure) uncontrolled, most will eventually progress to Stage 2, marked by organ disease. In Stage 2 (about 18% of diabetics in Whatcom County) macrovascular blood flow has become affected, impairing the functioning of organ systems and potentially leading to heart attack (MI), stroke, kidney disease, peripheral vascular disease, loss of sensation in the extremities, or eye disease (retinopathy, glaucoma, cataracts). At this stage there is still the opportunity for reducing 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% of diabetics in Whatcom County); this would include patients post-MI, 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, but, despite the advanced state of their disease, even Stage 3 diabetics may benefit from glycemic and blood pressure control.

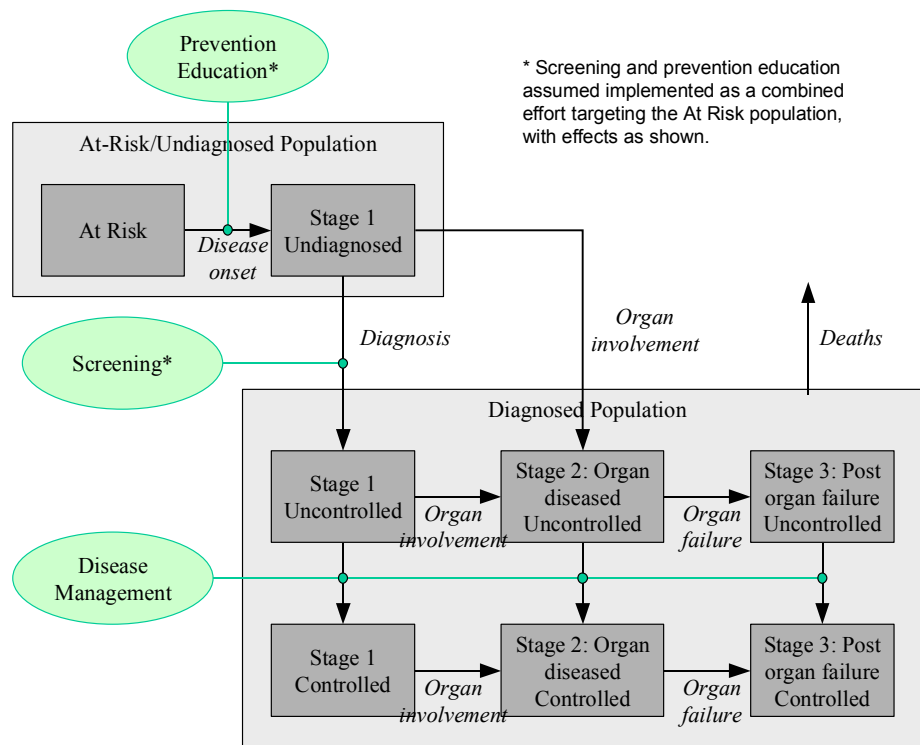


Figure 3. Diabetes Stages and Intervention Points

Several studies have demonstrated that the incidence, progression, and complications of diabetes can be reduced significantly through concerted intervention. As indicated in Figure 3, 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%. 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% typically seen without a program up to nearly 100% for those patients who make the required lifestyle changes and take the required medications, regardless of their stage of disease. (We have estimated, more conservatively, that 80% of known diabetics could be brought under control under P2, assuming drug affordability were not an issue.) 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.

Figure 4 presents a 20-year *status quo* projection of diabetes prevalence by stage in Whatcom County, which assumes no intervention program. The number of total diabetics grows from about 8,000 in 2001 to nearly 13,000 in 2021, an average growth rate of 2.2% per year. During this same period the total county 18-and-over population grows by only 1.5% per year. As a

result, total diabetics increase from 6.5% of the population to 7.5% over the 20 years. The reason for this growth of diabetes more rapid than the overall population is that the prevalence of diabetes is much greater among the faster-growing elderly population (with about 17% prevalence of diabetes) than among the slower-growing non-elderly (less than 5% prevalence of diabetes). Note in Figure 4 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 of the population at risk for diabetes.

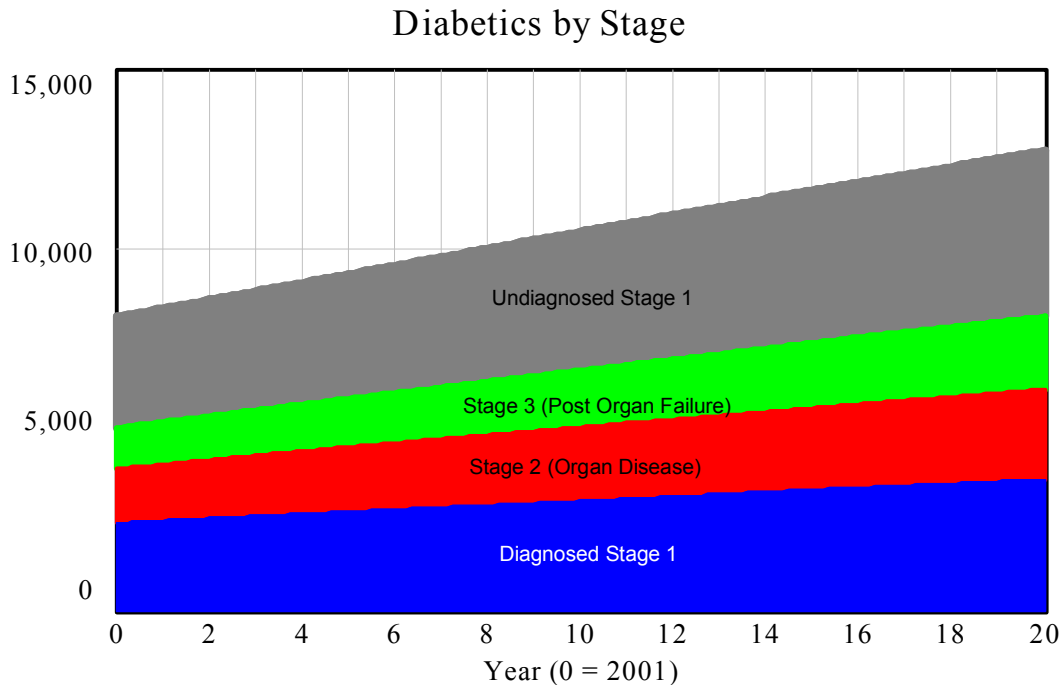


Figure 4. *Status Quo* Projection of Diabetes in Whatcom County, 2001-2021

Figure 5 presents a *status quo* projection of diabetes-related costs, broken into four major categories. These costs are presented in constant 2001 dollar terms, reflecting neither inflation in the general economy nor in healthcare *per se*. The observed growth in costs is instead 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, which reflects payments for physician visits and both outpatient and inpatient hospital visits, and the cost of any associated lab work and testing. Within this category, hospital costs account for 74% of the total, ancillary costs for 14%, specialist MD visits for less than 10%, and primary care physician (PCP) visits for less than 3%. Pharmacy is the cost of drugs for diabetics, most of which is covered by insurers for patients in the 18-to-64 age bracket, but only about 40% of which is covered by Medicare (including supplemental “Medigap” plans) for patients in the 65-and-over bracket. Somewhat less tangible but no less important for the community are the losses of productivity due to disability, shown in Figure 5 as Employer loss and Social loss. These reflect assumptions, based on the literature, that for an

employed (typically younger and more active) person a sick day costs employers an average of \$120 and costs society another \$116; while for an unemployed (typically elderly) person a sick day costs society an average of \$74.

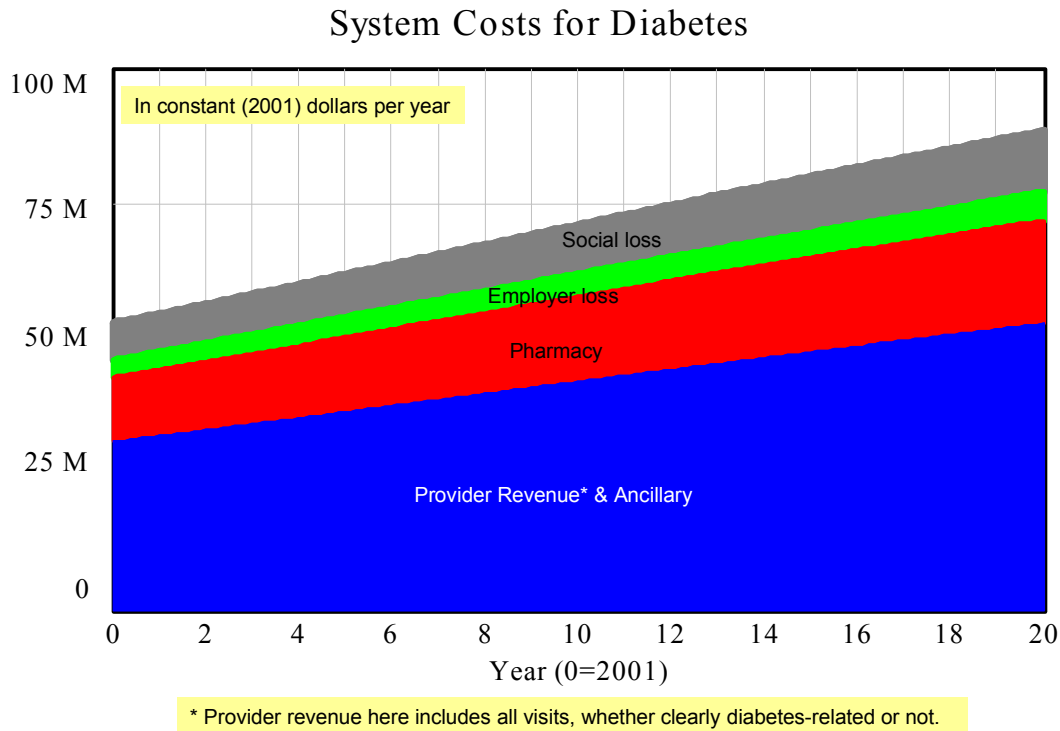


Figure 5. *Status Quo* Projection of Diabetes-Related Costs in Whatcom County, 2001-2021

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 Medicare 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 lab 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.

Figure 6 presents a simplified view of the stock-and-flow structure used in modeling heart failure (HF). (Like the diabetes model, the HF model has two separate structures for each age bracket, plus flows of patients turning 18, turning 65, and migrating into and out of the county, and deaths both unrelated to the illness and due to disease complications.) The four-part scheme seen in this figure (Stages A, B, C, D) is based on a similar scheme identified by a joint task force of the American College of Cardiology and American Heart Association (ACC/AHA), which in 2001 developed broadly recognized guidelines for the evaluation and management of HF. (Another well-known four-part scheme is the one developed by the New York Heart Association, which categorizes only symptomatic patients—NYHA Classes I-IV—but does not address ones who are asymptomatic or at risk.)

About 25% of the adult population is at risk for developing HF (Stage A) by virtue of being hypertensive or hyperlipidemic (hypertension being by far the leading cause of HF), having other risk factors for atherosclerotic disease such as diabetes and smoking, or having valvular disease or other structural heart syndromes. HF is marked by reshaping (“remodeling”) of the heart, which impairs the ability of the left ventricle to fill with and/or eject blood, and may be accurately identified through echocardiography (echo, for short). Stage B patients, who have never had symptoms of HF, probably account for 40-50% of all heart failure patients. Only 20-25% of these patients are diagnosed while still in Stage B, primarily as a result of an echo done following a heart attack (a routine practice in most of the U.S.) or to monitor a pre-existing structural heart condition. Most Stage B patients ultimately progress to a symptomatic stage, either gradually and without immediate hospitalization (Stage C) or with the need for immediate hospitalization (Stage D).

The primary symptoms of HF are shortness of breath, fatigue, and fluid retention, the latter often leading to pulmonary congestion and peripheral edema. In the ACC/AHA scheme, Stage D patients are defined as having refractory disease, with marked symptoms even at rest and often recurrently hospitalized. Unlike diabetes--where standard diagnostic codes reported to payors allowed us to clearly distinguish among Stages 1, 2, and 3 in the Whatcom County data--there are no payor codes that would allow us to distinguish less severe from more severe or refractory symptomatic HF. Thus, for the purposes of modeling, we needed some other operational way to distinguish between Stage C and D patients in our local data. The experts with whom we consulted on the project suggested that recent HF-related hospitalization, say, within the past year, was probably as good proxy as we were likely to find for severe illness. The Whatcom County data showed that about 18% of symptomatic HF patients have been hospitalized within the past year and so are in Stage D by this definition.

Figure 6 shows that a patient may enter Stage D as a result of hospitalization, either from Stage B (previously asymptomatic) or Stage C (previously symptomatic). About half of those who are hospitalized are rehospitalized within the following year and so remain in Stage D; the others flow back to Stage C. Of first-time hospitalizations for HF, 15% die soon after from complications; of readmissions, the number is closer to 50%. Another statistic attesting to the

high fatality rate of HF: for patients with symptomatic HF, the risk of death is increased about 50% over what it would be without HF.

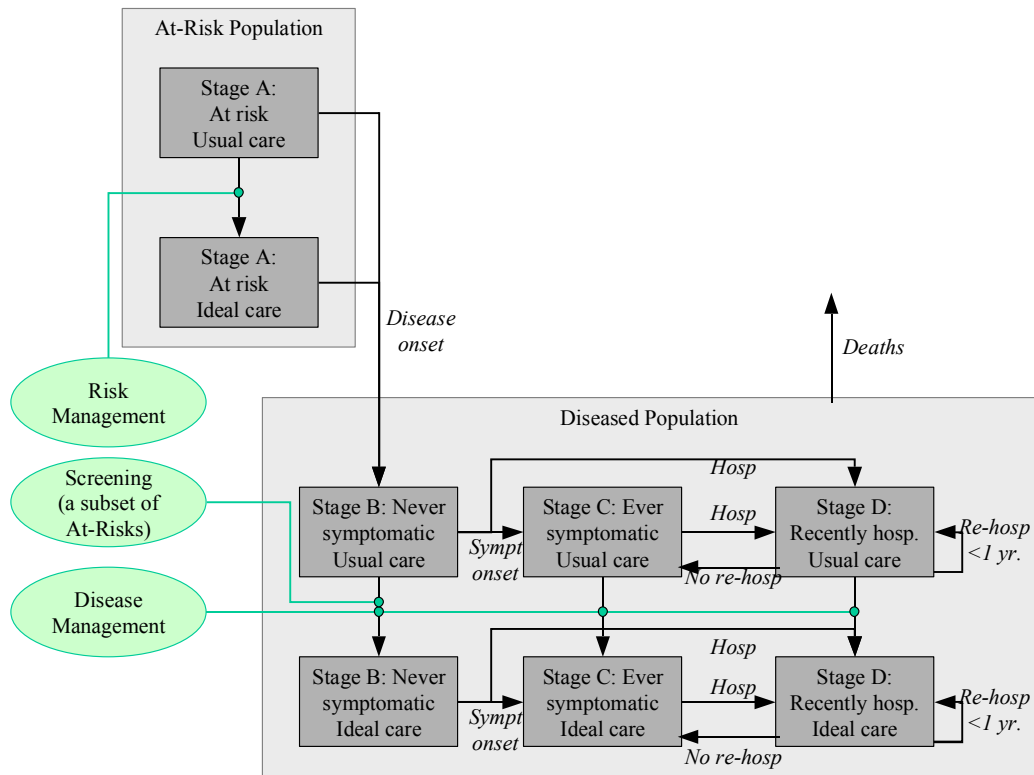


Figure 6. Heart Failure Stages and Intervention Points

Numerous studies have demonstrated that the incidence, progression, and complications of HF can be reduced significantly through concerted intervention. The studies have varied widely in their approaches and in their results, but show clearly that greater success can be achieved when the interventions are more thoroughgoing, rather than aimed only at optimizing drug therapy. Risk management, as indicated in Figure 6, would consist primarily of efforts to reverse or control hypertension and hyperlipidemia through lifestyle changes and greater use of appropriate medications. It has been estimated that only half of the patients at risk for HF are treated for their conditions, and of those only half get the right drugs and at the right doses. We estimate that the 25% of the at-risk currently receiving “ideal care” could be increased to 75% under P2. Studies suggest that risk management can reduce the incidence of HF by 23% to 81%, with the distribution of results centered around a 56% reduction.

Disease management would involve a multidisciplinary team approach, as in P2, and would address the majority of diagnosed patients in Stages B, C, and D. We estimate that only about 10% of known HF patients currently receive the ideal care characteristic of a comprehensive approach, a number that could be raised to about 68% under P2. This 68% figure is perhaps conservative, but it reflects the fact that there is deep uncertainty about the potential impact of ideal care on the half of HF patients who have the diastolic rather than systolic variant of the

disease. (Perhaps because diastolic HF is a bit harder to diagnose than systolic, it has not thus far received much attention from researchers.) Studies suggest that disease management can reduce the progression of asymptomatic HF to symptomatic by 37%. Studies also suggest that disease management can reduce HF-related hospitalizations by 36% to 86%, with the distribution of results centered around a 56% reduction.

Figure 7 presents a 20-year *status quo* projection of HF prevalence by stage in Whatcom County. The number of people with HF grows from 3,700 in 2001 to about 7,700 in 2021, an average growth rate of 3.6% per year. As a result, HF grows from 3.0% of the population to 4.5% over the 20 years. This rapid growth is mostly attributable to the fact that HF is predominantly a disease of the faster-growing elderly population (with about 16% prevalence of HF) than among the slower-growing non-elderly (with less than 1% prevalence of HF). Another part of the story of prevalence growth is that, primarily during the 2002-2005 period, implantable defibrillators and biventricular resynchronization pacers become increasingly used and, in the years that follow, save the lives of some HF patients who would have died without these devices. The fact that these devices save lives and reduce hospitalizations has the effect of shifting the distribution of HF patients in the direction of Stage C and away from Stage D, though only by a few percentage points over the 20 years of simulation.

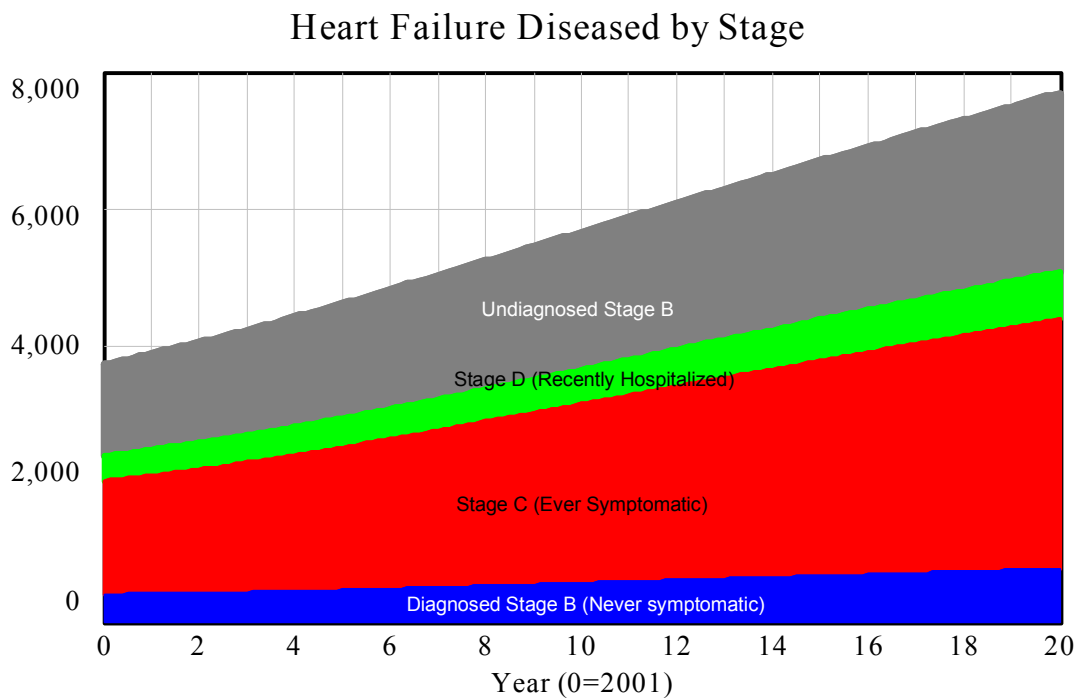


Figure 7. *Status Quo* Projection of Heart Failure in Whatcom County, 2001-2021

Figure 8 presents a *status quo* projection of HF-related costs, broken into six major categories. The Provider revenue and Ancillary category appears here to be a smaller portion of total costs for HF than it was in Figure 5 for diabetes, but this reflects only a difference in how provider revenue was defined for HF, not a difference in reality. For diabetes, all physician and hospital

visits by diabetics were included in provider revenue, whether actually related to the diabetes or not. For HF, only those visits by HF patients clearly related to HF were included. (These were about 39% of the total, including visits coded for HF itself, fluid overload, MI or cardiac arrest, or tachyarrhythmias.) The reason for this difference in definition is that, whereas the leading studies of diabetic disease management describe the benefits in terms of reductions in total healthcare utilization regardless of cause, the leading studies of HF disease management focus on reductions in healthcare utilization directly related to HF.

Within the category of Provider revenue and Ancillary, hospital costs account for 70% of the total, ancillary costs for 5%, specialist MD visits for 21%, and PCP visits for 4%. In addition to physicians and the hospital, other significant healthcare services for HF we have modeled include skilled nursing facilities (SNF), hospice, and home care for Stage D patients, and exercise rehab for Stages C and D. Pharmacy costs for HF are significant, and because most HF patients are elderly and covered by Medicare, a large fraction of these costs must be self-paid by patients. Also shown in Figure 8 are the costs for implanted devices, reflecting rapid growth in their use during Years 1-4 (2002-2005), with an expansion in use of defibrillators to include non-severe patients, and the commercialization and acceptance of biventricular pacers for severe patients starting in 2002. Finally, it should be noted that the employer loss category of disability costs is relatively small in comparison with the social loss category, reflecting the fact that most HF patients are elderly and not employed, though they still contribute to society when not disabled.

### System Costs for Heart Failure

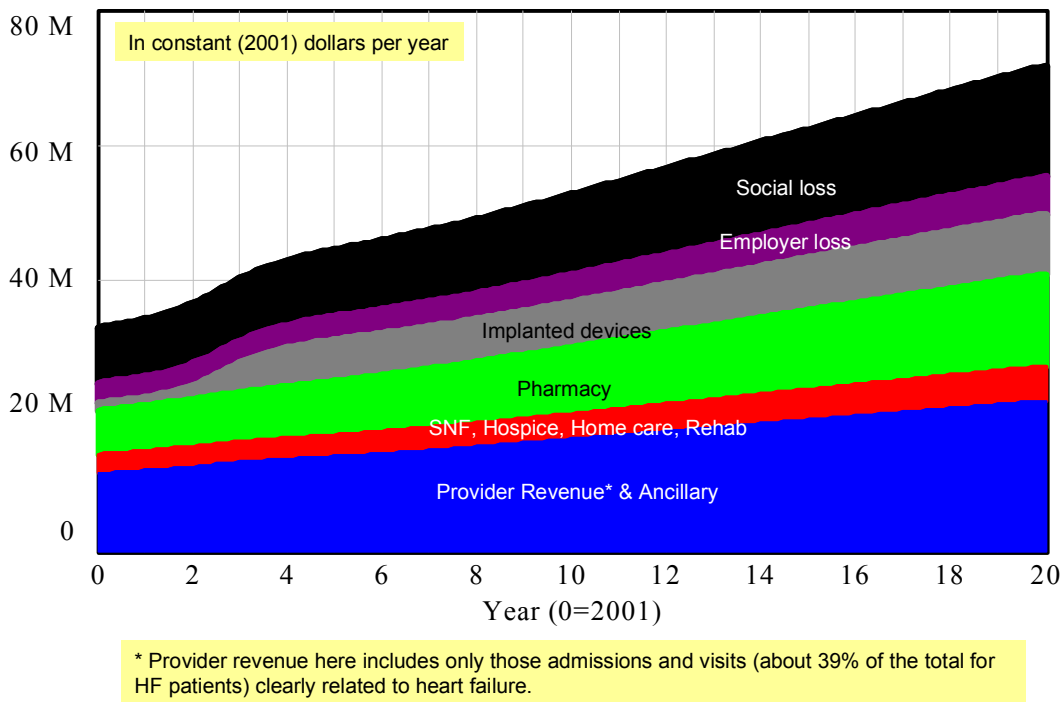


Figure 8. *Status Quo* Projection of Heart Failure-Related Costs in Whatcom County, 2001-2021



## Testing Program Impacts using the Diabetes and Heart Failure Models

We have described above the patient stock-and-flow structures associated with diabetes and HF, the types of healthcare utilization associated with these structures, and also the basic clinical intervention components of the P2 program in Whatcom County that would affect patient flows (namely, screening and preventive education for diabetes, risk management for HF, and disease management for both.) Table 1 presents more detail on the intervention components, in particular the personnel, information systems, and healthcare costs that the program is expected to entail. The direct healthcare cost impacts include an increase in routine primary care for both illnesses (including recently introduced group visits and telephone and e-mail consults), and, specifically for HF, an increase in the use of exercise rehab for Stage C and D patients and the use of home care for Stage D patients.

- **Both diseases:**
  - Disease management increases primary care routine visits, reduces urgent visits, and reduces visits to specialists and hospital
  - Primary care practices to employ group visits, and telephone and e-mail consults
  - Physicians must purchase PC hardware and software, and subscribe to county-wide info network
  - Patients in need of more frequent assistance referred to clinical care specialists (nurses) employed by program to make house calls and do telephone monitoring and counseling
  - Lack of sufficient drug coverage (esp. Medicare) could prevent some patients from receiving proper disease management
  - If number of clinical care specialists does not grow sufficiently to keep up with demand, could prevent some patients from receiving proper disease management
- **Diabetes:**
  - Screening and prevention education program is feasible at low cost; some debate over cost-benefit of identifying more early-stage diabetics and putting them on drugs
- **Heart Failure:**
  - Risk management (drugs, lifestyle changes) for hypertensives and hyperlipidemics is widely supported, but screening these patients for asymptomatic heart failure is not, on grounds of expense (echocardiography) or low test accuracy (BNP blood test)
  - Disease management to promote exercise rehab for all symptomatics, and increased use of home care as needed, even if not covered by insurance
  - Diastolic type HF accounts for about half of all HF patients but is much less studied and understood than systolic HF. Debate as to whether patients with diastolic HF can benefit as much from disease management as patients with systolic HF do

Table 1. Special Considerations in Modeling Program Impacts on Diabetes and Heart Failure

Table 1 also describes two possible factors that could mitigate the ability of the program to bring patients successfully under disease management. The first of these issues is drug affordability, particularly for elderly patients who lack sufficient drug coverage under Medicare. The second issue is the possible insufficiency of clinical care specialists (CCSs) to keep up with the demand for their services. Both the diabetes and HF models contain equations addressing these factors.

The equations are more intricate in the case of CCS insufficiency, where new referral backlogs may build up over time, and where CCS time is increasingly siphoned off to meet the maintenance demand of a growing panel of existing clients.

Table 2 presents assumptions for the key parameters that determine how the program will affect the flows of incidence, progression, hospitalization, and death in the diabetes and heart failure models. For diabetes, these parameters determine the increase in screening and preventive education under the program, the increase in the fraction of known disease controlled, and the assumed benefits of prevention and control in terms of reducing disease flow rates. For HF, these parameters determine the increase in ideal care of the at-risk and the known diseased under the program, and the assumed impacts of ideal care in terms of reducing disease flow rates. These parameter values are, of course, subject to uncertainty. The spectrum of intervention outcomes reported in the literature, especially with regard to HF (as described in the previous section), suggest an important role for sensitivity testing with respect to these parameters.

	<i>Status Quo</i> (age 18-to-64/ age 65+)	Under program
<b>DIABETES</b>		
Screening/preventive ed % of at-risks	25%	70%
Controlled % of known diseased	40% / 46%	max 80%
Incidence rate reduction if preventive ed		42%
Stage 2 & 3 onset rate reductions if controlled		67%
All stage hospitalization rate reductions if controlled		50%
Stage 3 fatality rate reduction if controlled		67%
<b>HEART FAILURE</b>		
Screening % of at-risks	25% / 20%	25% / 20%
Ideal care % of at-risks	10%	max 75%
Ideal care % of known diseased	10%	max 68%
Incidence rate reduction if ideal care		56%
Stage C onset rate reduction if ideal care		37%
First hospitalization rate reduction if ideal care		60%
Rehospitalization rate reduction if ideal care		50%

Table 2. Key Assumptions about Program Impacts on Patient Flows

Table 3 presents a group of scenarios for evaluating program impacts. These scenarios, and a few others not seen here, were presented to program participants and other community stakeholders as part of the P2 planning process. (Among other scenarios presented to

participants but not shown here are ones assessing the impact of CCS sufficiency, and the impact of mass screening of patients at risk for HF.) 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, which requires them to bear the costs of clinical information systems, and also to incur the short-term (several months) inconvenience and inefficiency associated with altering office practices to pave the way for greater patient access and satisfaction as well as greater office efficiency. It also assumes comprehensive disease management for both diabetes and HF, similarly rigorous risk management for HF, 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.

<ul style="list-style-type: none"> <li>• <b>Status Quo</b> <ul style="list-style-type: none"> <li>– No program implementation, costs or benefits</li> </ul> </li> <li>• <b>Full program adoption</b> <ul style="list-style-type: none"> <li>– Administrative costs incurred starting Year 0 (2001)</li> <li>– PCP &amp; specialist adoption grows to 100% during Years 1 to 4 (2002-2005): <ul style="list-style-type: none"> <li>• (Yr 1) 2 FCN sites, SeaMar, and CSH; (Yr 2) Other 6 FCN sites;</li> <li>• (Yr 3) Half of other PCPs; (Yr 4) All remaining PCPs</li> <li>• Specialists: Ramp-up in parallel with PCP adoption</li> </ul> </li> <li>– Clinical care specialists hired to meet demand as projected by model <ul style="list-style-type: none"> <li>• Start with 2 CCS’s, grow to 7 by Year 4, up to 10 by Year 18</li> </ul> </li> <li>– Program components included: <ul style="list-style-type: none"> <li>• Diabetes: Community-based screening &amp; prevention ed for At-Risks (with referral to PCP if test positive), and Disease management for known diseased</li> <li>• 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)</li> </ul> </li> </ul> </li> <li>• <b>Partial program adoption</b> <ul style="list-style-type: none"> <li>– FCN, SeaMar, and CSH adopt, but other PCPs do not</li> <li>– Partial adoption affects disease and risk management, but community-based diabetes screening and preventive ed are unaffected</li> </ul> </li> <li>• <b>Full adoption but disease management only</b> <ul style="list-style-type: none"> <li>– Diabetes: No screening or preventive ed of At-Risk beyond <i>status quo</i> amount</li> <li>– Heart failure: No risk management beyond <i>status quo</i> amount</li> </ul> </li> <li>• <b>Full adoption plus comprehensive Medicare drug coverage</b></li> <li>• <b>Full adoption but with benefits undercut by poor execution*</b> <ul style="list-style-type: none"> <li>– Less effective preventive ed (Diabetes) or risk management (HF) leading to less reduction of disease incidence rates</li> <li>– Less effective disease management leading to less reduction of disease progression and complication rates</li> </ul> </li> </ul> <p>* For heart failure, assumed values based on least beneficial outcomes reported in the literature on ideal care. For diabetes, assumed values based on expert judgment.</p>
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Table 3. Selected Scenarios Tested with Diabetes and Heart Failure Models

Figure 9 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 3 other than *Status Quo* and “Partial program adoption”.) The largest category is personnel costs, which include administrative, process/OD consultants for reforming 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 (2005), growing to ten by Year 18, at a cost of \$74,000 apiece. 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 apiece. 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 by guidelines. The screening involves a very quick blood glucose reading, while the preventive component involves brief discussion and receipt of an educational booklet. The whole procedure takes about ten minutes and can be administered by trained lay people. The model suggests that about a quarter of those tested will get a positive reading. These positives will be referred to their physician for additional testing and counseling; the cost of the additional physician visit is reflected in the model but not shown in Figure 9. Studies suggest that of those subjects referred, about 35% will turn out to have diabetes and the other 65% the pre-diabetic condition of impaired glucose tolerance (IGT).

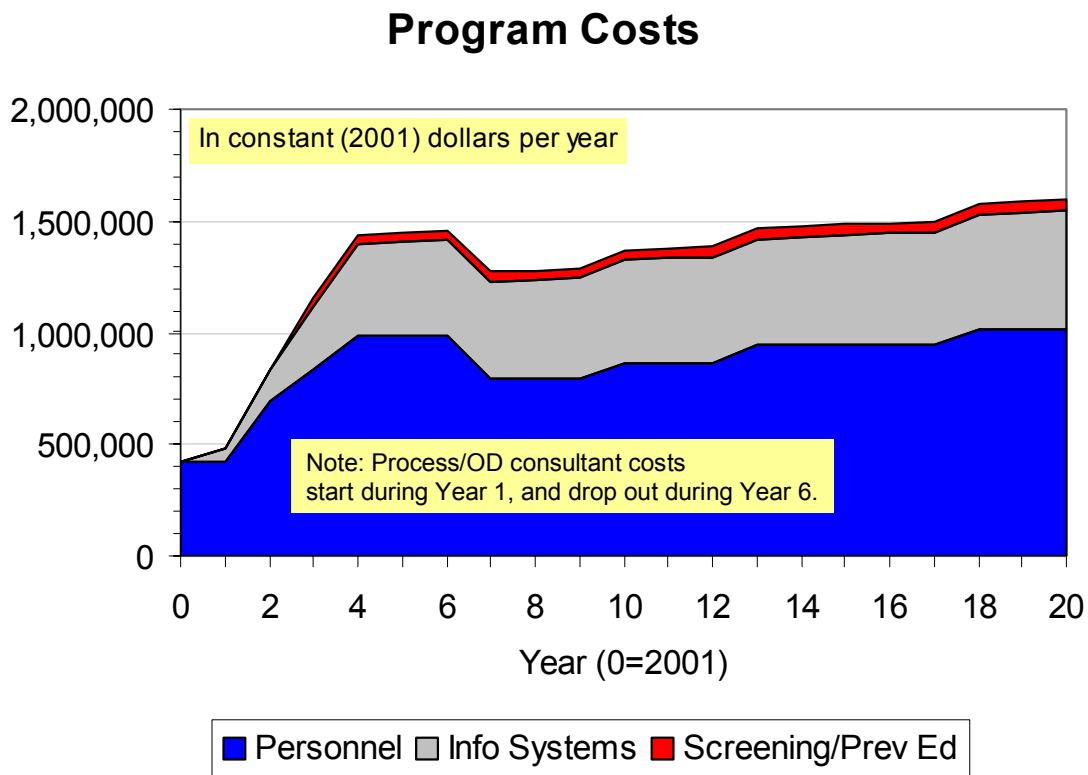


Figure 9. Program Costs under Full Adoption Scenarios

Figures 10 to 19 present graphical output from the diabetes and HF models allowing comparison of the six scenarios described in Table 3 over the full 20-year time horizon. (It should be noted that the graphs presented here are in a format that is condensed, with several lines of output on a single graph, in contrast to the simpler and more user-friendly—but also more numerous—graphs presented to the program planning participants in Whatcom County.) The graphs are paired so that for each diabetes graph there is a corresponding HF graph. The following is a summary of the graphical results:

Fraction of Patients under Effective Disease Management

- Diabetes (Figure 10): The fraction of known diabetics under control starts at a *status quo* value of 43%. It is assumed that 80% of known diabetics could be brought under control if they could afford the drugs and there were sufficient CCS support. With partial program adoption, the fraction under control is increased to 57%, with full adoption to 72%, and with full adoption plus full Medicare drug coverage it is raised to 77%. This final value is short of 80% only because of the steady influx of newly diagnosed diabetics not yet under control.

Controlled Fraction of Diabetics

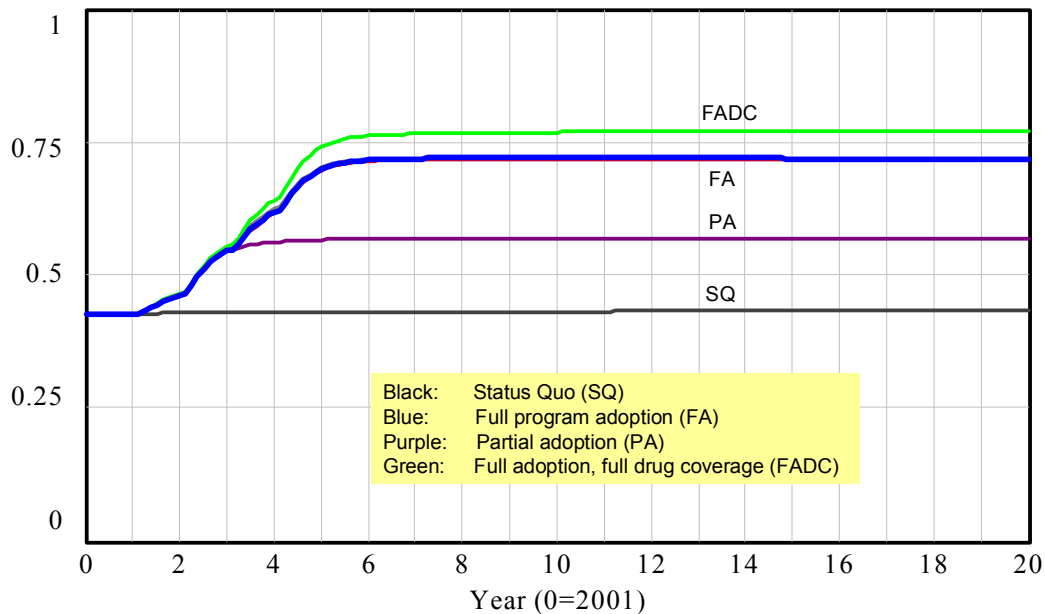


Figure 10. Program Impact on Fraction of Diabetics under Control

- HF (Figure 11): The fraction of symptomatic HF patients under ideal care starts at a *status quo* value of 10%. It is assumed that 68% could benefit from and be willing to comply with ideal care, if they could afford the drugs and there were sufficient CCS support. With partial program adoption, the fraction under ideal care is increased only to 19%, because the majority of the elderly, thus most HF patients, are seen by PCPs other than those who are among the starting group of program participants (FCN, SeaMar, CSH). With full program adoption, the fraction under ideal care rises to 47%, still well short of the potential 68%. With full Medicare drug coverage, a value of 67% is achieved by Year 7, but then falls to about 60% by Year 10 and thereafter because of a shortage of CCSs to handle the extra

demand (new referrals plus maintenance) that is generated. This problem could be alleviated by hiring additional CCSs, beyond the 10 assumed in the standard Full adoption run.

### Ideal Care Fraction of Symptomatic HF

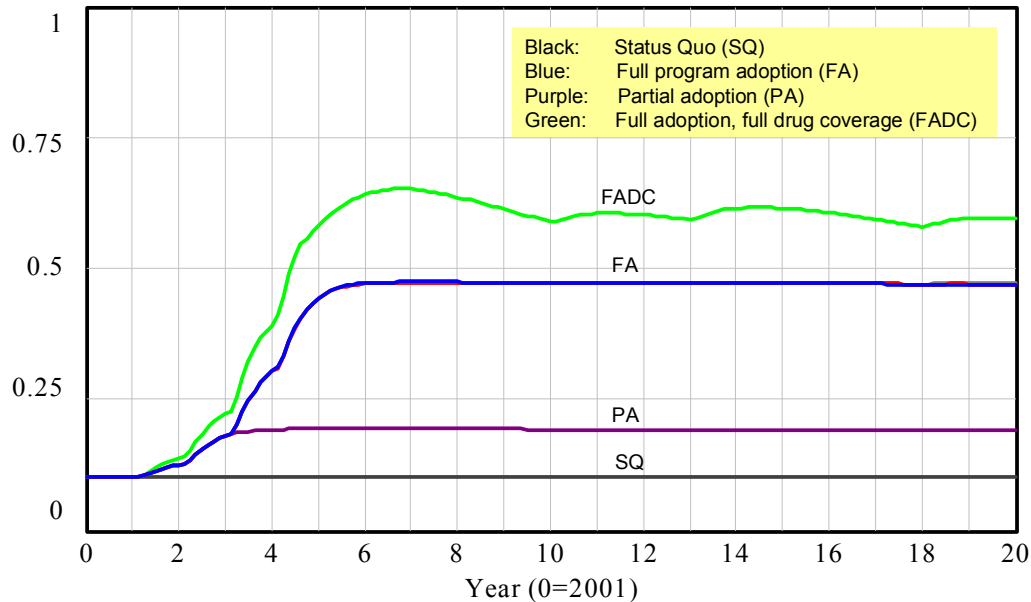


Figure 11. Program Impact on Fraction of Symptomatic Heart Failure Patients under Ideal Care

#### Deaths from Disease Complications

- Diabetes (Figure 12):** Under the *status quo*, the number of diabetes-related deaths grows continuously along with the size of the diabetic population. Partial program adoption reduces these deaths by 24%, full adoption by 40%, and full adoption plus drug coverage by 54%, in line with the greater fractions of diabetics being brought under control. A program with full adoption but disease management only (no screening and prevention component) is effective at reducing deaths early on, but becomes less and less effective as time progresses. A program with full adoption but poor execution (for example, bringing patients under control initially but allowing them to backslide, or not following through properly with referrals and lifestyle counseling when screened subjects test positive) ends up being little more effective at reducing deaths than a program with partial adoption.
- HF (Figure 13):** Under the *status quo*, the number of HF-related deaths grows slowly during the first five years of simulation, as the use of implanted devices expands and lives are saved. With this reduction in the fractional death rate complete by Year 5, the absolute number of deaths then resumes more rapid growth in parallel with the HF patient population. Partial program adoption reduces these deaths by 8%, full adoption by 33%, and full adoption plus drug coverage by 42%, in line with the greater fractions of HF patients being brought under ideal care. A program with disease management only (no risk management) is effective at reducing deaths early on, but less and less so as time progresses. A program with full adoption but poor execution ends up being little more effective at reducing deaths than a program with partial adoption.

### Deaths from Diabetic Complications

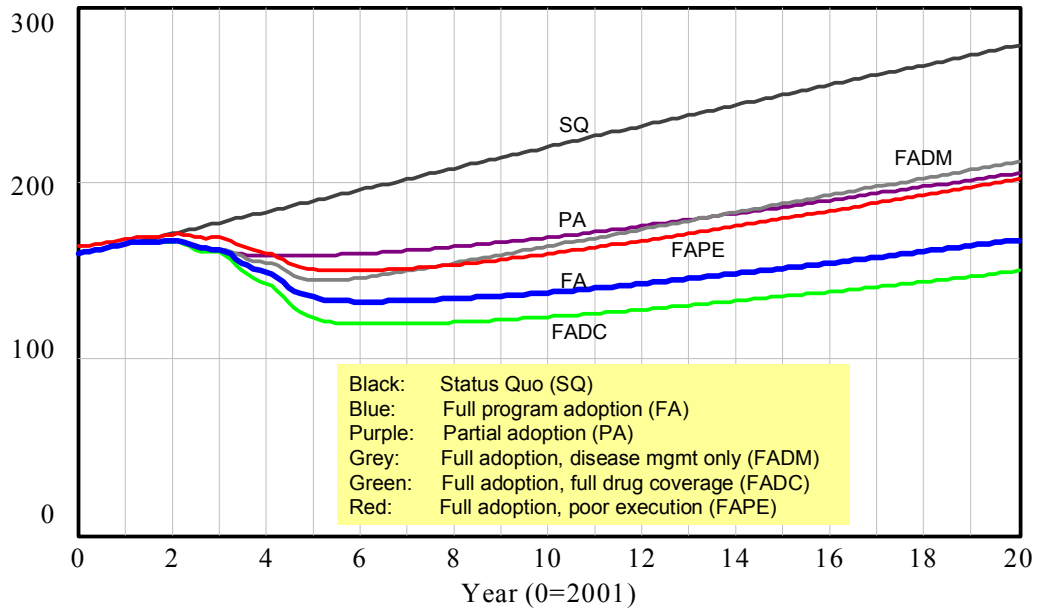


Figure 12. Program Impact on Deaths from Diabetic Complications

### Deaths from Disease Complications

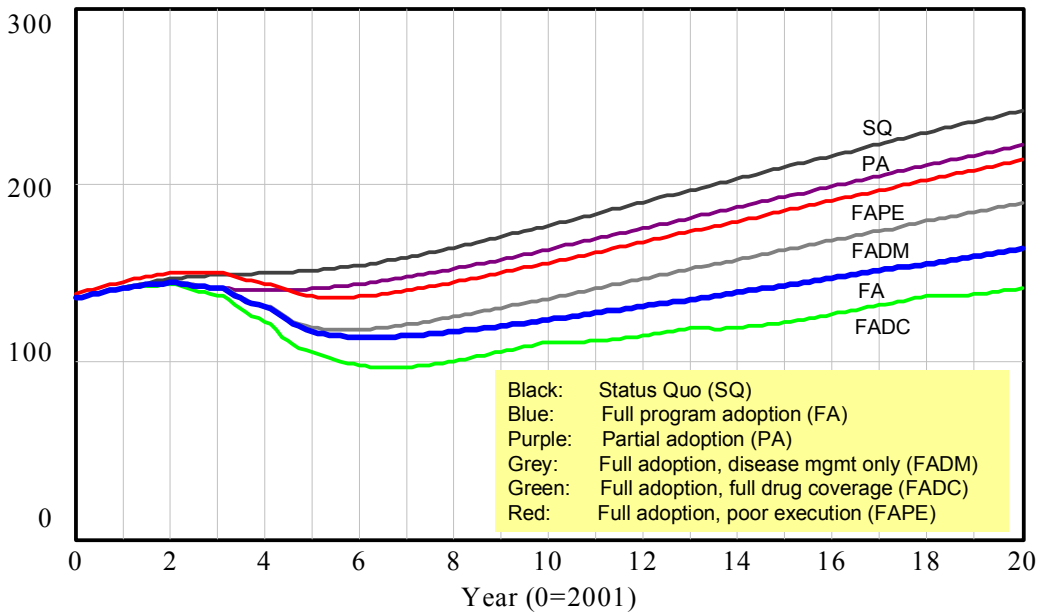


Figure 13. Program Impact on Deaths from Heart Failure Complications

### Patients with Advanced Disease

- Diabetes (Figure 14): 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 year. The program—whether with partial adoption, full adoption, or full adoption with drug coverage—ends up reducing the number of later stage diabetics by about 20% relative to the *status quo*. All three of these scenarios share the same screening and prevention component, a component which dramatically reduces the incidence and progression of diabetes to later stages. A program with disease management only 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. A program with poor execution weakens the effectiveness of the screening and prevention component, and so allows somewhat more diabetics to progress to advanced stages.

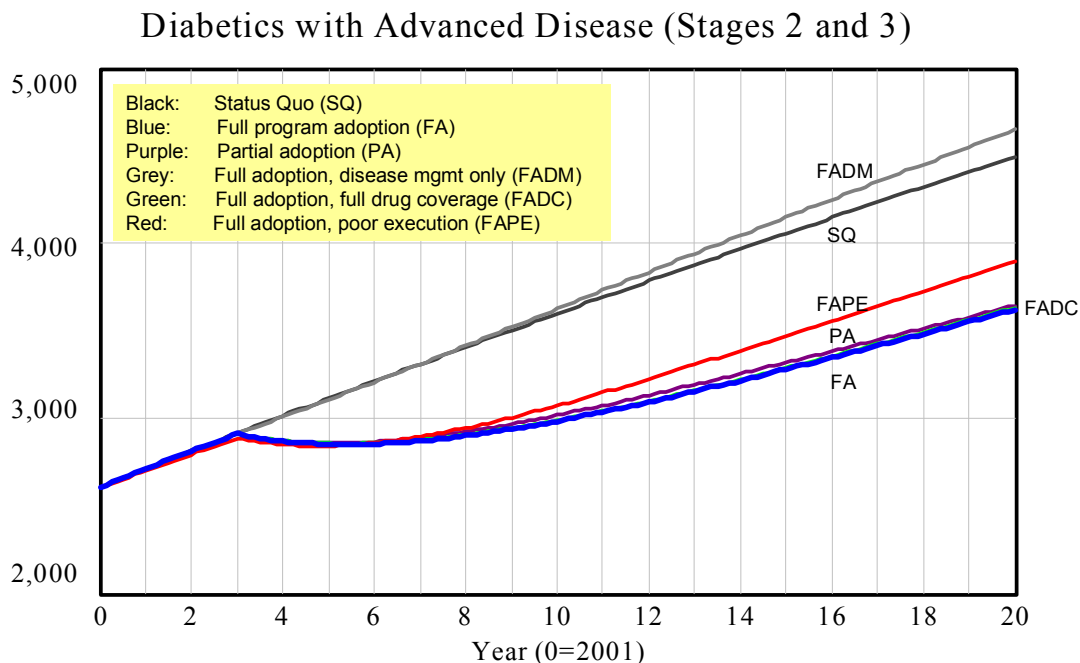


Figure 14. Program Impact on Prevalence of Advanced Diabetes (Stages 2 and 3)

- HF (Figure 15): Under the *status quo*, the number of patients with symptomatic (Stage C or D) HF grows at an average rate of 3.8% per year. This rate of growth can be slowed somewhat with a program including risk management, an effect which is maximized with full program adoption plus drug coverage. (Unlike prevention of diabetes, prevention of HF includes a key role for drugs.) Without risk management, or with poor execution of risk management, the program can end up increasing the number of patients with symptomatic HF relative to the *status quo*, by doing more to keep them alive longer than to reduce their inflow.



### Symptomatic diseased (Stages C & D)

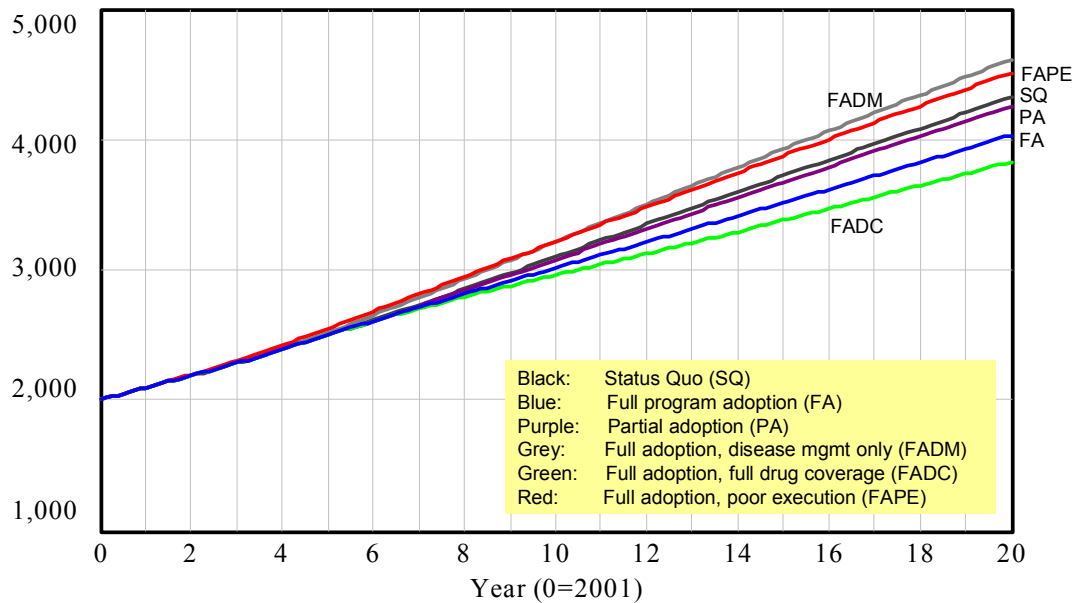


Figure 15. Program Impact on Prevalence of Symptomatic Heart Failure (Stages C and D)

### Total Outlay Costs

- Diabetes (Figure 16):** A useful combined measure of diabetes-related costs for the county is what we call “outlay costs” (alternatively, “total system costs excluding disability”), the sum of all program costs plus all payments by payors (insurers and patients). Payor payments in the case of the diabetes model cover provider visits and ancillary services (decreased overall as a result of the program), and pharmacy (increased). From a cost-benefit standpoint, one would hope to minimize the net increase in total outlay costs for the program relative to the *status quo*, and eventually to achieve a net savings. This goal of net savings is in fact achieved in the partial program adoption scenario (by Year 7), in standard full adoption (by Year 7), and in full adoption plus drug coverage (by Year 6). The goal is not achieved in the “disease management only” and “poor execution” scenarios, where the net outlay costs always exceed the *status quo*, and increasingly so over time. This result speaks again to the importance of the diabetes screening and prevention component, and of solid program execution.
- HF (Figure 17):** In the case of the HF model, payor payments cover provider visits and ancillary services (decreased overall as a result of the program), pharmacy (increased), implanted devices, skilled nursing facilities, hospice, and home care (all decreased due to the reduction in Stage C and D patients), and exercise rehab services (increased). The relative positions of the various scenarios in this graph look different than they do in the diabetes graph, especially in the early years, because of the significant cost of risk management in the case of HF. Only the poor execution scenario is a clear loser throughout the 20-year time horizon, because it incurs the full expense of both risk management and disease management, without doing either one well. “Disease management only” looks like a winner in the early

### Total Outlay Costs for Diabetes

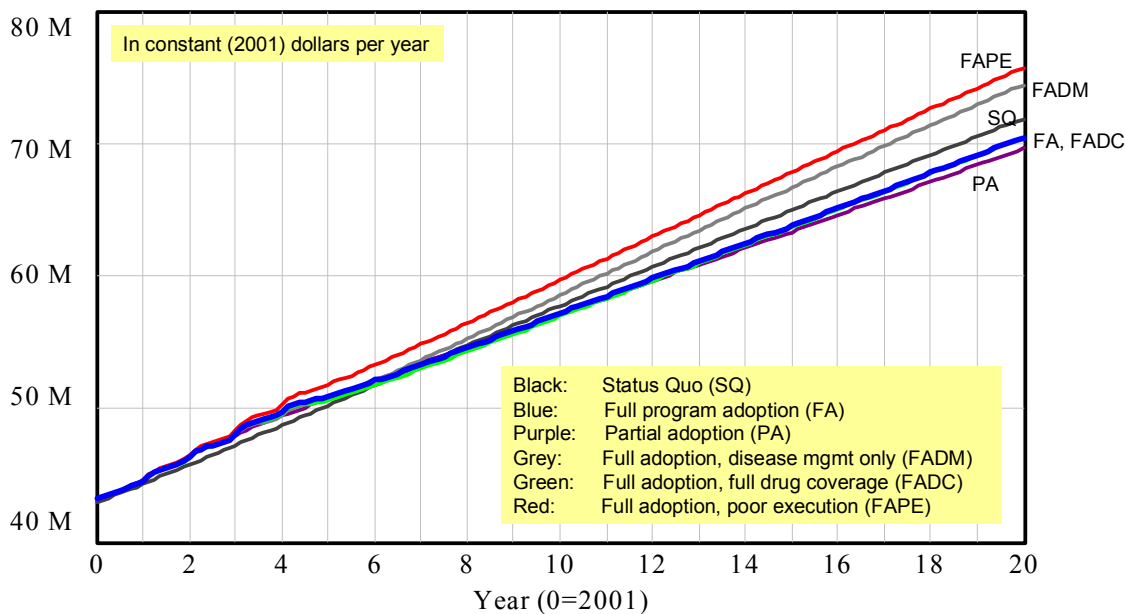


Figure 16. Program Impact on Total Outlay Costs for Diabetes (does not include Productivity Losses due to Disability)

### Total Outlay Costs for Heart Failure

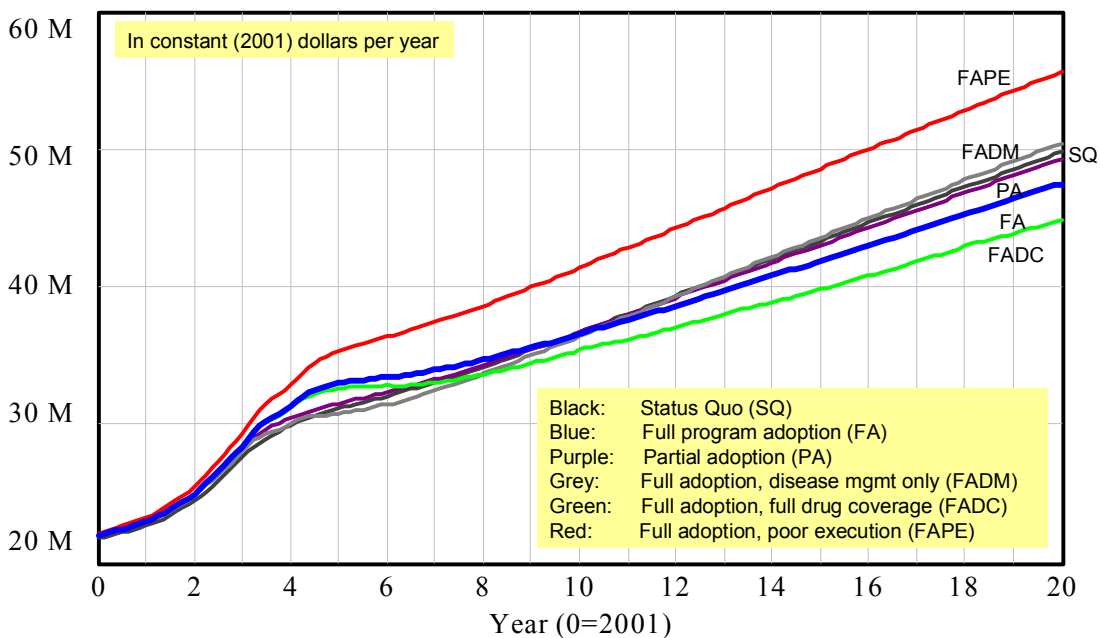


Figure 17. Program Impact on Total Outlay Costs for Heart Failure (does not include Productivity Losses due to Disability)

years, but becomes a net loser after the first ten years, because the cost burden of additional HF prevalence has not been alleviated by reduced incidence as in the other scenarios. The scenarios generating long-term net savings are the same scenarios as those mentioned for diabetes, with full program adoption and drug coverage even more important in the case of HF because of their impact on both disease management and risk management. There is a clear short-term cost bulge relative to *status quo* (\$1.5-1.8 million at its greatest in Year 5), in the cases of the full program adoption and full adoption-plus-drug-coverage scenarios, that precedes significant long-term savings. The partial program adoption does not generate as great a short-term bulge (only \$0.7 million at its peak in Year 3), but also does not generate significant long-term savings. Because of the costs of risk management, the crossover points come later for HF than they do for diabetes: Year 9 for the full adoption scenarios, Year 6 for the partial adoption scenario.

### Total System Costs

- Diabetes (Figure 18): A breakdown of total system costs for the *status quo*, including disability losses to employers and society-at-large, was previously shown in Figure 5. When disability losses are taken into account, the program is seen to generate a net savings much earlier than when only outlay costs are considered. In the partial program adoption, full adoption, and full adoption-plus-drug-coverage scenarios, net savings are achieved by Year 3 (2004), only two years after the program is launched. By Year 5 (2006), the further reduction in disability due to full adoption makes this option superior to partial adoption from a total system costs standpoint; full drug coverage results in still further reductions in disability losses. The “disease management only” and “poor execution” scenarios, in contrast, achieve total net savings initially, but give back most or all of these savings by the end of 20 years. These results underscore again the importance of an effective screening and prevention component for diabetes. By the end of 20 years, the full adoption approach results in a net savings of \$6 million per year, or 7% of the *status quo* costs, including a \$4 million reduction in disability losses.
- HF (Figure 19): A breakdown of total system costs for the *status quo* was previously shown in Figure 8. Although the great majority of HF patients are elderly and non-employed, the magnitude of disability losses to society is large, significantly larger than it is for diabetes in both per-patient and absolute dollar terms. The reduction of these disability losses under a comprehensive program can thus have an even more dramatic impact on total system costs for HF than it does for diabetes. With disability losses taken into account, the partial program adoption, full adoption, and full adoption-plus-drug-coverage scenarios all generate net savings by Year 3. Over the longer term, the net savings under partial adoption remain limited relative to those of full adoption, as is true of a program that includes only disease management and not risk management. By the end of 20 years, the full adoption approach results in a net savings of \$9 million per year, or 13% of the *status quo* costs, including a \$7 million reduction in disability losses.

### Total System Costs for Diabetes

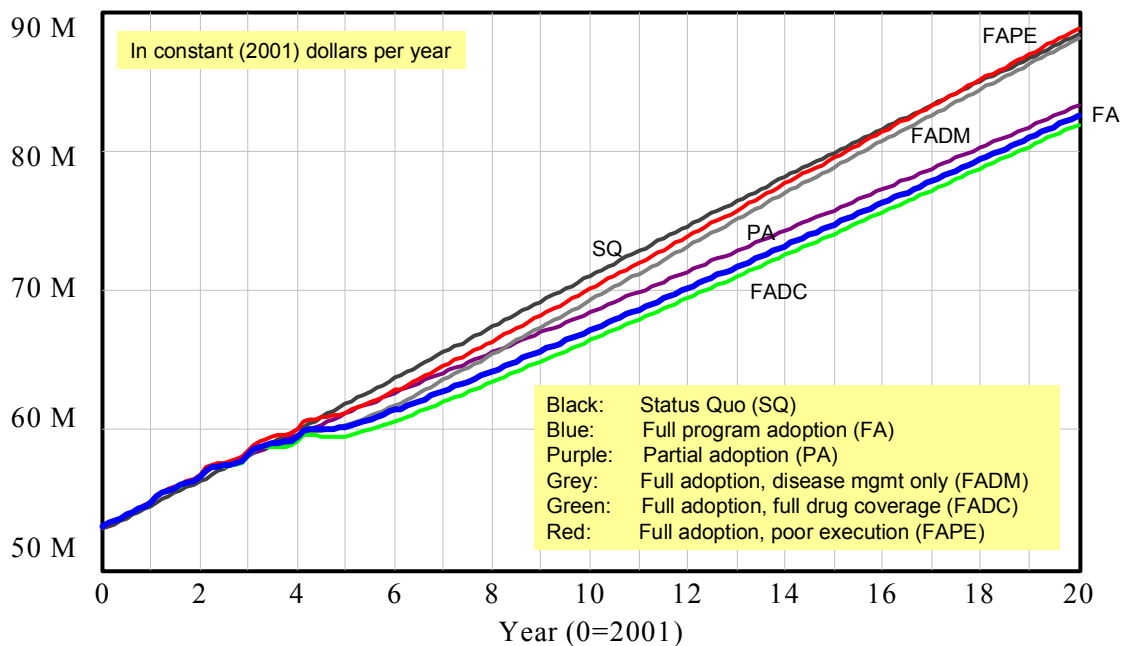


Figure 18. Program Impact on Total System Costs of Diabetes (includes Productivity Losses due to Disability)

### Total System Costs

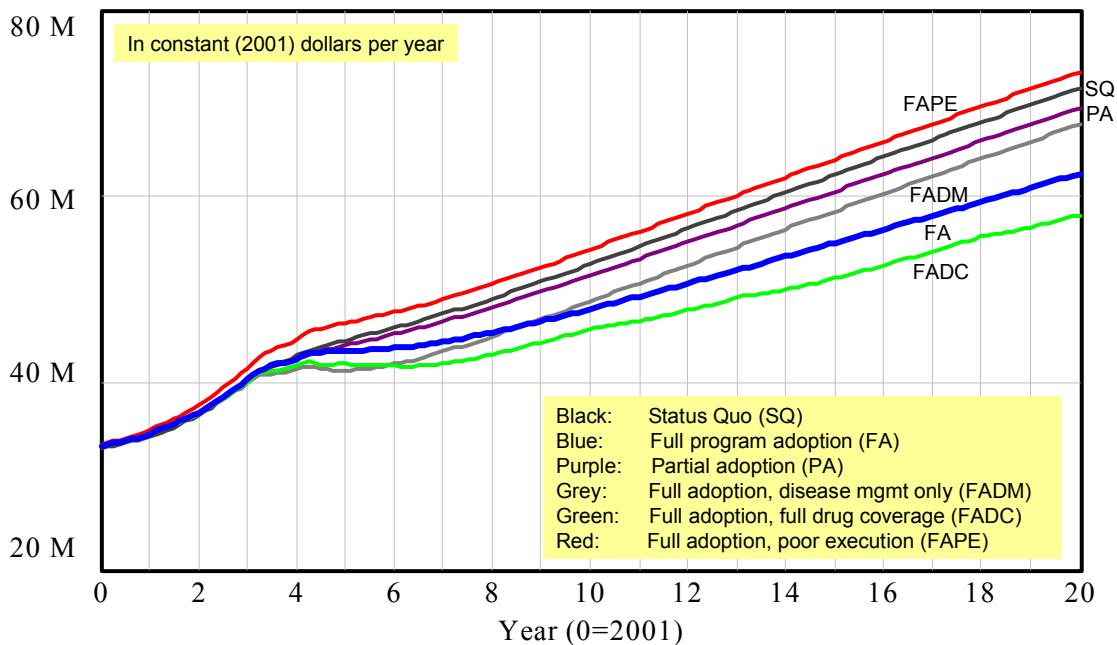


Figure 19. Program Impact on Total System Costs of Heart Failure (includes Productivity Losses due to Disability)

The P2 program planners and stakeholders in Whatcom County appreciate the long-term view afforded by the preceding graphs, but also require a more detailed sense of the program's impacts over the shorter term. Table 4 presents a numerical table, covering the period 2003-2008 (model Years 2-7), that describes the impact of the full program adoption scenario relative to the *status quo* for diabetes and HF 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, and 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. Even with this narrower view, the final section at the bottom of Table 4 suggests that over the 2003-2008 time period program-related outlays will generate health benefits that rival or beat those of other accepted health interventions on the basis of cost-benefit ratio. For example, one study found that the incremental cost of treating patients with an implantable defibrillator versus giving them antiarrhythmic drugs for three years had an incremental cost of about \$14,000 for an additional 0.21 years of life saved, giving a cost-benefit ratio of \$66,000 per life-year saved. This is a ratio that is viewed as acceptable enough for insurers including Medicare to cover such device implants. The model suggests that the P2 program will result in an outlay per life-year saved of less than \$66,000 by the year 2005, and less than \$10,000 per life-year saved by 2008 (and turning negative—indicating net savings—by 2010.)

### **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. 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 the P2 on the community and were essential for helping to build commitment to continue with the program. Key insights included the following:

- Complete implementation of P2 involving all providers in the community would produce more extensive benefits than partial implementation involving only those providers already participating.

As of start of year:	2003	2004	2005	2006	2007	2008	TOTAL
<b>1. HEALTH IMPACTS</b>							
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
<i>Financials below are in constant 2001 dollars.</i>							
<i>Values are the result of subtracting status quo projections from full-program projections.</i>							
<i>Black indicates increase relative to status quo; (Red) indicates decrease relative to status quo.</i>							
<b>2. PROGRAM COSTS (\$000)</b>							
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
<b>3. IMPACT ON PROVIDER NET INCOME (\$000)</b>							
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)
<b>4. IMPACT ON SUPPLIER REVENUE (\$000)</b>							
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)
<b>5. IMPACT ON PAYOR COSTS (\$000)</b>							
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
<b>6. IMPACT ON DISABILITY LOSSES (\$000)</b>							
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)
<b>7. IMPACT ON COMBINED COSTS (\$000)</b>							
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)
<b>8. COST-BENEFIT RATIOS (\$)</b>							
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

Table 4. Six-Year Program Impacts on Diabetes and Heart Failure Combined,  
Comparing Full Adoption Scenario to *Status Quo*

- Knowing the magnitude and growth of P2 costs over time enabled participants to budget for 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. People often worry that improved care for older people will lead to dramatically 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 acute complications of these diseases that require expensive hospitalizations. Given the sensitivity of those paying for care who were already bearing high costs, this was an important insight to help motivate their continued participation in the program.
- 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 suggests 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 if the crossover point for net savings does not occur as soon as it does in the mid-range or best-case simulations.

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 4. 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 help 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, so that these insurers will have an interest in supporting P2.
- The other big “winner” is the pharmaceutical industry; see Table 4. This windfall for the pharmaceutical industry suggested that the drug companies be “brought to the table” and asked to help fund P2.
- Physicians and the hospital are likely to see reductions in their net income as a result of P2, as seen in Table 4. This reduction is, of course a concern to providers, especially the hospital. 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 HF 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 HF 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. The amounts paid under such a payment mechanism could be weighted for the different stages of severity to avoid a windfall to the hospital, a windfall that would otherwise occur under P2 as the proportion of less severely ill patients in the community increases (due to the slowing of disease progression). Tests of the diabetes model demonstrated the feasibility of using such a severity-adjusted capitation 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 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--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 the support of the P2 program in Whatcom County for a period of nine months after the RWJF funding was due to run out and before other 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 the Leadership Board meeting in March, 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 the subject of pursuing perfection 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 U.S. P2 grantee institutions, 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 currently under discussion in Congress. On one side of the debate is a proposal to provide expanded drug benefits to seniors under privately-run disease management programs. On the other side is a more ambitious “case management” approach, involving not only drug benefits but also multi-disciplinary provider teams, and presumably greater up-front cost as in P2. Our models suggest that the broad-based case management approach is likely to be more cost-effective than one that is narrowly focused on disease management services.

Every group we have met with 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, and 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.

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