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Are Coverage and Quality Enough? A Dynamic Systems Approach to Health Policy

Technical Appendix

Our simulation model of the U.S. health system represents an application of system dynamics (SD), a general modeling methodology that has been applied since the 1970s to many issues of health care and public health (see Sterman 2000; Homer and Hirsch 2006). The SD approach is useful in analyzing situations that have elements of both rapid change and gradual change, and in which interventions may encounter resource constraints, delays, and unintended side effects, with repercussions that may take years to play out fully.

The model was implemented using the Vensim™ simulation software package. It consists of some 850 calculated variables, 200 specified constants, 9 X-Y lookup functions, and 20 intervention "gaming" variables. The calculated variables include both integral equations (used for defining accumulators and delay functions) and straightforward algebraic equations. The simulation is deterministic; although there are no stochastic elements, uncertainties may be explored through sensitivity testing of uncertain inputs. The model simulates forward in 3-month intervals, allowing the model (a) to closely approximate the continuous-time solution of the model's equations and (b) to complete a 25-year run in less than a second—thereby facilitating rapid testing of many possible intervention scenarios and sensitivity settings.

Because of our model's broad scope, we have defined its variables at a high level of aggregation. We have attempted to disaggregate concepts enough to allow the model to depict intervention outcomes adequately (for example, with regard to morbidity, mortality, cost, and health equity), but not so far that the model becomes difficult to comprehend or impossible in practice to test and analyze thoroughly. For example, we do not model individual types of disease or injury, but rather combine them all into a single measure of disease and injury prevalence (based on analyses of the National Health and Nutrition Examination Survey.) We also do not model multiple demographic categories of the population (age, gender, race, education, geography, etc.), but only divide the population demographically into two groups described as advantaged and disadvantaged (based on Census data on household income and household size.) We also do not model the various flows of payments between medical providers, private insurers, the government, patients, and employers, but instead calculate system-wide health care costs based on the volumes of services provided and applying average prices estimated for each type of service (based on analysis of the National Health Expenditures Accounts.)

An overview of the model's main causal pathways and intervention areas is presented in Figure A-1. Some of the more intricate parts of the model's detailed causal logic are presented in diagram form, in Figures A-2 to A-10, and described below. However, due to the sheer size of the model, other parts are not diagrammed, and we provide no discussion here of the model's individual equations. The complete model is available upon request.

Table A-1 lists proxy measures and data sources for all of the major concepts in the model, grouped by the sector categories described in the main paper. Tables A-2 to A-19 present all of the model's constants and lookup functions.

Table A-20 presents the model's 20 intervention variables. Specifics for the scenario and sensitivity testing done for this paper are described below.

The model is initialized in a "status quo" equilibrium, with all outcome variables unchanging and sitting close to where they were in real life around the year 2003. The model's calculated variables replicate a variety of data from that period, as presented in Tables A-21 to A-23.

Health status and socioeconomic status (Figures A-2 and A-3)

The population stocks and flows associated with health status and socioeconomic status are diagrammed in Figure A-2. Two levels of socioeconomic status are considered: Advantaged (*Adv*) and Disadvantaged (*Disadv*). Three levels of health status are considered: No significant health problem (NSHP), Asymptomatic disorder but no disease or injury (AD no DI), and Disease or injury (DI). (Many people in the Disease or injury stock also have an asymptomatic disorder; i.e., DI with AD.) Initial values of the population stocks are calculated from several parameters in Tables A-2 and A-3.

The inflow of births and net immigration is normally (for all simulations presented in the paper) set constant and equal to the baseline outflow of deaths, to keep the model in equilibrium. It is possible, however, to portray a growing population by specifying a rate of births and net immigration that produces an inflow greater than the number of deaths.

The annual transition rates from Advantage to Disadvantage are considered fixed and appear in Table A-3; from these "downflow" rates the model calculates the "upflow" rates from Disadvantage to Advantage necessary to keep the model in its baseline equilibrium. The Pathway to Advantage intervention in Table A-20 can increase these upflow rates, as specified by other parameters in Table A-3.

As shown in Figure A-2, deaths occur at a rate determined by the urgent event rate (which can be reduced by improved DI management) and the fatal fraction of urgent events (which can be reduced by improved quality of urgent care). Parameters for the urgent event rates and fatal fraction of urgent events appear in Table A-6.

Some people with DI recover back to the NSHP and AD-no-DI stocks, specified by rates of recovery (assumed constant) in Table A-2.

The rates of onset to AD (from NSHP) and DI (from NSHP or from AD-no-DI) can vary with other factors, as diagrammed in Figure A-3. All three onset rates start at rates that maintain the initial equilibrium. Reduction in the prevalence of unhealthy behavior (e.g., poor nutrition or physical activity) will reduce the onset of AD (hypertension, high cholesterol, pre-diabetes). Reduction in unhealthy behavior (e.g., smoking) will also reduce the onset of DI (e.g., COPD or lung cancer). The onset of DI can also be reduced through reduction in the fraction of the population living in an unsafe environment (e.g., disease due to pollution, or injuries due to unsafe buildings or to violent crime.) Also, the elevated risk of moving from AD to DI can be mitigated to some degree through improved management of asymptomatic disorders. Parameters affecting these onset rates appear in Table A-2.

<u>Health-related behavior (Figure A-4)</u>
The fraction of the population with unhealthy behavior is calculated through the stock-flow structure (shown for the Advantaged population) in Figure A-4. Unhealthy behavior prevalence is increased through the flow of *behavior lapse* and is decreased through the flow of *behavior reform*. The initial values of unhealthy prevalence and the parameters affecting rates of behavior lapse and reform are specified in Table A-4.

Behavior lapse occurs initially at a fractional rate exactly offsetting the initial flow of behavior reform to keep the model in equilibrium. But the rate will increase if (a) the unsafe environment fraction increases, or (b) if the unhealthy behavior fraction itself increases. The first effect reflects the fact that, for example, danger will cause people to stay inside more and do less exercise; it also reflects the "broken windows" effect of environment on risky behavior. The second effect describes the effect of social imitation with regard to behavior. Social imitation creates a reinforcing feedback loop that can amplify (up or down) any initial changes in the prevalence of unhealthy behavior.

Behavior reform occurs at a fractional rate that is constant unless it is boosted by intervention. The reform rate with maximum intervention is specified by the lookup function in Table A-4. This lookup function indicates a high potential rate of reform when unhealthy behavior is more prevalent, but declining as unhealthy behavior becomes less prevalent. This formulation is based on a "low-hanging fruit" theory that says that progress is much easier when unhealthy behavior is highly prevalent than it is when it has been reduced to a smaller "hard core" of problems that are more difficult to reform.

<u>Health-related environment (Figure A-5)</u>
The fraction of the population living in an unsafe environment is calculated through the stock-flow structure (shown for the Advantaged population) in Figure A-5. Unsafe environment prevalence is increased through the flow of *environment degradation* and is decreased through the flow of *environment remedy*. The initial values of unhealthy prevalence and the parameters affecting rates of behavior lapse and reform are specified in Table A-5.

Environment degradation occurs at a fractional rate exactly offsetting the initial flow of environment remedy. Environment remedy occurs at a fractional rate that is constant unless it is boosted by intervention. The reform rate with maximum intervention is specified by the lookup function in Table A-5. This lookup function indicates a high potential rate of remedy when unsafe environment is more prevalent, but declining as unsafe environment becomes less prevalent. This formulation is based on a "low-hanging fruit" theory that says that progress is much easier when unsafe environment is highly prevalent than it is when it has been reduced to a smaller "hard core" of problems that are more difficult to remedy.

Disease and injury (DI) diagnosis and management (Figure A-6)

Figure A-6 presents the chain of causation that leads to the *effectively managed fraction of people with DI* (shown for the Advantaged population). Not shown is a similar chain of causation that leads to the managed fraction of people with AD-no-DI. The parameters affecting these causal chains are specified in Tables A-7 and A-8.

The chain begins with the left-side structure that determines the *intended preventive and chronic care [PCC] fraction*; this is the fraction of non-urgent care providers who provide a high quality of PCC. The term "intended" refers to the fact that the fraction of patients actually *receiving* quality PCC may be less than the fraction of providers *providing* PCC care, as described below. The intended PCC fraction may be increased by intervention with a preventive and chronic care program.

The *routine screening fraction* is less than the intended PCC fraction to an extent determined by (1) the uninsured fraction, (2) the self-pay fraction of the insured, and (3) the fraction of PCC demand not accommodated. The *diagnosed fraction of DI* is determined by this screening fraction and by parameters describing the diagnosed fraction of DI without screening and with screening. The impact of a change in routine screening on the diagnosed fraction does not occur all at once but is gradual, because of the time between screenings for an individual patient. (Because of this delay, the diagnosed fraction is portrayed as a rectangle, or stock variable, in Figure A-6.)

The *managed fraction of DI* is determined by the diagnosed fraction of DI, the intended PCC fraction, and the fraction of PCC demand not accommodated. The *effectively managed fraction of DI* is normally equal to the managed fraction, but will be reduced below it if elective hospital capacity becomes insufficient. Elective hospital capacity will become insufficient if the reimbursement rate for hospital care is reduced below its baseline value; see the relevant parameters in Table A-10.

Choice of non-urgent care venue (Figure A-7)

Figure A-7 indicates (shown for the Advantaged population) how the model determines the fractional breakdown by venue for two types of non-urgent demand: preventive and chronic care (PCC) demand, and acute non-urgent demand (e.g. for colds and other minor ailments and injuries). The relevant parameters are listed in Table A-9, including two parameters describing the fraction of non-urgent demand that would go, respectively, to PCPs or to specialists, if PCPs were fully sufficient to handle this indicated demand. One minus the sum of these two parameters describes the fraction of non-urgent demand that would go to hospital emergency or outpatient departments (ED/OPD) even if PCPs were fully sufficient, for reason of convenience or cost. (This minimum ED/OPD fraction is 6% for Advantaged and 14% for Disadvantaged.)

If PCPs are less than fully sufficient, then two other parameters specify the extent to which some patients may be able and willing to shift over to a specialist for their non-urgent care, and the average delay time that this shifting process takes. This delay process produces the adjusted fractions of non-urgent demand going to PCPs or to specialists. Any *acute non-urgent* demand that is not satisfied by PCPs or specialists will end up going to a hospital emergency department. Any *preventive and chronic care* demand that is not satisfied by PCPs or specialists, or that does not normally go to a hospital outpatient department, will become non-accommodated.

Insurance coverage (Figure A-8)
Figure A-8 indicates how the insured fraction is determined for both the Advantaged and Disadvantaged populations. The relevant parameters are listed in Table A-15. Insured fractions are first calculated absent any insurance coverage program intervention, and then adjusted upward (that is, reducing the fraction uninsured) to the extent that such a program is implemented. Based on historical data, we specify an X-Y lookup function that describes how the overall insured fraction declines in reaction to increasing health care costs per capita—or, by the same token, how the insured fraction would increase in reaction to a decrease in costs. The reaction by employers to a change in health care costs does not occur all at once but takes some time. (Because of this delay, *the insured fraction of total population no program* is portrayed as a rectangle, or stock variable, in Figure A-8.) Whatever the overall insured fraction is, the Disadvantaged are more likely to be uninsured than the Advantaged are; this relative risk is determined by the parameter *Disadv vs. Adv uninsured ratio no program*.

Primary care providers (PCPs) (Figure A-9)
As seen in Figure A-9, PCPs are modeled as a stock variable (portrayed as a rectangle), with an inflow of new PCPs completing their training and going into practice, and an outflow of retiring PCPs. Figure A-9 shows the structure for PCPs whose practices serve primarily the Advantaged population; an identical structure is used for PCPs whose practices serve primarily the Disadvantaged population. The relevant parameters are listed in Table A-12. The inflow of new PCPs may be affected by changes in the population, or in average net income per PCP, or by a possible PCP training and placement program intervention.

If there is no change in average net income and no intervention, then the inflow of new PCPs will equal the outflow of retiring PCPs. The inflow will then adjust upward (over a specified adjustment time reflecting delays in demand and in medical school capacity) only if there is growth in the population, in order to adjust the ratio of PCPs to population back to its starting point. But if net income changes, an X-Y lookup function causes the indicated PCP ratio to change accordingly, the PCP ratio rising when income is higher. The inflow of new PCPs can be amplified by a training and placement program to a specified extent (the *Max possible multiplier* parameter in Table A-12) beyond what it would be based on changes in population and net income alone.

Health care costs (Figure A-10)
As seen in Figure A-10, we model health care costs as the sum of payments to hospitals, payments to office-based physicians, payments for personal medical products, spending on nursing homes and home health care, payments to dentists and miscellaneous health professionals, spending on miscellaneous personal care services, and insurance overhead costs—categories all specified in the National Health Expenditures Accounts (NHEA). Each of these costs has its own unique operational drivers, along with corresponding unit costs specified in Tables A-16, A-17, and A-18.

Payments to hospitals and to attending specialist physicians are broken out further in the model into payments for emergency and outpatient (ED/OPD) department visits, payments for inpatient stays, and payments for outpatient procedures. Parameters modulating these volumes appear in Table A-11. Some ED/OPD visits are non-urgent (see Figure A-7), while others reflect the volume of urgent events (see Figure A-2). Some inpatient stays are the result of urgent ED visits (and made greater if the quality of urgent care is poor), while others are elective and determined (as is the volume of outpatient procedures) by the volume of non-urgent acute care visits and DI management visits.

Payments for personal medical products are broken out further (as in the NHEA) into payments for prescription drugs and spending on all other personal medical products. Payments on prescription drugs, in turn, are broken out into drugs used in patients with DI and drugs used in patients with AD-no-DI. Spending on other personal medical products (non-prescription drugs and all personal equipment and supplies) is assumed to be driven by the number of people with DI.

Spending on nursing homes and home health is driven by the number of people requiring such extended care; this number, in turn, is driven (see Table A-11) by the number of people with DI (and made greater if the quality of urgent care is poor).

Spending on dentists, miscellaneous health professionals, and miscellaneous personal care products—unlike the other categories of spending above which are driven by particular health-status subsets of the population—are assumed to be proportional to the entire population.

Insurance overhead costs are determined by the number insured, and by whether insurance has been expanded as the result of a program (see Figure A-8), and also by whether one assumes a diversity of insurers as at present or, alternatively, a switch to a government single-payer system. NHEA data give the administrative cost of private insurance, from which (together with Census data on the number of people with private insurance) we have calculated the average overhead cost of private insurance. Based on Medicare data we estimate the overhead cost of government insurance as about one-third the overhead cost of private insurance. A program to expand insurance coverage may do so through a mix of employer mandates and expansion of government coverage; we have assumed a 50-50 approach (see Table A-16). A government single-payer system would reduce overhead costs by shifting all insured people to government coverage.

Scenario and sensitivity testing

Table A-20 indicates the values of the intervention parameters corresponding to the scenarios tested in the paper. When all of these parameters are set to their baseline values without change, the model remains in equilibrium, with key outputs shown in Tables A-21, A-22, and A-23. The intervention parameter changes made in alternative scenarios are implemented during the first 3-month interval of the run and kept in place to the end of its 25 years.

"Coverage" involves changing two intervention parameters, one expanding insurance for the Advantaged and one for the Disadvantaged. "Quality" involves changing one parameter for increasing the extent of preventive and chronic care, and another parameter for increasing the fraction of hospitals offering high-quality urgent care. "Capacity" involves changing one parameter for expanding the supply of PCPs for the Disadvantaged, and another parameter for increasing the fraction of PCPs with highly-efficient operations. "Reimburse-cut" involves reducing two relative reimbursement rates, one for office visits and the other for hospital visits. "Protection" involves changing two parameters for increasing behavior reform (Advantaged, Disadvantaged) and two parameters for increasing environmental remedy (Advantaged, Disadvantaged).

Each of these interventions has direct costs and effects that are subject to some uncertainty. We have estimated the ranges of this uncertainty for 22 model parameters, as follows:

- 1 for "Coverage", related to its cost (see Table A-15);
- 8 for "Quality", 2 related to its costs and 6 to its benefits (Tables A-6, A-7, A-10);
- 6 for "Capacity", 2 related to its costs and 4 to its benefits (Tables A-12, A-13, A-14);
- 3 for "Reimburse-cut", related to its adverse effects (Tables A-7, A-10); and
- 4 for "Protection", 2 related to its costs and 2 to its benefits (Tables A-4, A-5).

For each scenario, we ran the model under three settings for the uncertain cost and effect parameters: First, with all of these parameters at their baseline values; second, with all of these parameters at their "optimistic" values, where cost is lower than the baseline or benefit greater (or adverse effect less) than the base value; and third, with all of these parameters at their "pessimistic" values, where cost is greater than the baseline or benefit less (or adverse effect greater) than the base value.

In the main body of the paper, Table 2 presents detailed results at Year 5 and Year 25 corresponding to layering the interventions on one another in various configurations, using the baseline uncertainty settings. Table 3 presents 25-year cumulative cost and QALY impacts for these same scenario configurations and for all three uncertainty settings.

Figure A-1: Major causal pathways in the model

The model's main outcome variables are shown in red. Concepts in brown italics indicate possible areas for policy intervention. Blue arrows indicate same-direction effects; e.g. more environmental hazards lead to more disease and injury. Green arrows indicate opposite-direction effects; e.g., greater sufficiency of primary care providers leads to less use of specialists and hospitals for non-urgent care.

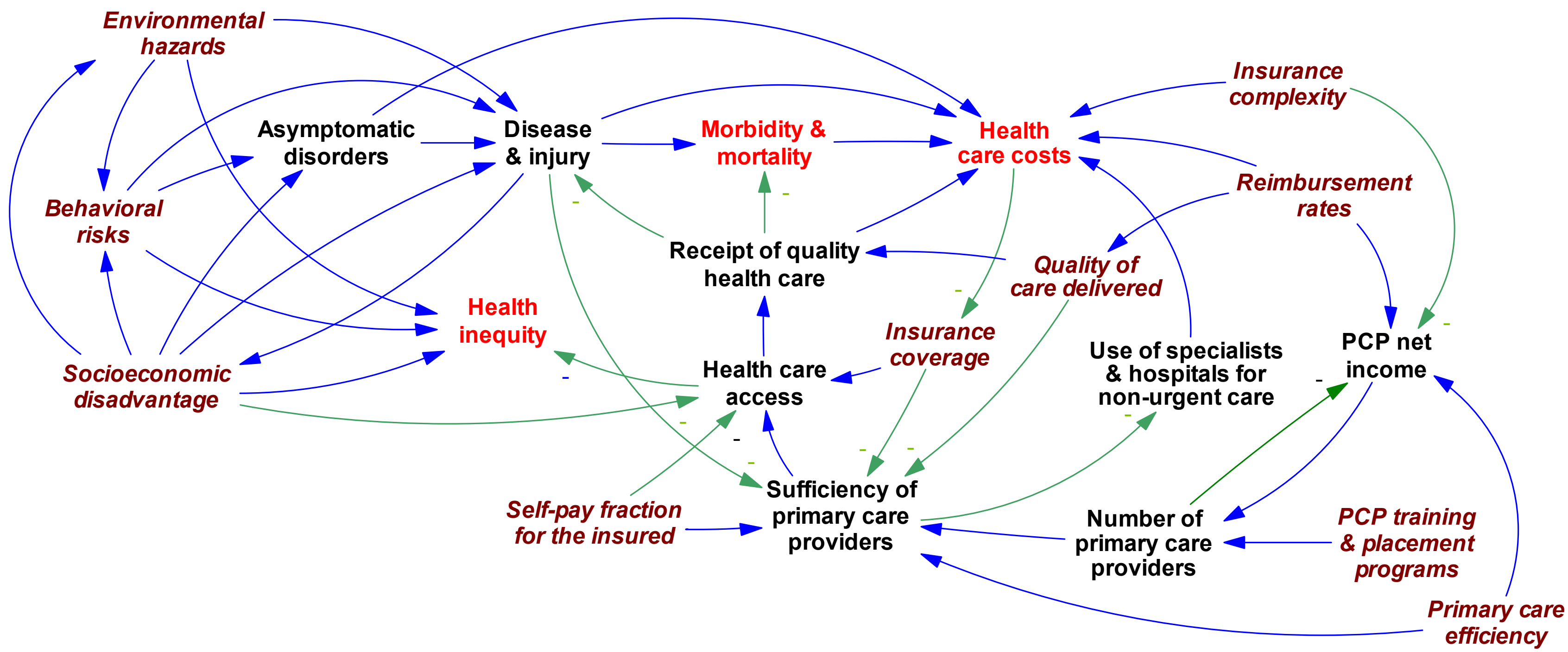

Figure A-2. Structure for population health status and socioeconomic status

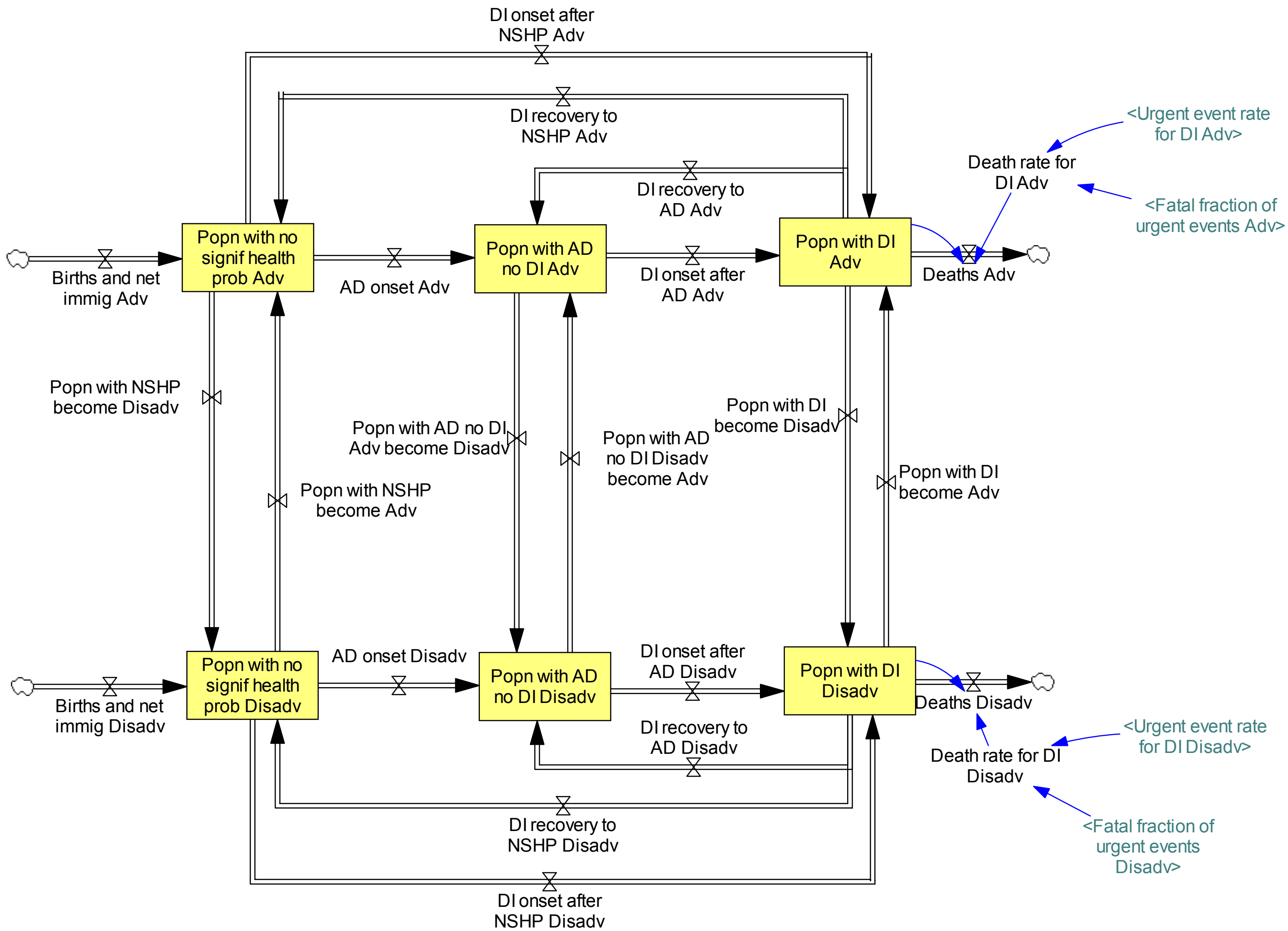

Figure A-3. Structure for onset of asymptomatic disorders and of disease and injury (shown for Advantaged population)

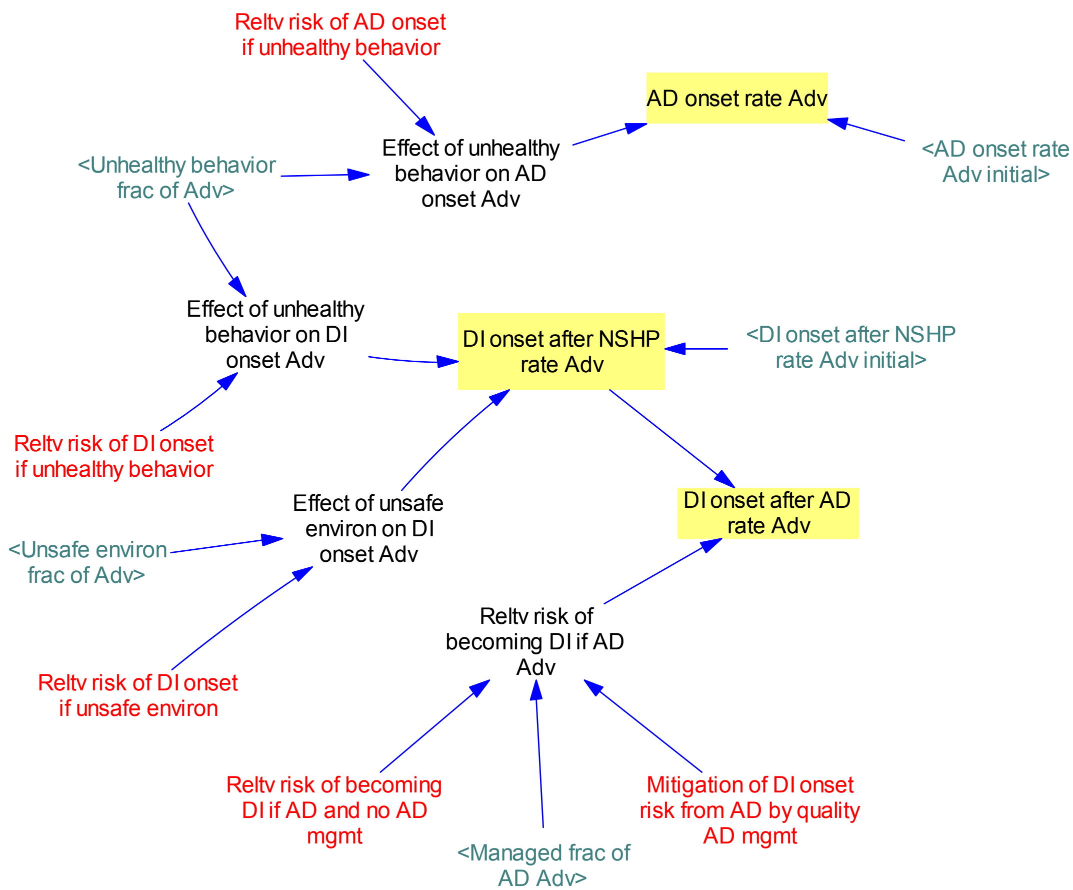

Figure A-4. Structure for healthy-unhealthy behavior fractions (shown for Advantaged population)

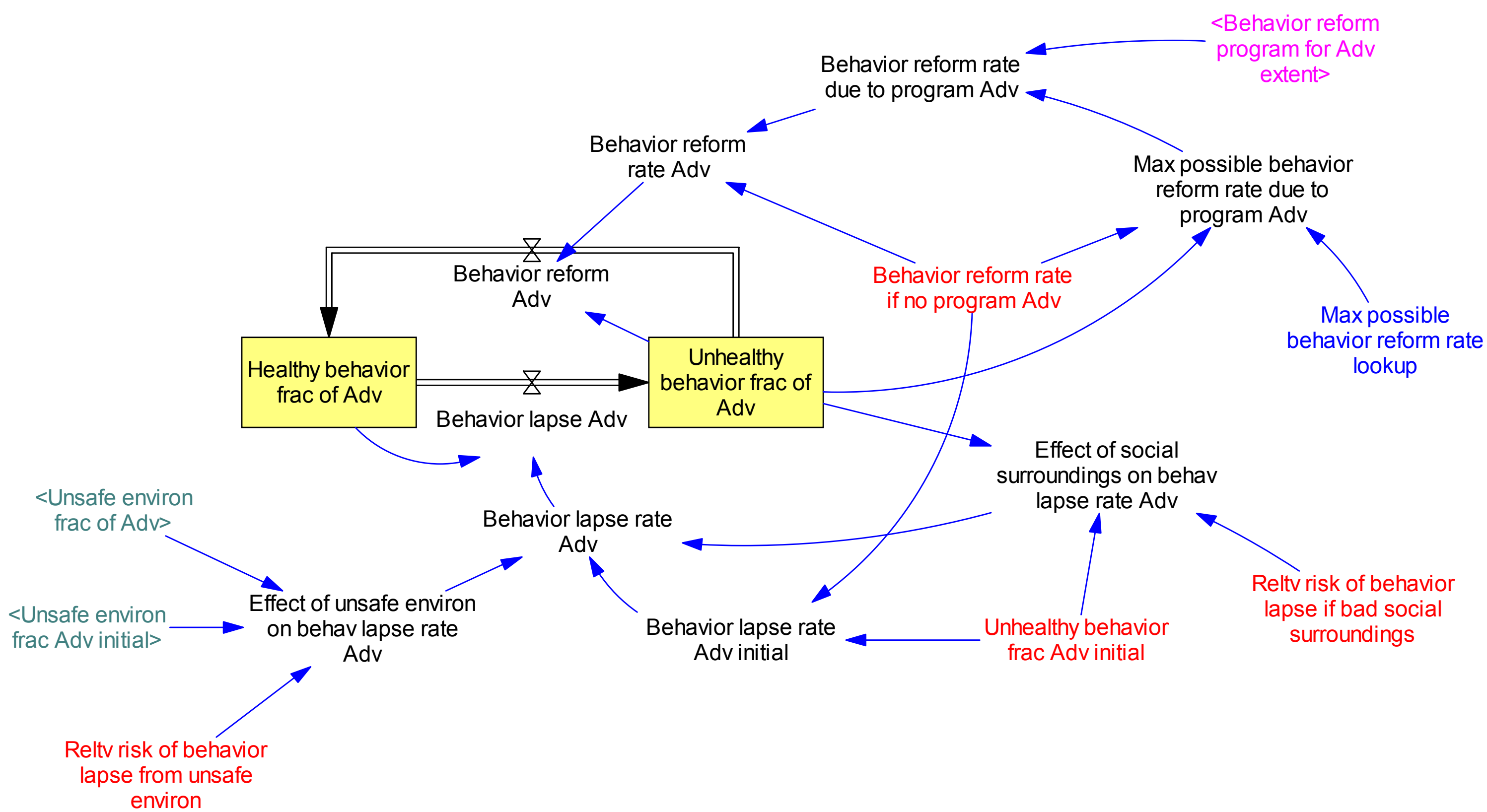

Figure A-5. Structure for safe-unsafe environment fractions (shown for Advantaged population)

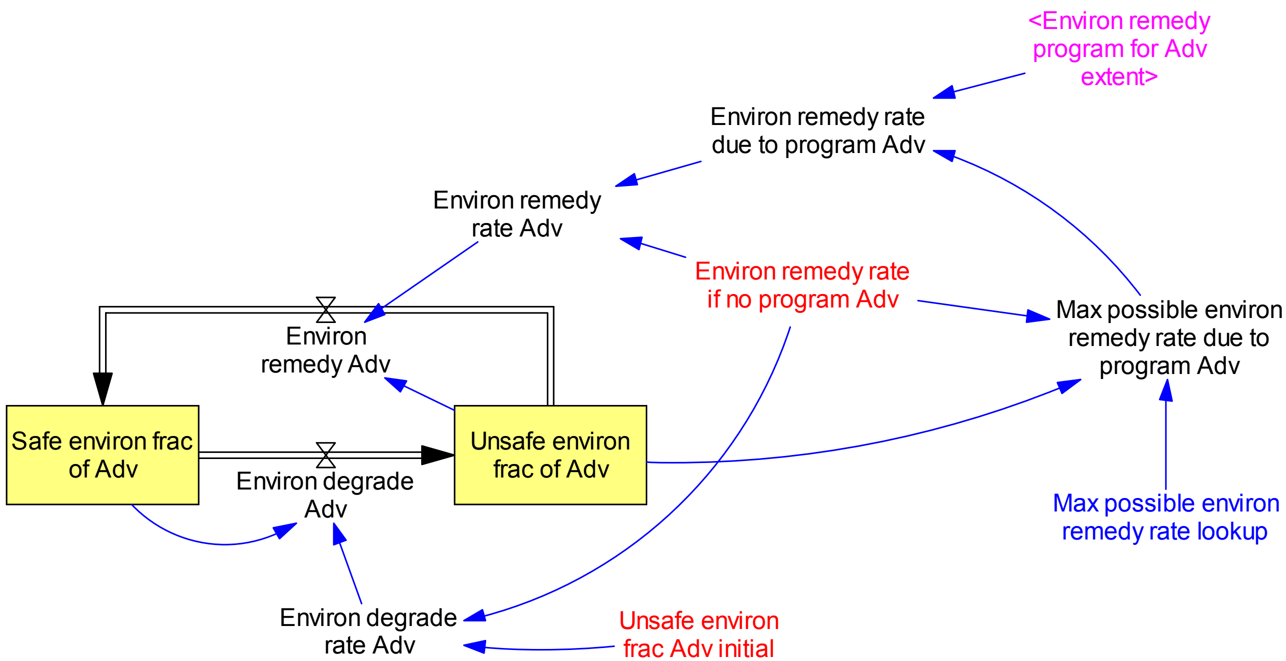

Figure A-6. Structure for disease and injury diagnosis and management (shown for Advantaged population)

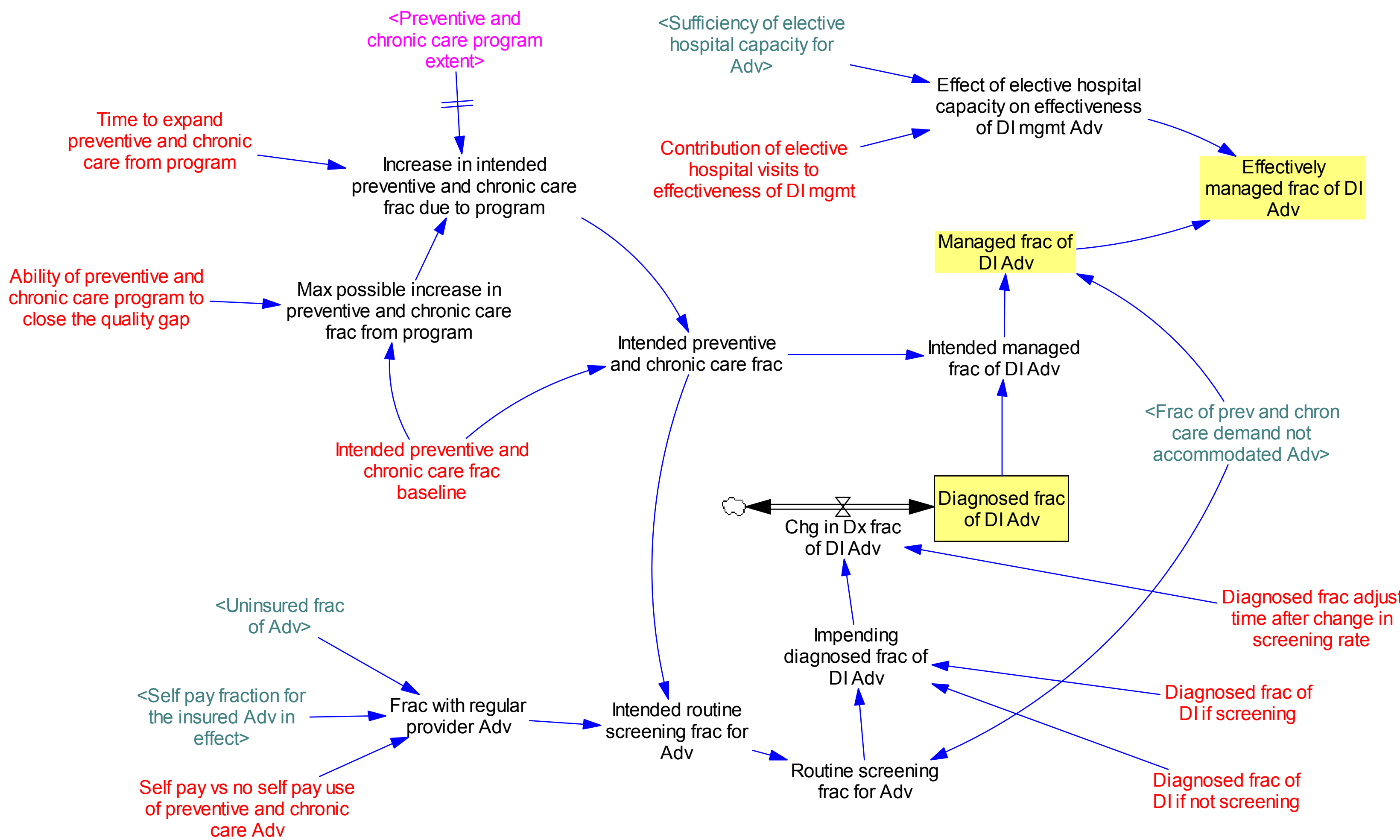

Figure A-7. Structure for choice of non-urgent care venue (shown for Advantaged population)

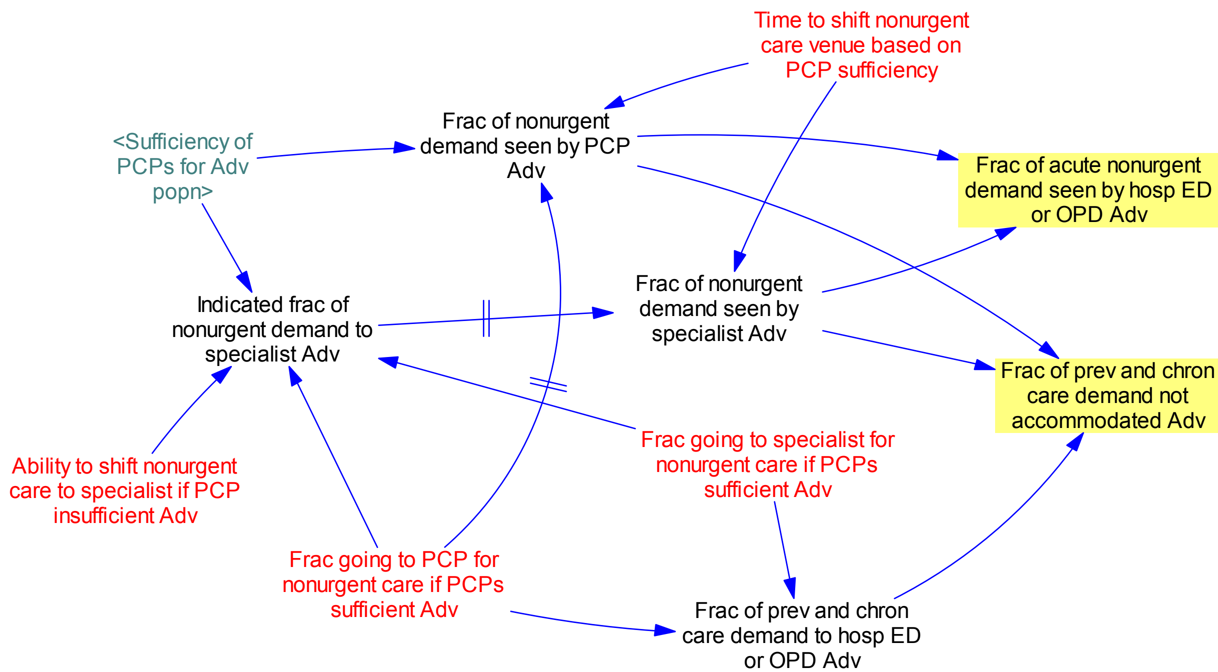

Figure A-8. Structure for insurance coverage

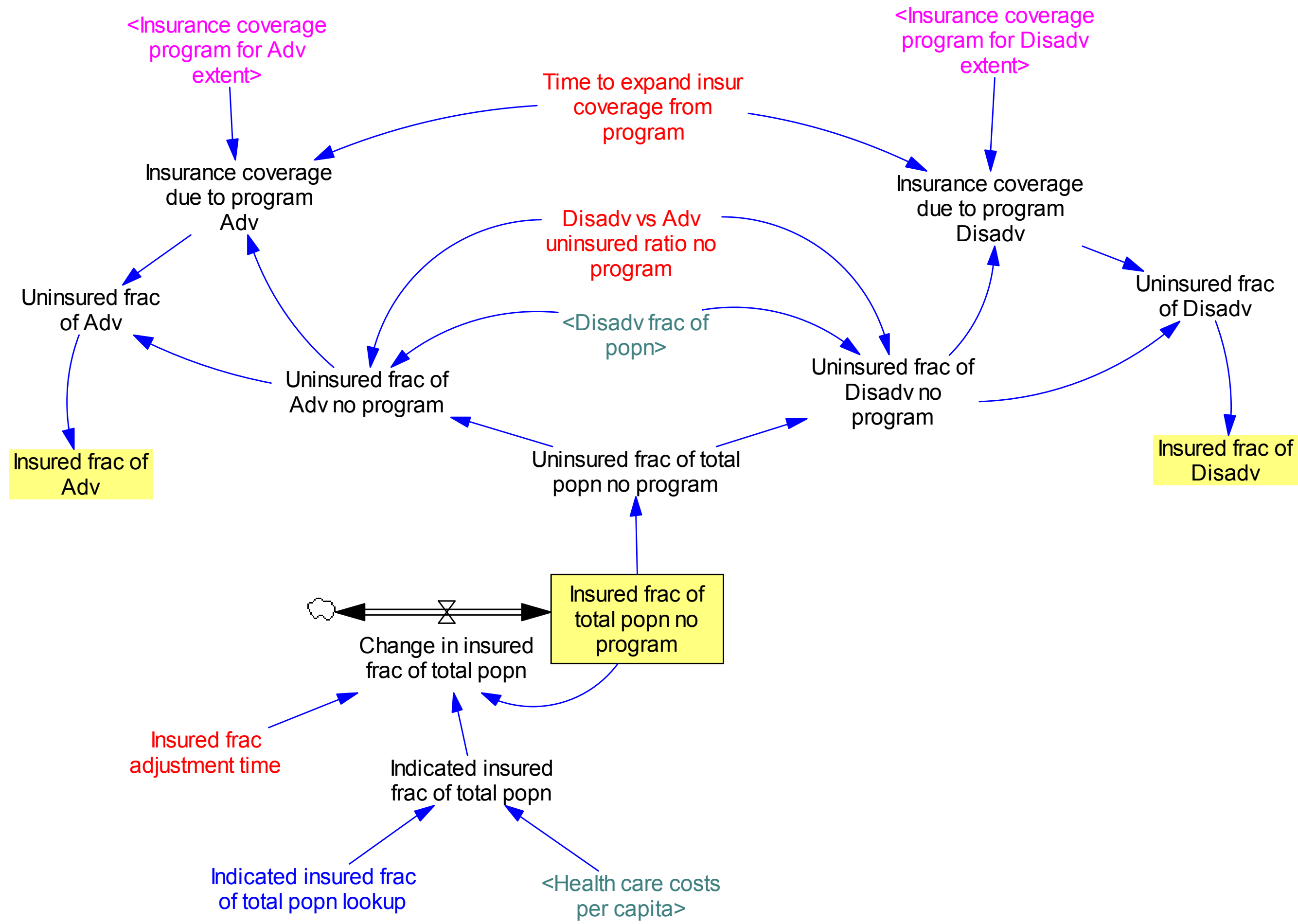

Figure A-9. Structure for primary care providers (shown for Advantaged population)

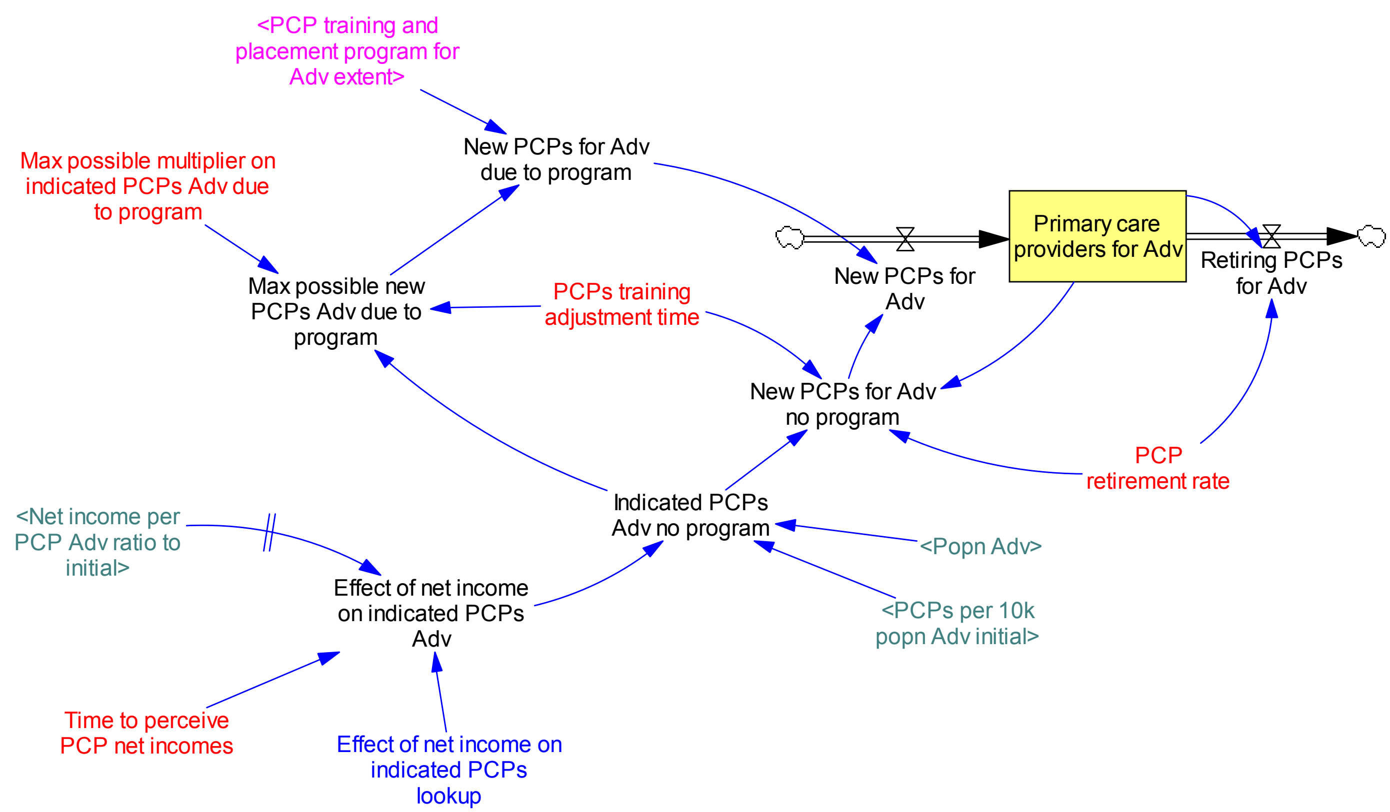

Figure A-10. Structure for health care costs

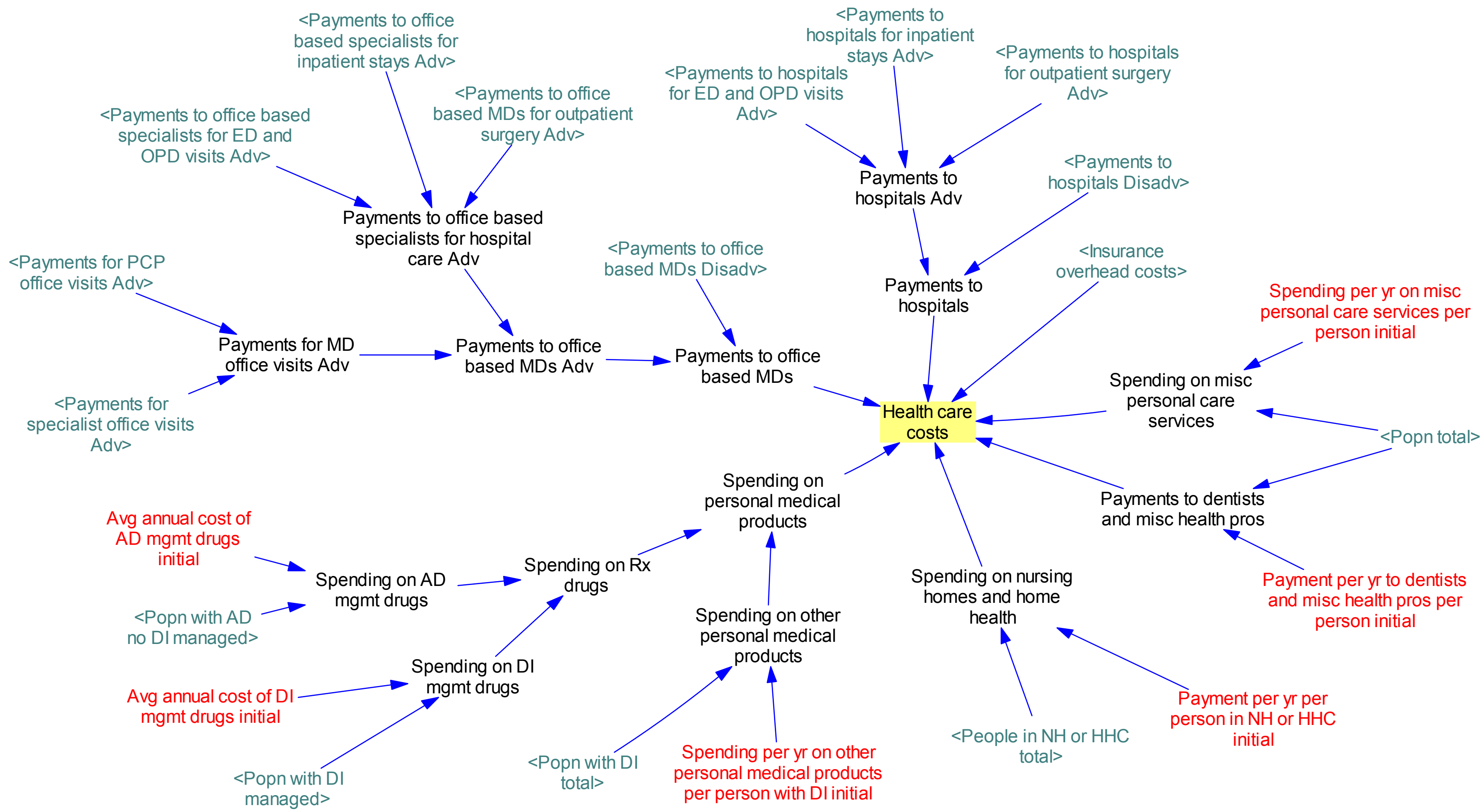

Table A-1. Concepts, proxy measures, and data sources used for modeling the U.S. health system (part 1 of 3)

Concept	Proxy measure	Sources
ADVERSE CONDITIONS		
Socioeconomic disadvantage prevalence	Fraction of population in households with income less than $25,000	Census 2005, adjusting for average household size per income segment
Behavioral risk prevalence and its SES disparity	Combined prevalences of smoking and physical inactivity, adjusting for overlap. For smoking disparity, compare high school education vs. not; for physical activity disparity, compare lower vs. higher SES sections of Austin, Texas.	Smoking: National Health Interview Survey (NHIS) 2006; Inactivity: county-level Behavioral Risk Factor Surveillance System (BRFSS) 2004-06
Unsafe environment prevalence and its SES disparity	Fraction of people who say their neighborhood is unsafe, comparing lower and higher SES sections of Austin, Texas.	County-level BRFSS 2004-06.
HEALTH STATUS		
Disease and injury prevalence	Fraction of adults with any of 22 serious/persistent conditions; children with any of 12	NHIS 2003
Asymptomatic disorder prevalence	Fraction of people ages 16+ with high blood pressure or high cholesterol or pre-diabetes; assume zero for younger ages	National Health & Nutrition Examination Survey (NHANES) 2003-04
SES disparities for disease/injury and asymptomatic disorder prevalence	Comparison of low vs. middle/high income tertiles on 5 specified diseases, hypertension, and obesity	Banks et al. 2006 (data from Health and retirement Survey 2002, ages 55-64)
Morbidity and its SES disparity	Unhealthy days per month per capita, by household income	BRFSS 1993-2001 (MMWR ss5404a1.htm)
Death rate	Deaths per thousand population, age-adjusted	National Vital Statistics Reports 2001-03
SES disparity for death rate	Comparison of poor/near-poor with middle/high income on all-cause mortality	Lochner et al. 2001 (data from NHIS-National Death Index 1987-1995)

Table A-1. Concepts, proxy measures, and data sources used for modeling the U.S. health system (part 2 of 3)

Concept	Proxy measure	Sources
TYPE & LOCUS OF CARE		
Preventive, chronic, and acute non-urgent visits to PCPs, specialist offices, and hospital emergency and outpatient departments (ED/OPD), by SES	Ambulatory visits by reason and setting and insurance type	National Ambulatory Medical Care Survey (NAMCS) 2005
Urgent and non-urgent visits to ED, by SES	ED use frequency by income and insurance type, and non-urgent fraction by insurance type	(1) Health, United States 2007 Table 90 (for 2000 and 2005); (2) National Hospital Ambulatory Medical Care Survey (NHAMCS) 2002
Hospital stays, urgent and elective	Hospital admissions total, and fraction of ED visits resulting in admission	(1) Health, United States 2007 Tables 101-103 (for 2000, 2003, 2005); (2) NCHS Fast Facts, ED visits resulting in admission (for 2005)
Outpatient surgeries	Hospital ambulatory procedures	Vital and Health Statistics 13(139) (for 1996)
People in nursing homes and home health care	Average census in nursing homes, home health	(1) National Nursing Home Survey (2004); (2) National Home Health Care Survey (2000)
PROVIDERS		
Primary care providers (PCPs) per capita, by SES	Active PCPs per 10,000 population in the US overall; comparison of lower vs. higher SES sections of Austin, Texas.	(1) Physician Characteristics and Distribution in the US, AMA (annual; 2003); (2) Texas DSHS for 2004-06 (see Homer et al. 2009)
Access to PCPs, by SES	(1) Self-report no regular provider (US overall, and comparison of lower vs. higher SES sections of Austin, Texas); (2) Medically disenfranchised fraction of US based on PCP density.	(1) BRFSS 2004-06 (national and county level); (2) "Access Denied", Robert Graham Center 2007 (data for 2005)
Net income for PCPs and specialists	Average net income for PCPs, medical specialists, and surgical specialists, in 2003 dollars	Center for Studying Health System Change, June 2006; www.hschange.com/CONTENT/851 (for 1995 and 2003)
Time per patient visit	Visits and consultations per week, by specialty	Vital and Health Statistics 13(164); 2007: Characteristics of office-based physicians and their practices: US 2003-04.
PCP office efficiency	Use of electronic medical records	NAMCS 2005

Table A-1. Concepts, proxy measures, and data sources used for modeling the U.S. health system (part 3 of 3)

Concept	Proxy measure	Sources
CARE STANDARDS & QUALITY		
Standards of office care	Fraction of recommended care received, by visit type, household income, and insurance type	Asch et al 2006 (RAND Community Tracking Survey, 1998-2000)
Diagnosed and managed fractions of asymptomatic disorders	Diagnosed and controlled fractions of high blood pressure and high cholesterol	Unpublished analysis of NHANES 1999-2004 (see Homer et al 2009)
INSURANCE & COSTS		
Lack of insurance coverage, by SES	Lack of insurance coverage by household income	Census 2003
Self-pay fraction for the insured, by SES	Cost sharing fractions for Disadvantaged and Advantaged, based on estimates for those with private plans, for Medicare, and for Medicaid	Private plan cost-sharing estimates based on Kaiser Family Foundation 2005 (www.kff.org/insurance/7315/sections [6, 7, 8]. Regarding Medicaid cost sharing, see Pear R, NY Times 11/26/08. Census 2003 for number of Medicare, Medicaid insured.
Impact of self-pay fraction on health care utilization, by SES	Impact of cost sharing, for poor and non-poor	Newhouse JP et al. 1993 (RAND Health Insurance Experiment); Tables 4.17 and 5.11
Health care costs	Health care spending for personal health services and supplies, plus administrative costs of health insurance. Does not include public health activity, nor research, nor investments in structures and fixed equipment.	National Health Expenditure Accounts (NHE) 2003

Table A-2. Inputs for population health status

Population by Health Status

Popn total initial	290.8 million people
Popn with DI frac of Adv initial	0.335
Popn with DI frac of Disadv initial	0.536
Popn with AD frac of Adv initial	0.499
Popn with AD frac of Disadv initial	0.574
Popn with AD no DI frac of Adv initial	0.305
Popn with AD no DI frac of Disadv initial	0.233
Reltv risk of AD onset if unhealthy behavior	2
Reltv risk of DI onset if unhealthy behavior	2
Reltv risk of DI onset if unsafe environ	1.5
Reltv risk of becoming DI if AD and no AD mgmt	2
Mitigation of DI onset risk from AD by quality AD mgmt	0.75
DI recovery rate Adv	0.1/year
DI recovery rate Disadv	0.09/year

Table A-3. Inputs for socioeconomic status

Population by Socioeconomic Status

Disadv frac of popn initial	0.215
Popn DI become Disadv rate	0.01/year
Popn with AD become Disadv rate	0.007/year
Popn with NSHP become Disadv rate	0.005/year
Max possible become Adv rate for popn with AD	0.15/year
Max possible become Adv rate for popn with DI	0.1/year
Max possible become Adv rate for popn with NSHP	0.15/year
Program cost to provide pathway to Adv per person	$5,000/person
Effect of Disadv frac on become Adv due to program (Y) as a function of Disadv frac of popn (X)	(X,Y): (0,0) (.05,.35) (.1,.65) (.15,.85) (.2,1) (.2,1)

Table A-4. Inputs for health-related behavior

Population by Health-Related Behavior	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Unhealthy behavior frac Adv initial	0.3		
Unhealthy behavior frac Disadv initial	0.5		
Behavior reform rate if no program Adv	0.1/year		
Behavior reform rate if no program Disadv	0.08/year		
Reltv risk of behavior lapse if bad social surroundings	5		
Reltv risk of behavior lapse from unsafe environ	1.6		
Program cost to reform behavior per person	$2,000/person	$200	$5,000
Max possible behavior reform rate per year (Y) as a function of Unhealthy behavior frac (X)	(X,Y): (0,.12) (.1,.12) (.2,.15) (.3,.2) (.4,.26) (.5,.3) (.6,.3)	(X,Y): (0,.12) (.1,.12) (.2,.16) (.3,.23) (.4,.31) (.5,.36) (.6,.36)	(X,Y): (0,.12) (.1,.12) (.2,.14) (.3,.17) (.4,.2) (.5,.23) (.6,.23)

Table A-5. Inputs for health-related environmental conditions

Population by Health-Related Environment	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Unsafe environ frac Adv initial	0.2		
Unsafe environ frac Disadv initial	0.5		
Environ remedy rate if no program Adv	0.05/year		
Environ remedy rate if no program Disadv	0.04/year		
Program cost to remedy unsafe environ per person	$500/person	$200	$3,000
Max possible environ remedy rate per year (Y) as a function of Unsafe environ frac (X)	(X,Y): (0,.12) (.1,.12) (.2,.15) (.3,.2) (.4,.26) (.5,.3) (.6,.3)	(X,Y): (0,.12) (.1,.12) (.2,.16) (.3,.23) (.4,.31) (.5,.36) (.6,.36)	(X,Y): (0,.12) (.1,.12) (.2,.14) (.3,.17) (.4,.2) (.5,.23) (.6,.23)

Table A-6. Inputs for unhealthy days and acute, urgent, and fatal events

Unhealthy Days and Acute, Urgent, & Fatal Events	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
UD per person mo for DI Adv initial	13.45 days/person/month		
Disadv vs Adv UD per person mo for DI ratio initial	1.11		
Reltv likelihood of UD if full DI mgmt	0.6	0.5	0.7
Acute nonurgent event rate for DI Adv initial	4.889 events/person/year		
Disadv vs Adv acute nonurgent event rate for DI ratio initial	1.08		
Reltv likelihood of acute nonurgent event if full DI mgmt	0.7	0.5	0.85
Urgent event rate for DI Adv initial	0.951 events/person/year		
Disadv vs Adv urgent event rate for DI ratio initial	1.08		
Reltv likelihood of urgent event if full DI mgmt	0.6	0.5	0.7
Fatal fraction of urgent events Adv initial	0.02		
Disadv vs Adv fatal fraction of urgent events ratio initial	1.04		
Reltv fatality of urgent events if quality urgent care	0.6	0.5	0.7

Table A-7. Inputs for extent and effectiveness of preventive and chronic care

Extent and Effectiveness of Preventive & Chronic Care	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Intended preventive and chronic care frac baseline	0.8		
Ability of preventive and chronic care program to close the quality gap	0.5	0.7	0.35
Program cost to get additional office provider to do preventive and chronic care	$10,000 per provider/yr	$2,000	$20,000
Time to expand preventive and chronic care from program	2.5 years		
Self pay vs no self pay use of preventive and chronic care Adv	0.51		
Self pay vs no self pay use of preventive and chronic care Disadv	0.4		
Contribution of elective hospital visits to effectiveness of DI mgmt	0.5		

Table A-8. Inputs for detection of disorder and disease

Detection of Disorder & Disease	
Diagnosed frac of AD if not screening	0.1
Diagnosed frac of AD if screening	0.95
Diagnosed frac of DI if not screening	0.8
Diagnosed frac of DI if screening	0.98
Diagnosed frac adjust time after change in screening rate	4 years

Table A-9. Inputs for non-urgent ambulatory care volume and locus

Non-Urgent Ambulatory Care Volume & Locus	
Frac going to PCP for nonurgent care if PCPs sufficient Adv	0.52
Frac going to PCP for nonurgent care if PCPs sufficient Disadv	0.7
Frac going to specialist for nonurgent care if PCPs sufficient Adv	0.42
Frac going to specialist for nonurgent care if PCPs sufficient Disadv	0.16
Ability to shift nonurgent care to specialist if PCP insufficient Adv	0.5
Ability to shift nonurgent care to specialist if PCP insufficient Disadv	0.1
Time to shift nonurgent care venue based on PCP sufficiency	2 years
Normal frequency of routine screening visits	1.22/year
Normal frequency of AD mgmt visits	3.20/year
Normal frequency of DI mgmt visits	3.47/year
Self pay vs no self pay use of acute nonurgent care Adv	0.51
Self pay vs no self pay use of acute nonurgent care Disadv	0.40

Table A-10. Inputs for quality of urgent care and sufficiency of hospital capacity

Quality of Urgent Care & Sufficiency of Hospital Capacity	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Quality of urgent care at baseline reimbursement	0.8		
Disadv vs Adv poor quality of urgent care ratio	1.5		
Ability of urgent care program to close the quality gap	0.5	0.7	0.35
Program cost to get additional hospital to follow quality guidelines	$500,000 per hospital/yr	$100,000	$1,000,000
Hospitals per 100k popn	2.235 hospitals per 100,000 people		
Time to influence hospital quality from program	2.5 years		
Fractional effect of reimbursement change on quality of urgent care	0.5	0.35	0.65
Sufficiency of elective hospital capacity for Adv (Y) as a function of Reltv reimbursement rate for hospital visits (X)	(X,Y): (.5,.7) (.6,.76) (.8,.88) (1,1) (1.2,1) (1.4,1)	(X,Y): (.5,.8) (.6,.84) (.8,.92) (1,1) (1.2,1) (1.4,1)	(X,Y): (.5,.6) (.6,.68) (.8,.84) (1,1) (1.2,1) (1.4,1)
Disadv vs Adv insufficiency of elective hospital capacity	2		
Time for reimbursement to influence hospital quality and capacity	2.5 years		

Table A-11. Inputs for inpatient stays, outpatient surgery, and people in nursing homes and home health care

Inpatient Stays, Outpatient Procedures, People in Nursing Homes & Home Health Care	
Frac of urgent events leading to inpatient stay if good quality urgent care	0.105
Reltv risk of nonelective inpatient stay if poor quality urgent care	2
Frac of DI visits leading to elective inpatient stay normal	0.031
Frac of DI visits leading to elective outpatient procedure normal	0.044
Reltv propensity of specialists vs PCPs to order elective hospital visits	1.5
Reltv propensity of ED OPDs vs PCPs to order elective hospital visits	1.3
Reltv likelihood of DI mgmt visits vs acute nonurgent visits to be followed by elective hospital visits	0.5
Frac of people with DI in nursing home or receiving home health if good quality urgent care	0.0231
Reltv risk of ending up in nursing home or home health care if poor quality urgent care	1.5
Life expectancy of people in nursing home or receiving home health	10 years

Table A-12. Inputs for primary care providers

Primary Care Providers	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
PCPs per 10k popn Adv initial	9.0 providers per 10,000 people		
PCPs per 10k popn Disadv initial	6.75 providers per 10,000 people		
PCP retirement rate	0.033/year		
PCPs training adjustment time	10 years		
Effect of net income on indicated PCPs (Y) as a function of Net income per PCP ratio to initial (X)	(X,Y): (.5,.25) (.75,.65) (1,1) (1.25,1.25) (1.5,1.5) (1.75,1.7) (2,1.85)		
Time to perceive PCP net incomes	2 years		
Max possible multiplier on indicated PCPs for Adv due to program	1.5		
Max possible multiplier on indicated PCPs for Disadv due to program	1.5	1.65	1.35
Program cost to train an additional PCP for Adv	$150,000 per provider		
Program cost to train an additional PCP for Disadv	$300,000 per provider	$200,000	$600,000

Table A-13. Inputs for primary care provider operations

Primary Care Provider Operations	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Workdays per year for PCPs	240 days/year		
Daily visit capacity for PCP Adv initial	8.53 visits/PCP/day		
Daily visit capacity for PCP Disadv initial	13.82 visits/PCP/day		
Reltv visit capacity for efficient PCP office	1.33	1.4	1.2
Efficient frac of PCP offices no program	0.2		
Program cost to get operational efficiency for additional PCP	$10,000 per provider/yr	$5,000	$20,000
Time to influence PCP operational efficiency from program	2.5 years		

Table A-14. Inputs for primary care provider expenses

Primary Care Provider Expenses	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Nonbilling expenses per visit PCP Adv initial	$35/visit		
Nonbilling expenses per visit PCP Disadv initial	$35/visit		
Reltv nonbilling expenses for efficient PCP Adv	0.7	0.65	0.85
Reltv nonbilling expenses for efficient PCP Disadv	0.7	0.65	0.85
Billing expenses per visit PCP Adv initial	$35/visit		
Billing expenses per visit PCP Disadv initial	$35/visit		
Reltv billing expenses for simplified insurance PCP Adv	0.5		
Reltv billing expenses for simplified insurance PCP Disadv	0.8		

Table A-15. Inputs for insurance coverage

Insurance Coverage	Base value	Optimistic: Less cost or more benefit	Pessimistic: More cost or less benefit
Indicated insured frac of total popn (Y) as a function of Health care spending per capita(X)	(X,Y): (2000,.876) (4000,.858) (5434,.8442) (6000,.835) (8000,.79) (10000,.73) (12000,.67)		
Disadv vs Adv uninsured ratio no program	1.82		
Insured frac adjustment time	3 years		
Program cost to provide insur coverage per person	$20 per person/yr	$10	$40
Time to expand insur coverage from program	2.5 years		

Table A-16. Inputs for insurance overhead costs

Insurance Overhead Costs

Insurance overhead cost per insured avg no program	$572 per person per year
Insurance overhead cost per privately insured	$626 per person per year
Insurance overhead cost per govt insured	$200 per person per year
Govt administered frac of insur coverage program	0.5
Program cost per insured person to implement standardized insurance	$1 per person/yr
Program cost per insured person to implement single payer	$2 per person/yr

Table A-17. Inputs for health care unit costs for physicians and hospitals

Health Care Unit Costs for Physicians and Hospitals

Payment per visit to PCP Adv initial	$145 per visit
Payment per visit to PCP Disadv initial	$105 per visit
Ratio of specialist vs PCP payment per visit initial	1.5
Significance of reimbursement rate for specialist office visit payments	0.75
Payment to office based specialists per ED or OPD visit initial	$200 per visit
Payment to office based specialists per inpatient stay initial	$3,000 per visit
Payment to office based specialists per outpatient procedure initial	$2,000 per visit
Payment to hospital per ED or OPD visit initial	$1,000 per visit
Payment to hospital per inpatient stay initial	$7,000 per visit
Payment to hospital per outpatient procedure initial	$2,000 per visit

Table A-18. Inputs for other health care unit costs

Other Health Care Unit Costs

Payment per yr per person in nursing home or receiving home health initial	$53,000 per person per year
Avg annual cost of AD mgmt drugs	$1,095 per person per year
Avg annual cost of DI mgmt drugs	$2,035 per person per year
Spending per yr on other personal medical products per person with DI	$480 per person per year
Payment per yr to dentists and misc health pros per person initial	$430 per person per year
Spending per yr on misc personal care services per person	$170 per person per year

Table A-19. Quality-adjusted life year parameters

Quality-Adjusted Life Year Parameters

QALYs lost per preventable death	17.5 years
Value per QALY	$75,000 per QALY

Table A-20. Intervention decision inputs

Intervention parameter	Baseline value	Alternate value used for scenarios in paper
Insurance coverage program for Adv decision	0	1 for "Coverage"
Insurance coverage program for Disadv decision	0	1 for "Coverage"
Self pay fraction for the insured Adv	0.25	
Self pay fraction for the insured Disadv	0.1	
Reltv reimbursement rate for office visits	1	0.8 for "Reimburse-cut"
Reltv reimbursement rate for hospital visits	1	0.8 for "Reimburse-cut"
Insurance standardization decision	0	
Single payer decision	0	
Preventive and chronic care program decision	0	1 for "Quality"
Urgent care program decision	0	1 for "Quality"
PCP training and placement program for Adv decision	0	
PCP training and placement program for Disadv decision	0	1 for "Capacity"
PCP operational efficiency program decision	0	1 for "Capacity"
Care coordination program decision	0	
Behavior reform program for Adv decision	0	1 for "Protection"
Behavior reform program for Disadv decision	0	1 for "Protection"
Environ remedy program for Adv decision	0	1 for "Protection"
Environ remedy program for Disadv decision	0	1 for "Protection"
Pathway to Adv program decision	0	

Table A-21. Baseline output values for key event frequencies

Baseline values of event frequencies	Overall population	Advantaged population	Disadvantaged population	Disadvantaged-Advantaged ratio
Deaths per thousand population	7.46	6.37	11.50	1.80
Unhealthy days per person per month	5.26	4.51	8.00	1.78
Visits to hospital emergency or outpatient department per thousand population	754	523	1,600	3.06
Non-urgent visits to hospital emergency or outpatient department per thousand population	386	204	1,049	5.14
Preventive and chronic care visits per thousand population	1,991	2,041	1,808	0.89
Hospital inpatient stays per thousand population	121	106	176	1.66

Table A-22. Baseline output values for key fractions and ratios

Baseline values of fractions and ratios	Overall population	Advantaged population	Disadvantaged population	Disadvantaged-Advantaged ratio
Fraction of population with disease or injury	37.8%	33.5%	53.6%	1.60
Fraction of population with asymptomatic disorder	51.5%	49.9%	57.4%	1.15
Fraction of population with unhealthy behavior	34.3%	30.0%	50.0%	1.67
Fraction of population in unsafe environment	26.5%	20.0%	50.0%	2.50
Uninsured fraction of population	15.6%	13.2%	24.1%	1.83
Routinely screened fraction of population	63.5%	66.3%	52.9%	0.80
Managed fraction of disease and injury	58.3%	62.6%	48.6%	0.78
Managed fraction of asymptomatic disorders	48.8%	51.7%	34.7%	0.67
Ratio of PCP demand to capacity	110.6%	95.9%	140.8%	1.47
Net income per PCP per year	$142,000	$147,300	$116,100	0.79

Table A-23. Baseline output values for key health care expenditures per capita

Baseline values of health care costs per capita	Overall population	Advantaged population	Disadvantaged population	Disadvantaged-Advantaged ratio
Health care costs per capita	$5,434	$4,930	$7,276	1.48
Payments to hospitals per capita	$1,806	$1,448	$3,116	2.15
Payments to office-based providers per capita	$1,243	$1,174	$1,495	1.27
Spending on personal medical products per capita	$785	$760	$876	1.15
Spending on nursing homes and home health care per capita	$516	$451	$755	1.67
Insurance overhead costs per capita	$483	$496	$434	0.88

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