
# Creating an Analytical Structure to Demonstrate the Value of Investments in Primary Prevention to Health Outcomes and Health Care Costs

## Final Report

October 30, 2014

ALTARUM INSTITUTE

SYSTEMS RESEARCH FOR BETTER HEALTH

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The authors are, of course, soley responsible for the content of this final report.

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# 1.0 Introduction and Background

With funding from the Robert Wood Johnson Foundation (RWJF), Altarum Institute's Center for Sustainable Health Spending (CSHS) is creating a structure to demonstrate the value of investing in nonclinical primary prevention – interventions outside of the medical system that reduce the incidence of injury and illness – and their impact on health care costs. In this context, primary prevention is defined very broadly to include investments in the social determinants of health. One important feature of the analytical structure is its ability to show the benefits and costs of an investment to those people and organizations that can influence the investment.

To provide a foundation for this structure, we have developed a high-level framework describing the process by which an investment in primary prevention acts through the determinants of health to produce impacts on health, costs, and other outcomes of interest. We have also developed a prototype of a valuation tool that synthesizes existing results describing the financial and health impacts of an investment in prevention from the perspectives of alternative stakeholder groups comprising those people and organizations that can influence the investment and might benefit from it. Stakeholder groups currently represented include federal and state governments; a societal perspective is also included. Two demonstration applications of the tool assess the value of a smoking prevention investment and an investment to address childhood obesity from various perspectives.

This report documents these accomplishments. Chapter 2 is a review of the determinants of health and their impact on non-clinical primary prevention. The high-level framework is described in Chapter 3. Chapter 4 documents the prototype valuation tool, and Chapter 5 describes the results of its application to smoking and obesity. Finally, Chapter 6 describes next steps in this research program, which is continuing under a follow-on grant from RWJF.

# 2.0 The Determinants of Health and Non-Clinical Primary Prevention[1]

The last several decades have seen a growing interest in what defines and shapes health. Despite having the highest per capita health spending, the United States lags behind many other countries in many health indicators, and glaring health disparities remain. The United States devotes a small share of its health expenditures – less than 9 percent (Miller et al., 2011) – toward disease prevention.

One theme gaining strength in the research literature posits that many benefits from the extremely high health care spending in the United States are undermined by the nation's very low investments in social services (Bradley and Taylor 2013), broadly defined to

[1] This chapter was adapted from the following publication, which was produced under this grant: McGovern L, Miller G, Hughes-Cromwick P. Health Policy Brief: The Relative Contribution of Multiple Determinants to Health Outcomes. Health Affairs, August 21, 2014.Available at: http://www.healthaffairs.org/healthpolicybriefs/brief.php?brief_id=123.

include support services for older adults, survivor benefits, disability and sickness benefits, family supports, housing programs, employment programs, unemployment benefits, and other social policy issues.

Furthermore, there is an increasing awareness that other nonclinical factors such as education and income have a major impact on health. To understand and address these issues, researchers have focused on understanding the factors that affect people's health, commonly referred to as health determinants. The goal of this research is to effectively design interventions and create policy choices that value health for all people and that address not only the more obvious, direct determinants of health but also the structural and societal issues that may be causing persistent health disparities. A better understanding of what influences health outcomes will ultimately lead to better policies and allow for more effective use of limited resources directly on health and otherwise.

In this chapter, we focus on multiple determinant studies that seek to quantify the relative influence of the major categories of determinants on health (in contrast to the extensive body of research that examines single classes of determinants in detail). This is intended to provide context for the high-level framework described in Chapter 3 of the process by which an investment in primary prevention acts through the determinants of health to produce impacts on health, costs, and other outcomes of interest to various stakeholder groups. Central to this framework is an understanding of the relative contribution of the determinants of health to health outcomes and costs.

## 2.1 The Literature on Determinants of Health

The literature highlights five major categories of health determinants: genetics, behavior, social circumstances, environmental and physical influences, and medical care. There are diverging opinions as to how those categories relate to each other and to health and health-related outcomes. A number of researchers and organizations such as the World Health Organization (WHO 2002) and the Centers for Disease Control and Prevention (CDC 2010) have previously proposed frameworks to explain these complex relationships. These frameworks generally reflect four elements of complexity, including:

- Multiple *determinants* of health, such as the factors described in this chapter.
- Multiple *dimensions* of health that are influenced by determinants, including mortality, morbidity, functioning, and well-being, among others.
- Multiple causal *pathways* through which determinants influence each other and health outcomes, including direct and indirect influences on health and different time frames across which effects and outcomes are realized (including across the life course and generations).
- Multiple *levels* of influence, including individual, interpersonal, community, and societal effects.

One framework, developed by the CDC, highlights the role of "social determinants of health," which refer to determinants that are "not controllable by the individual but affect the individual's environment." Different organizations have proposed definitions to

delineate the social determinants: The WHO refers to social determinants as "the conditions in which people are born, grow, live, work and age, and which are shaped by the distribution of money, power and resources at global, national and local levels," and are "mostly responsible for health inequities," while Braveman et al. (2011) state that "the term social determinant of health is often used to refer broadly to any nonmedical factors influencing health."

Social determinants of health generally encompass the social and physical environment and health services. They include things such as income and wealth, family and household structure, social support and isolation, education, occupation, discrimination, neighborhood conditions, and social institutions, among others.

While the five categories of determinants are generally accepted as the major contributors to health, recent research has suggested that other factors have a strong and unique impact on health and might be considered as possible mechanisms linking direct and indirect determinants, or as determinants in their own right. For example, stress is often considered a component of social or "psycho-social" circumstances. However, although the research is still evolving, particularly with regard to the subjectivity of the experience of stress and how to appropriately measure it, stress appears to have a direct effect on health outcomes and may influence the way in which a person responds to other determinants.

Thoits (2010) states that "the bulk of the literature indicates that differential exposure to stressful experiences is one of the central ways that gender, racial-ethnic, marital status, and social class inequalities in health are produced." The National Research Council and Institute of Medicine (2013) review the physiological mechanisms involved in stress, noting the cumulative damage caused by chronic lifelong stress as well as the potentially harmful and permanent effects of stressful experiences in early life.

## 2.2 Estimating the Contribution to Health Outcomes

As stated by Mokdad et al. (2004), "Most diseases and injuries have multiple potential causes and several factors and conditions may contribute to a single death. Therefore, it is a challenge to estimate the contribution of each factor to mortality." The World Health Organization (2002) states that, "a key initial question when assessing the impact of a risk to health is to ask 'compared to what?'"

Comparisons of health outcomes can occur across socioeconomic status (including income and education), race and ethnicity, sex, age, marital status, and geographic location, among others. In addition, health can be defined and measured in a number of ways, including but not limited to morbidity (both mental and physical health outcomes), mortality, life expectancy, health expenditures, health status, and functional limitations. The major contributors to health may depend on the outcome or outcomes and population studied.

Other issues to consider when measuring impact include the importance of using life-course and intergenerational perspectives, the availability of data, and the existence of socioeconomic gradients with regard to health outcomes. It is also important to

consider the timing of impacts and outcomes. For example Danaei et al. (2009) note that "the hazardous effects of some risk factors accumulate gradually after exposure begins and decline slowly after exposure is reduced. This is illustrated by results from trials that have lowered blood pressure and cholesterol, and from studies in which people quit smoking. Risk's dependence on time may further vary by disease, for example, the effects of tobacco smoking on lung cancer versus cardiovascular diseases."

Despite these challenges, researchers have calculated a range of estimates to assess the contribution of health determinants. It is important to consider relative contribution rather than absolute and to note that determinants do not act alone or in "simple additive fashion," but rather in concert with one another in complex, interdependent, bidirectional relationships.

These complexities introduce considerable uncertainties in the empirical estimates of relative contributions to health. For example, as noted above, feedback loops among health determinants play out over the life course, inter-generationally, and at both the individual and the population and community levels -- making it difficult to parse out cause and effect. The estimated contribution of a health determinant will depend upon the time frame and perspective employed by the research.

However, as noted by McGinnis et al. (2002), "More important than these proportions is the nature of the influences in play where the domains intersect." For example, there is a body of literature that addresses the intersections of environmental and socioeconomic determinants. As noted by Currie (2011), the study of prenatal exposures to environmental hazards demonstrates that "differences that appear to be innate may in fact be the product of environmental factors;" that those of lower socioeconomic status are disproportionately exposed to pollution and other environmental hazards; and that these prenatal exposures, in turn, affect people as adults and the next generation as well, leading to the propagation of disadvantage.

Exhibit 1 summarizes the evidence of relative contribution by source for each determinant. While these papers are presented in tandem, comparisons are contentious, given the variation in methods, outcome measures, differences in the definition of health, problems identifying causality, and other methodological differences that arise when attempting to parse out relative contributions of individual, community, and societal level factors on health outcomes over the life course.

**Exhibit 1. Relative Contributions of Health Determinants to Health Outcomes**

| | | Determinants of health | | | | | |
|---|---|---|---|---|---|---|---|
| **Source** | **Metric** | **Behaviors** | **Social circum-stances** | **Environment** | **Genetics** | **Medical care** | **Stress** |
| DHHS, Public Health Service, "Ten Leading Causes of Death in the United States," Atlanta (GA): Bureau of State Services, July 1980[a] | Percentage of total deaths in 1977 (US) | 50% | — | 20% | 20% | 10% | — |
| J. M. McGinnis and W. H. Foege, "Actual Causes of Death in the United States," *JAMA* 270, no. 18 (1993):2207–12 | Percentage of total deaths in 1990 (US) | Tobacco: 19%<br>Diet/activity patterns: 14%<br>Alcohol: 5%<br>**Total = 38%** | — | Microbial agents: 4%<br>Toxic agents: 3% | — | — | — |
| P. Lantz et al., "Socioeconomic Factors, Health Behaviors, and Mortality: Results from a Nationally Representative Prospective Study of US Adults," *JAMA* 279, no. 21 (1998):1703–8 | Mortality hazard rate ratio (HRR) attributable to income (controlling for sociodemographic variables and 4 health behaviors) | Controlled for:<br>Cigarette smoking<br>Alcohol drinking<br>Sedentary lifestyle<br>Relative body weight | Mortality HRR for middle-income group: 2.14<br>Mortality HRR for low-income group: 2.77 | — | — | — | — |
| J.M. McGinnis et al., "The Case for More Active Policy Attention to Health Promotion," *Health Affairs* 21, no. 2 (2002):78–93 | Percentage of "early deaths" (undefined) | 40% | 15% | 5% | 30% | 10% | — |
| A. Mokdad et al., "Actual Causes of Death in the United States, 2000," *JAMA* 291, no. 10 (2004):1238–45 | Percentage of total deaths in 2000 (US) | Tobacco: 18%<br>Poor diet/physical inactivity: 17%<br>Alcohol: 3.5%<br>**Total = 39%** | — | Microbial agents: 3.1%<br>Toxic agents: 2.3% | — | — | — |
| G. Danaei et al., "The Preventable Causes of Death in the United States: Comparative Risk Assessment of Dietary, Lifestyle, and Metabolic Risk Factors," *PLoS Medicine* 6, no. 4 (2009):e1000058[b] | Percentage of total death (US) (various years, depending on variable) | Tobacco: 19%<br>Overweight/obesity: 9%<br>Physical inactivity: 8%<br>**Total = 36%** | — | — | — | — | — |

| Source | Metric | Determinants of health: Behaviors | Social circum-stances | Environment | Genetics | Medical care | Stress |
|---|---|---|---|---|---|---|---|
| World Health Organization, Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks, Geneva: WHO, 2009[c] | Percentage of total deaths in 2004, in high-income countries | Diet and physical inactivity (high blood pressure, high blood glucose, physical inactivity, overweight and obesity, high cholesterol, low fruit and vegetable intake): 25%<br>Alcohol and drug use: 2%<br>Tobacco use: 18%<br>**Total = 45%** | — | 3% (urban outdoor air pollution, unsafe water/ sanitation, and lead exposure) | — | — | — |
| B. Booske et al., "Different Perspectives for Assigning Weights to Determinants of Health," County Health Rankings Working Paper. Madison (WI): University of Wisconsin Population Health Institute, 2010[d] | Estimates derived to assign weights to determinants for County Health Rankings, drawing on a number of different perspectives | 30% | 40% | 10% | — | 20% | — |
| S. Stringhini et al., "Association of Socioeconomic Position with Health Behaviors and Mortality," *JAMA* 303, no. 12 (2010):1159-66 | SES differences (gradient) in all-cause mortality, 1985-2009 (civil service population in London, England) | Health behaviors (smoking, diet, alcohol consumption, and physical activity):<br>42% (when assessed at baseline)<br>72% (assessed 4 times over 24 years of follow-up) | — | — | — | — | — |
| P. Thoits, "Stress and Health: Major Findings and Policy Implications," *Journal of Health and Social Behavior* 51 Suppl (2010): S41-53[e] | Percentage of the variance in psychological distress and depressive symptoms | — | — | — | — | — | 25-40% |

NOTES: As noted, this chapter focuses on studies of multiple determinants for which relative quantitative contributions to health outcomes are estimated. There are, however, many summaries of the social determinants of health: this table is not intended to be an exhaustive list. For a superb and fascinating survey and theoretical assessment of mortality determinants that spans human history, international comparisons (including rich versus poor countries), and within-country analysis of social determinants of health, see David Cutler, Angus Deaton, and Adriana Lleras-Muney, "The Determinants of Mortality," Journal of Economic Perspectives 20, no. 3 (2006): 97-120. Unfortunately, Cutler and colleagues' paper does not align well with the basic approach we take in this chapter of apportioning health (in varied ways) to factors (coefficients). Accordingly, we do not incorporate it into Exhibit 1. SES is socioeconomic status. [a]DHHS (1980) uses the "four elements of the health field" – lifestyle, human biology, environment, and the health care system – listed here as behavior, genetics, environment, and the health care system, respectively. [b]Danaei et al. also estimate mortality due to high blood pressure (16%) and high blood glucose (8%), but these are left out of this exhibit based on their physiological, rather than behavioral, nature. [c]The WHO (2009) focuses on two factors: behavioral and environmental risks. [d]Booske et al. explain the absence of genetics from their model, noting that, when reviewing other models of the contribution of various determinants, "these estimates also include the contribution of genetic factors that are generally considered, at least for the moment, to be both non-modifiable and non-measurable." [e]Thoits uses measures of "cumulative stress burden" or "cumulative adversity" (events, strains, and lifetime traumas taken together) to explain the variance in psychological distress and depressive symptoms rather than mortality and notes that "although comparable studies of combined stressors on physical health outcomes have not been done, similar findings are probable, given that hundreds of studies show that at least one type of stress (negative events) harms physical and mental health alike."

These papers support the belief that investments that directly or indirectly affect a small number of modifiable risk factors (namely tobacco, poor diet, and physical activity) can have a large impact on mortality reduction and disease burden. A number of sources come to similar conclusions without offering a quantitative assessment of contribution to health outcomes but reaffirming the significant contribution of a small number of determinants, mostly behavioral in nature, to health outcomes.

However, health behaviors happen in larger social contexts. They are a downstream link between social environments and other upstream determinants and health status and outcomes, and should, therefore, not be thought to be the sole drivers of health disparities. For example, the recently released 2014 County Health Rankings (http://www.countyhealthrankings.org/), as well as a new study by the Institute for Health Metrics and Evaluation (2013), highlight the importance of addressing health behaviors according to multiple dimensions and at various points of intervention. The progress against tobacco use clearly supports this claim.

The latest County Health Rankings, developed by the University of Wisconsin Population Health Institute in collaboration with the Robert Wood Johnson Foundation, lists smoking and physical activity as two of their five "key measures," indicating that they are "more influential than others when it comes to how healthy you are or how long you live." In addition, seven new measures were added in 2014, including food environment and access to exercise opportunities, underscoring the belief that indirect or upstream determinants are extremely influential in shaping individual health behaviors.

Researchers, noting the fundamental contribution of social factors to mortality and morbidity, emphasize the need for both individual and population-based interventions –- both upstream and downstream – in order to make a lasting impact on behavior change and resultant health outcomes. As noted by Braveman and Egerter (2008), positive changes in health behaviors require action on the part of the individual, but also require "that the environments in which people live, work and play support healthier choices. Efforts focused solely on informing or encouraging individuals to modify behaviors, without taking into account their physical and social environments, often fail to reduce health inequalities. Making further improvements in health-related behaviors, and in particular, reducing disparities in those behaviors, may require adopting a much broader perspective based on a deeper understanding of what shapes behaviors."

Lantz et al. (1998) echo this conclusion, having found that, while risky health behaviors are prevalent among people with lower incomes or educational attainment, these health behaviors do not fully explain the relationship between income and mortality. And, as noted earlier, these behaviors may develop as a result of early life experiences and exposures, both adverse and protective, further complicating and broadening the possible points of intervention.

## 2.3 Associated Policy Issues

Policy has often focused on health care rather than health, with a significant lack of emphasis on prevention – in spite of the fact, as the literature suggests, that the multilevel

promotion and adoption of healthy behaviors stands to reap the most "bang" for our health care "buck." Knowledge of the relative importance of health determinants can help design programs that prioritize interventions in areas where they are likely to have the greatest impact. However, addressing even the few determinants that are thought to be most responsible for good health requires policy makers to work across all sectors, public and private, and at the federal, state, and local levels.

In his blog, "Obstacles to Population Health Policy: Is Anyone Accountable?" Kindig highlights a number of obstacles to the use of population heath policy as a means of community health improvement, including the broad array of determinants and the resultant diffusion of accountability across a range of stakeholders (such as employers, businesses, health care professionals, schools, and government), including those not typically associated with health. Public health agencies also play roles in mobilizing community-level interventions through their assessment and planning functions along with their regulatory and program implementation responsibilities.

Despite these challenges, there are a number of innovative policy approaches that address the promotion of population health through action on health determinants and the possible causes of their unequal distribution. While it is beyond the scope of this chapter to highlight them all, we briefly discuss a few notable examples, including the "health in all policies" approach, prevention and population health elements of the Affordable Care Act (ACA), and a more specific example of cross-cutting policy aimed at addressing early childhood development.

At a global level, the "health in all policies" (HiAP) approach challenges policy makers at all levels to consider the health ramifications of policies in all sectors, including those not directly related to health, such as transportation, education, agriculture, and housing. The HiAP approach requires strong intersectoral and interagency collaboration, with a focus on the broader, upstream determinants of health that are thought to create the greatest inequities in health.

While noting there is no one "right way" to implement HiAP, and there are many mechanisms through which it can be achieved, the American Public Health Association (APHA) outlines five major elements of the HiAP approach: promoting health, equity, and sustainability (through the incorporation of health considerations into specific policies, but also by embedding health into governmental decision making overall); supporting intersectoral collaboration; benefiting multiple partners (such as policies that improve health can also benefit other nonhealth partners); engaging stakeholders; and creating structural or process change. The WHO states that efforts to include health as part of all policies is happening "almost everywhere," and the approach has been promoted and supported by the Institute of Medicine (IOM), the APHA, and the National Association of County and City Health Officials, and is reflected in the Healthy People 2020 goals around social determinants of health and in the National Prevention Strategy.

In "Health in All Policies: Prospects and Potentials," the WHO highlights a number of examples of HiAP in practice across Europe, while the APHA, the Public Health Institute, and the California Department of Health offer "Health in All Policies: A Guide

for State and Local Governments" to assist policy makers in the implementation of HiAP, drawing on the experiences of the California Health in All Policies Task Force.

At the national level, the ACA provides a number of opportunities for population health improvement–"an unprecedented opportunity," as noted in the IOM's "Population Health Implications of the Affordable Care Act" Workshop Summary, "to shift the focus of health experts, policy makers, and the public beyond health care delivery to the broader array of factors that play a role in shaping health outcomes."

As noted by Michael Stoto in "Population Health in the Affordable Care Act Era," the ACA addresses population health in a number of ways that go beyond the expansion of insurance coverage and improvement in quality of care – including the enhancement of health promotion and prevention within the health care delivery system (for example, through the implementation of accountable care organizations) and, perhaps more importantly, beyond it as well, through the establishment of National Prevention, Health Promotion, and Public Health Council and the Prevention and Public Health Fund.

Other ACA funding mechanisms with the potential to improve population health include Community Transformation Grants (focused on community-level efforts to prevent chronic disease) and workplace wellness program incentives for small businesses, as well as Internal Revenue Service requirements for tax-exempt hospitals to develop Community Health Needs Assessments, and Community Health Assessment requirements for health departments seeking accreditation through the Public Health Accreditation Board. The latter two strategies tackle the challenging aspect of accountability by not only creating measures of population health, but measures for performance as well, and require the identification of entities accountable for specific activities that contribute to overall community and population health.

As noted above, behavior change is particularly difficult to realize and requires multi-faceted approaches using tools from a variety of fields and across sectors, including health psychology, health behavior and education, health communications, community psychology, program evaluation, public policy, and behavioral economics. Despite a small number of (mostly behavioral) "targets," there are still many possible interventions (and combinations of interventions) that may make a difference at both an individual and population level. In the process, it is also important to take into account the many environmental and social factors that can influence behavior over the life course, beginning before birth.

Early childhood investments offer a promising cross-cutting solution to many social determinant pathways. Early life exposures affect health over the life course, including the propensity for risky health behaviors. Research shows that early life exposures affect cognitive and noncognitive development (for example, executive function and prefrontal cortex development), which, in turn, affects time preferences and self-control skills (delayed gratification), which are major determinants of risky health behaviors.

These are key neuro-psycho-social pathways connecting socioeconomic status, health behavior, and health outcomes. The challenge with investments in early childhood is that they require up-front costs that will produce health and economic benefits only over the

long term. This has led to the development of novel long-term financing mechanisms, such as Social Impact Bonds (SIBs). According to the Brookings Institution, in this model, “private investors put up capital to fund a social intervention and governments repay the investor only if an agreed-upon outcome is achieved. An independent evaluator then confirms whether the outcome is achieved through a rigorous impact evaluation. The key feature of a SIB is funding for prevention programs that have the potential to reduce more costly remediation later on. In addition, SIBs introduce an incentive for government agencies to work together to capture savings jointly.”

## 2.4 Needs for Future Research in Health Determinants

Underpinning all of the above efforts, as well as the literature regarding the determinants of health, is the need for more robust data on what produces health, the effectiveness of interventions that work through health determinants to produce health, timely outcomes data, and measures that capture population health and progress toward those goals.

There is a need for more precise measures and comparability between studies of health determinants to bolster the evidence regarding the relative contribution and importance of various determinants in the production of health. A number of studies cited above and reviewed for this study do not precisely define their measures and methodology employed, and the majority of papers cited in Exhibit 1 discuss the lack of comparability between studies as a result of these differences.

In addition, as the most potent health determinants are identified, policy makers will need more information on the effectiveness of interventions that act on those determinants in order to target limited resources and to determine “what works for whom in what context” (as stated by Stoto), given the wide variation in communities and populations in the United States.

Timely outcomes data – in particular, measures that assess population health rather than individual-level outcomes, especially in the context of shared accountability – are also needed. Despite these methodological challenges, there are many interventions to improve population health that are being implemented and have substantial evidential bases.

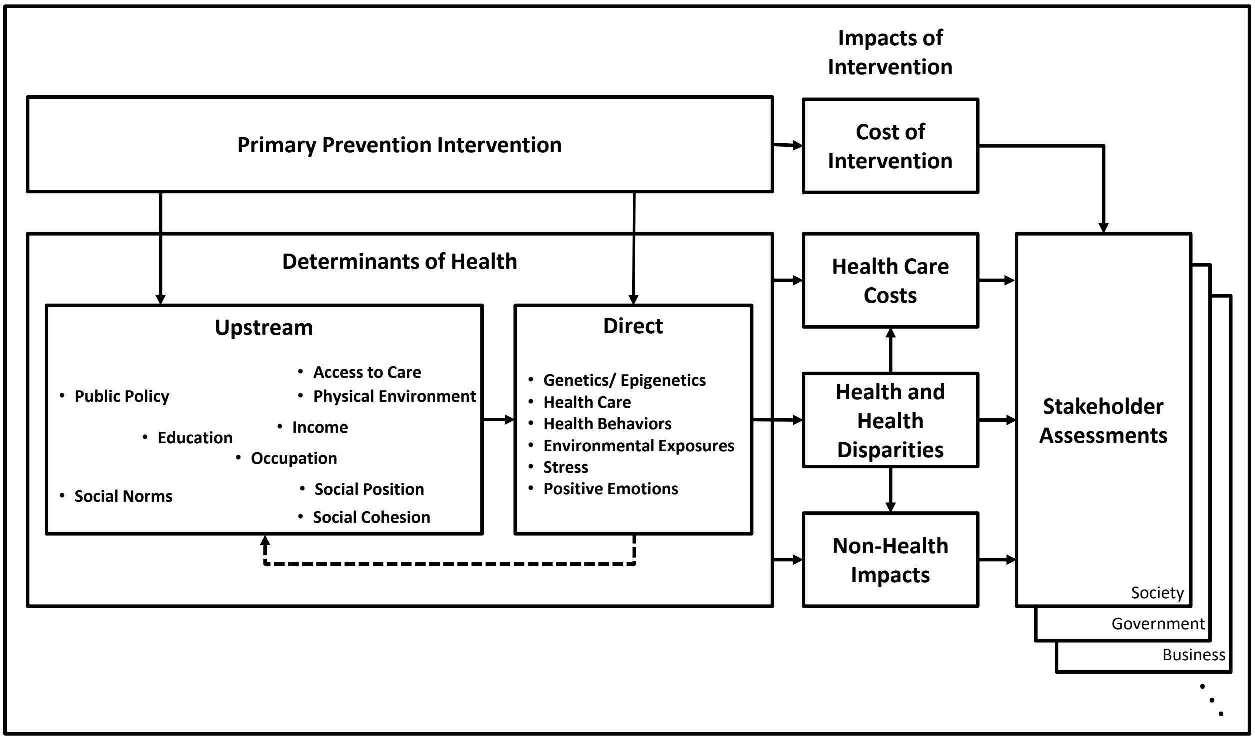
With the increasing appreciation of health as the product of more than access to the health care system and individual behaviors, along with the many opportunities afforded by the ACA, comes the chance to transform how we think about health and how we can improve it for the population as a whole.

# 3.0 High-Level Framework for Investments in Non-Clinical Primary Prevention

In the context of this background, we have developed the high-level framework illustrated in Exhibit 2 to provide a foundation for our investigation of the value of investments in nonclinical primary prevention. A primary prevention intervention in the

form of an investment in one or more of the determinants of health has eventual impacts in the form of changes in the health of the affected population, changes in health care costs, and other (non-health) impacts, as well as expenditures in the form of the cost of the intervention itself. This chapter discusses each of the four major components of the sequence depicted here: the intervention, its effects on the determinants of health, the resultant impacts, and assessments of these impacts in ways that are useful to the disparate stakeholders who might be affected by the intervention.

**Exhibit 2. High-Level Framework**




## 3.1 Primary Prevention Intervention

We consider any investment in a determinant of health other than medical care to be a nonclinical primary prevention intervention. These can range from "upstream" interventions such as improvements to education (e.g., reducing public school class sizes or providing scholarships for preschool attendance) or the built environment (e.g., providing access to exercise opportunities with more parks or bicycle paths) to more direct interventions such as encouraging healthy behaviors (e.g., via banning smoking in public places or requiring motorcycle helmet use) or improving water or air quality (e.g., via more stringent control of automotive or industrial emissions of pollutants). For a partial list of such interventions and a discussion of the existing evidence for the effectiveness of each, see (University of Wisconsin Population Health Institute 2013).

## 3.2 Determinants of Health

As noted earlier, the determinants of health are commonly listed as genetics, health behaviors, social and physical environments, and medical care (McGinnis et al. 2002). These are the factors that combine to produce individual and population health; any health-improving intervention must address one or more of these determinants. Medical care interventions are, by definition, excluded from nonclinical primary prevention. Interventions involving the remaining determinants are, by definition, nonclinical. They typically improve health by reducing the occurrence of health problems (primary prevention).[2] Thus, nonclinical primary prevention includes interventions into all of the determinants of health other than medical care.

This, of course, includes interventions into the social determinants of health (SDH), a subset of the determinants of health that have gained broad recognition and generated extensive research. As noted in the previous chapter, the SDH include circumstances such as education, income, occupation, social position, and the interaction of race, ethnicity, and gender with prevailing discriminatory attitudes and practices. Interventions in any of these circumstances therefore contain elements of nonclinical primary prevention – nonmedical interventions that reduce the occurrence of health problems. For example, it has been argued that reducing class sizes in US primary schools leads to improved health status and, therefore, meets the literal definition of nonclinical primary prevention (Muennig and Woolf 2007). The *What Works for Health* website (University of Wisconsin Population Health Institute 2013) contains many additional examples.

## 3.3 Direct and Upstream Determinants

Our framework incorporates additional structuring of the determinants. There is a smaller set (which we call *direct* determinants) through which all others (*upstream* determinants) operate. The linkage of direct determinants and health is straightforward. The health impact of upstream determinants can best be understood through their linkage to the direct determinants. (The relative positioning of the upstream determinants in Exhibit 2 is intended to signify that some of these linkages are more circuitous than others.)

We define the direct determinants of health as those whose impact on health is readily apparent and which, taken together, fully explain variations in health. Upstream determinants affect health only through their impact on direct determinants. Direct determinants are closely related to the "downstream" determinants of health discussed by Braveman et al. (2011), and the "intermediate determinants" defined in the SDH conceptual framework developed by WHO (World Health Organization 2010).[3]

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[2] They may also improve outcomes from existing health problems, which represents an additional benefit beyond primary prevention.

[3] Some researchers have been reluctant to employ the term "direct" determinants because it could tempt policymakers into ignoring upstream interventions. We note that the most efficient way to impact direct determinants is often through an upstream intervention on indirect determinants.

Of the five determinants of health, we would call three direct: medical care, genetics (and epigenetics[4]), and health behaviors. Each has a clear pathway to health (whereas the upstream determinants affect health because of their effects on one or more of the direct determinants), but this list is incomplete. The remaining two determinants, social and physical environments, include both direct and upstream elements. We use the term *environmental exposures* to represent the direct elements and add it as a fourth direct determinant. It includes exposures to environmental toxins (air and water pollution, lead paint, asbestos), disease outbreaks, violent neighborhoods and relationships, and accident-prone surroundings, e.g., poorly lit streets or unfenced swimming pools.

We add *stress* as a fifth direct determinant of health, since it is not represented in the other four determinants.[5] We use the term very broadly to capture the effects of negative psychological reactions (such as feelings of isolation, feelings of low social position, low self-esteem, and chronic anxiety) induced by concerns about such factors as finances, personal safety, job loss, divorce, and social standing. As noted above, Thoits' (2010) survey of the literature identifies the importance of differential exposure to stressful experiences in producing inequalities in physical and mental health. We also add *positive emotions* as a sixth direct determinant to cover positive psychological attributes such as feelings of self-worth, social connection, and high social position.

The argument put forth above results in the following direct determinants of health:

- Genetics
- Medical care
- Health Behaviors
- Environmental Exposures
- Stress
- Positive Emotions

The remaining characteristics of the social and physical environments constitute the upstream determinants, which we have broken out in somewhat more detail in our framework, based in part on the WHO framework (World Health Organization 2010). The dashed arrow from the direct determinants to the upstream ones in Figure 2 is intended to represent the complex feedback and other interactions among the determinants that are not shown explicitly in the figure. For example, education affects income, income affects access to care, and improved medical care can affect the ability to pursue education.

This list is subject to possible revision as the determinants of health become better understood. For example, social cohesion is a key SDH element in the WHO framework

[4] We have expanded the genetics determinant to include epigenetics to reflect the fact that gene expressions can be affected by environmental exposures and health behaviors.

[5] We view stress as a product of the social environment rather than a characteristic of it. Thus, we do not consider it as an environmental exposure. Even if we did, we would break it out as its own direct determinant because of its importance.

and could be viewed as a seventh direct determinant. We currently treat it as an upstream determinant that affects health through its impact on direct determinants (e.g., by reducing stress, improving health behaviors, and perhaps helping to reduce environmental exposures). Should research reveal a strong, additional independent effect on health, we would include it as a direct determinant.

We believe that incorporating direct determinants into our framework contributes in the following ways toward identifying, describing, and tracking the impact of a policy or program on health and health care costs:

- It will *provide structure* to enable thinking about mechanisms that link a change in an upstream determinant of health to health outcomes, even where existing research results do not allow making such direct links quantitatively.
- It will provide a mechanism to help *convince stakeholders* of the validity of a study linking a policy or program to health outcomes and costs. Identification of likely causal mechanisms should help to explain the health-related effects of modifying an upstream determinant of health (such as education or income) that has no apparent direct relation to health and health care costs.
- It can help *reduce the dimensionality* associated with assessing the impact of each of many alternative policies and programs on health outcomes and costs. While there are many policies and programs that can influence a single direct determinant (such as programs designed to influence diet), the effects of the direct determinant need be assessed only once to partially capture the impacts of many of the interventions that affect it.
- Similarly, it *allows partitioning* the assessment of the impact of a policy or program into two analysis components:
    - Measuring the impacts of the policy or program on the direct determinants, and
    - Measuring the impact of the direct determinant on health outcomes and costs.

  If the latter impact has already been identified, only the former needs to be assessed in order to identify the health and cost impacts of a given policy or program.
- It can help encourage *identification of more targeted investments* in a given upstream determinant of health. As more evidence accumulates about the role of specific direct determinants in the health and cost impacts of an upstream determinant, that evidence can be used to tailor policies and programs to more specifically address those causes. For example, better understanding of the role of education in health and health care costs could help identify specific improvements to the educational system that would have the greatest impact.
- It can help drive *refinement of metrics* associated with each of the direct determinants (such as establishing how best to measure stress).

- It can provide *leading indicators* for near-term post-implementation tracking of the impact of a policy or program on health outcomes and costs. Because the impact on direct determinants is often more immediate and measurable than the impact on health, tracking changes in the direct determinants associated with a policy or program can provide early evidence about program effectiveness. This concept is analogous to the use of "surrogate endpoints" in clinical trials – just as LDL is used as a surrogate endpoint for a cardiovascular drug, direct determinants facilitate measuring the efficacy of preventive interventions.

Furthermore, if research led to identification of a small number of direct determinants that provided most of the health and cost benefits associated with investments in the social determinants of health, policy makers could focus on investments with the greatest impact on those causes. For a seminal example, see (Lantz et al. 1998).

## 3.4 Impacts of Intervention

We characterize four types of impacts that can result from a change in one or more of the determinants of health.

1. **Health and Health Disparities.** Any intervention that directly or indirectly affects the direct determinants of health will also have an impact on the health of the affected population. We show the association of these effects with the direct determinants via the arrow that connects the Direct Determinants box to the Health and Health Disparities box in Exhibit 2. These might include effects on health disparities, as when an intervention targets a disadvantaged population (e.g., via improvements to public housing). The effects will occur over time, sometimes with (possibly long) delays (e.g., improvements to early education can have health impacts much later in the lives of the children who are affected). The effects can also be intergenerational (such as with smoking cessation efforts that target pregnant women).

2. **Health Care Costs**. Interventions also can impact health care costs. This occurs directly when the intervention is a change in medical care itself (such as introduction of an immunization program), but is likely most significant as a result of changes in the health of the population, with possibly lower health care costs incurred on behalf of a healthier population as a result of an intervention. Because these health effects occur over time, so do the resultant changes in health care costs, which can have similar lags.

3. **Non-Health Impacts.** Many investments in the determinants of health have purposes other than (or in addition to) improvements in health. For example, job training programs are designed to improve employment opportunities and income of the participants but may have substantial, positive health benefits. Although the primary purpose of our analytical structure is to assess the impact of interventions on health and health care costs, comparing all the costs of such an investment with only the health benefits that accrue will understate the overall cost-effectiveness of the investment. For this reason, we include non-health impacts of interventions in the framework. Major types of non-health impacts include effects on income (and its

secondary effects, such as improvements to the economy and increased tax revenues) and on other aspects of non-health community well-being – wealth, education, employment, safety, transportation, housing, worksites, food, health care, and recreational spaces (Institute of Medicine 2012).

4. **Cost of Intervention.** Most interventions have direct costs (such as the cost of hiring additional teachers to improve high school graduation rates (Muennig and Woolf 2007)) that are combined with other costs or cost offsets and compared with the benefits they produce to assess whether they provide good value.[6] (Some interventions, such as increases in taxes on cigarettes, could have negative direct costs.) The framework provides for capturing these direct costs.

## 3.5 Stakeholder Assessments

The impacts of a primary prevention intervention can be converted to the various categories of costs and benefits that are of interest to the disparate stakeholders who can influence such investments. These stakeholder assessments are represented by the boxes on the right-hand side of Exhibit 2. In effect, the assessments convert the detailed impacts of a given intervention to metrics that are useful to each stakeholder group. To ensure that analyses using the analytical structure produce information of value to these disparate decision makers (elected and unelected government officials, public health representatives, provider groups, insurers, employers, etc.), these metrics must capture the varied benefits and costs of an investment that are most compelling to each of those decision-making groups. For example, the health impacts of an intervention could be expressed as a change in health-adjusted life expectancy (HALE) for some stakeholders (Institute of Medicine 2011), but the impact of the intervention on absenteeism or presenteeism might be a more meaningful metric for employers. Our discussion of future work in Chapter 6 enumerates these stakeholder groups and identifies the types of costs and benefits that are of primary interest to each group. An important component of the structure is our valuation tool that converts the impacts of an intervention in each of the four classes shown in Exhibit 2 to quantification of the specific costs and benefits that are important to each stakeholder group. The next chapter describes the prototype version of this tool that was developed under this grant.

# 4.0 Prototype Valuation Tool for Valuing Investments in Non-Clinical Primary Prevention

A major focus of this research is development and application of a valuation tool that can be used to conduct the stakeholder assessments described in the previous section. This chapter describes the prototype version of this tool that has been developed to date.

[6] In cost-effectiveness or cost-benefit analyses that are conducted from a societal perspective, all costs resulting from an intervention – including changes in health care costs as well as costs of the intervention itself – are included as relevant costs. Where appropriate, this combining of costs will be addressed within the stakeholder assessments discussed in the next section.

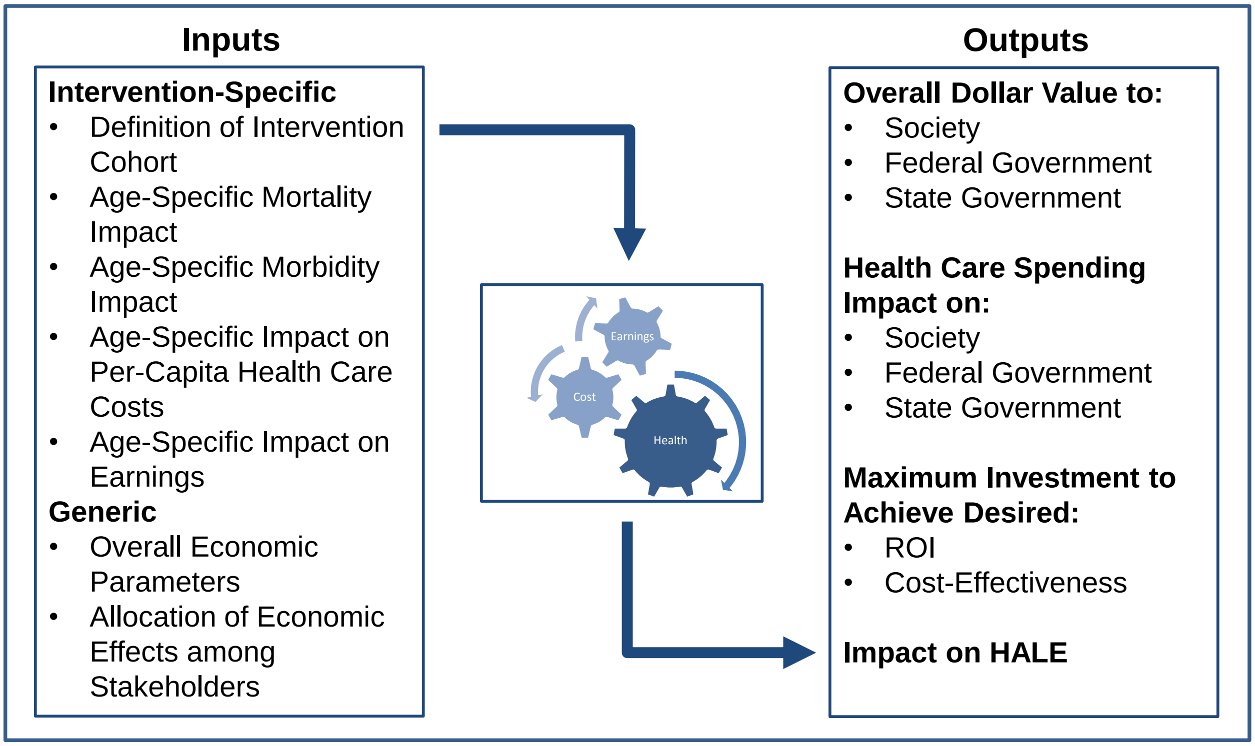
## 4.1 Valuation Tool Overview

The valuation tool is a spreadsheet application written in Microsoft Excel that synthesizes existing knowledge about the impact on health outcomes and costs of investments in the determinants of health. The outcomes and costs are characterized in ways that are meaningful to different stakeholders in the public sector (government), the private sector (businesses and other private sector organizations within and outside the health care industry), and society (including individuals and families). The prototype tool currently represents state and federal government stakeholders; a societal perspective is also included.

Consider an investment in one or more of the determinants of health (the details of the nature and cost of the investment are external to the valuation tool). Assume we can predict the annual impact of the investment on mortality (measured in life years), morbidity[7] (measured in quality-adjusted life years or QALYs), health care spending by payer (Medicare, Medicaid/CHIP, private insurance, out of pocket, other), and worker productivity (measured in earnings). Assume further that we can partition this impact into pre-longevity and longevity components, where a longevity impact occurs if the intervention extends life. As shown in Exhibit 3, the valuation tool accepts these annual impacts and other parameter values as input and converts them to an overall (positive or negative) dollar impact – and the portion of this impact that consists of health care spending – for society, the federal budget, and state budgets (as a whole, not currently for individual states). It also produces measures of value from the standpoint of each of these three stakeholder groups. The valuation options include increases in health-adjusted life expectancy (HALE), and the maximum investment that produces the input impacts while achieving a desired return on investment (ROI), a desired cost-effectiveness level (cost per QALY), or a desired payback period (which is captured by the overall dollar value of the intervention). Alternative scenarios for a given investment can be defined by varying the discount rate, the time horizon of interest, or other stakeholder-specific parameters.

[7] The tool includes a method that allows relating morbidity to health care costs, providing an alternative to direct estimates of the impact of an intervention on morbidity.

**Exhibit 3. Valuation Tool Inputs and Outputs**




From a societal perspective, interventions that improve health have multiple societal benefits, including increased longevity and more years of good health, greater productivity and longer labor force participation (leading to higher gross domestic product, or GDP), and lower health care costs (until the longevity years begin). Increased longevity brings additional societal impacts, including additional health care costs; costs of food, shelter, and other essentials of living; and, if life is extended during the working years, higher GDP. The tool captures all of these effects. These results are also aggregated into measures of overall societal value, including cost per QALY or, if a dollar value is placed on QALYs, ROI. In addition, some interventions that improve health can have other direct societal benefits or costs. If these can be monetized, they should be included in the cost-effectiveness and ROI calculations; if not, they should be described separately (outside the tool).[8]

From the federal or state budget perspective, better health leads to lower health care spending (pre-longevity period), which leads to lower Medicare and Medicaid costs. As noted above, better health also drives up GDP, which leads to greater tax revenues and lower safety net spending. Greater longevity leads to higher Medicare, Medicaid, and Social Security costs and, if life is extended during working years, greater tax revenues. These effects are incorporated into the tool.

[8] Note that this concept of societal value ignores distributional considerations that can be important to potential investors and that have ethical implications.

## 4.2 Valuation Tool Data Requirements

Data for the valuation tool are input via a separate workbook (of which multiple versions can describe different applications of the tool) that is linked to the tool itself. Each input workbook consists of two worksheets. The first of these worksheets (Exhibit 4) provides basic inputs to the model, while the second worksheet (Exhibit 5, which displays only selected rows from the worksheet) provides inputs that are age-dependent. Input definitions are included in the exhibits in comments (with yellow background). In addition to these inputs, a control panel in the tool workbook allows the user to update the link to the input workbook, specify the units used to display dollar outputs (e.g., millions or billions), and specify whether dollar outputs should be expressed as net costs or net value (the negative of costs).

**Exhibit 4. Sample Screen Shot of “BasicInput” Worksheet with Definitions**

## Basic Input

| Naming Convention | |
|---|---|
| Base Group | Nonsmoker |
| Alternate Group | Smoker |

Labels used to distinguish the group of individuals to whom the intervention has been successfully applied (Base Group) from the group who have the health problem (Alternate Group)

| Global Parameters | Active | Default |
|---|---|---|
| Intervention Age | 20 | 20 |
| Model Time Horizon (Years) | 100 | 100 |
| Cohort Size | 100,000 | 100,000 |
| Discount Rate | 3% | 3% |
| Desired Rate of Return (i*) | 5% | 5% |
| Desired Cost Effectiveness ($ / QALY) | $50,000 | $50,000 |
| GDP / Earnings | 1.92 | 1.92 |
| QALY lost per $HC | 0.00000544750 | 0.00000544750 |
| QALY Value | $0 | $50,000 |
| Cost of Living Per Year | $20,000 | $20,000 |

Default values are recommended for use; active values are used in the model

Initial age at which intervention takes effect

Time horizon over which effects are computed

Number of individuals in each annual cohort

Annual rate for discounting future cost and effectiveness

Target annual return on investment in the intervention

Target for cost-effectiveness of the intervention

Factor for converting a change in earnings to a change in GDP

Factor for converting a change in health spending to a change in QALYs

Dollar value of a QALY

Minimum cost for food, housing, etc. to sustain an individual for one year

| Alternate Group Adjustments | Active | Default |
|---|---|---|
| Mortality | 0.00 | 0.00 |
| Earnings | 0.00 | 0.00 |
| Health Care Costs | 0.00 | 0.00 |

Range of 0 to 1:

0 - No change

1 - Convergence to base group

Adjustment factors for modifying Alternate Group parameters for greater similarity to Base Group values (used for sensitivity analysis)

## Exhibit 4 (continued). Sample Screen Shot of "BasicInput" Worksheet with Definitions

| Real Growth Rates | Active | Default |
|---|---|---|
| Cost of Living | 0.0% | 0.0% |
| Earnings | 0.0% | 1.4% |
| Health Care Costs | 0.0% | 1.7% |
| Exhange Subsidy Spending | 0.0% | 0.0% |
| Social Security | 0.0% | 0.0% |

Annual average rates of real growth for cost and earnings parameters

First five rows express federal government share of asssociated costs

| Federal Parameters | Active | Default |
|---|---|---|
| Medicare Share | 100.0% | 100.0% |
| Medicaid/CHIP Share - Children 0-18 Years | 57.5% | 57.5% |
| Medicaid Share - Adults 19-64 Years | 63.4% | 63.4% |
| Medicaid Share - Adults 65+ Years | 57.0% | 57.0% |
| Other Share | 36.0% | 36.0% |
| Share of Extra Earnings As Safety Net Offset | 5% | 5% |
| Tax Share of GDP | 19% | 19% |
| Exchange Subsidy Spending ($/person) | $400 | $400 |
| Social Security Amount | $12,000 | $12,000 |

| Social Security Multipliers | |
|---|---|
| Age | Factor |
| 62 | 0.5 |
| 63 | 0.7 |
| 64 | 0.8 |
| 65 | 0.9 |
| 66 | 1 |

Fraction of individuals by age who receive social security

Percent of increased earnings by which federal safety net expenditures are reduced

Percent of GDP increase collected in federal taxes

Per-capita exchange subsidies, averaged over the entire population

Average annual social security income per capita

| State Parameters | Active | Default |
|---|---|---|
| Medicare Share | 0.0% | |
| Medicaid/CHIP Share - Children 0-18 Years | 42.5% | |
| Medicaid Share - Adults 19-64 Years | 36.6% | |
| Medicaid Share - Adults 65+ Years | 43.0% | |
| Other Share | 12.0% | 12.0% |
| Share of Extra Earnings As Safety Net Offset | 5% | 5% |
| Tax Share of GDP | 5% | 5% |

These are (1 - federal values)

State government share of "other" health care costs

Percent of increased earnings by which state safety net expenditures are reduced

Percent of GDP increase collected in state taxes

**Exhibit 5. Sample Screen Shot of "AgeRelatedInput" Worksheet with Definitions (Partial)**

## Age-related Input

Specifies denominator for mortality rates (e.g., deaths per hundred persons)

☑ Hide graphs

| Deaths per: | 100 |
|---|---|

Mortality rate by age for Base Group (and similarly for Alternate Group)

Interpolated and adjusted valuse are computed by the model (including interpolation between missing input values)

Average per-capita annual earnings by age for Alternate Group (and similarly for Base Group)

| Age | Mortality Rate, Nonsmoker | Interpolated, Nonsmoker | Mortality Rate, Smoker | Interpolated and Adjusted, Smoker |
|---|---|---|---|---|
| 20 | 0.08 | 0.08 | 0.08 | 0.08 |
| 21 | 0.08 | 0.08 | 0.08 | 0.08 |
| 22 | 0.09 | 0.09 | 0.09 | 0.09 |
| 23 | 0.09 | 0.09 | 0.09 | 0.09 |
| 24 | 0.09 | 0.09 | 0.09 | 0.09 |
| 25 | 0.07 | 0.07 | 0.13 | 0.13 |
| 26 | 0.07 | 0.07 | 0.13 | 0.13 |
| 27 | 0.07 | 0.07 | 0.13 | 0.13 |
| 28 | 0.07 | 0.07 | 0.14 | 0.14 |
| 29 | 0.07 | 0.07 | 0.14 | 0.14 |

| Age | Per Capita Earnings, Nonsmoker | Interpolated, Nonsmoker | Per Capita Earnings, Smoker | Interpolated and Adjusted, Smoker |
|---|---|---|---|---|
| 20 | $ 5,868 | $ 5,868 | $ 5,642 | 5,642 |
| 21 | $ 7,772 | $ 7,772 | $ 7,473 | 7,473 |
| 22 | $ 10,098 | $ 10,098 | $ 9,710 | 9,710 |
| 23 | $ 13,589 | $ 13,589 | $ 13,067 | 13,067 |
| 24 | $ 16,265 | $ 16,265 | $ 15,639 | 15,639 |
| 25 | $ 20,929 | $ 20,929 | $ 20,124 | 20,124 |
| 26 | $ 22,890 | $ 22,890 | $ 22,010 | 22,010 |
| 27 | $ 25,127 | $ 25,127 | $ 24,161 | 24,161 |
| 28 | $ 26,493 | $ 26,493 | $ 25,474 | 25,474 |
| 29 | $ 28,042 | $ 28,042 | $ 26,963 | 26,963 |

**Exhibit 5 (continued). Sample Screen Shot of "AgeRelatedInput" Worksheet with Definitions (Partial)**

Average per-capita annual health care costs by age for Base Group (and similarly for Alternate Group)

Optional input describing average health status in QALYs/year for an individual in Base Group (computed in next column if left blank)

| Age | Per Capita Health Care Costs, Nonsmoker | Interpolated, Nonsmoker | Per Capita Health Care Costs, Smoker | Interpolated and Adjusted, Smoker |
|---|---|---|---|---|
| 20 | $ 3,805 | $ 3,805 | $ 4,223 | 4,223 |
| 21 | $ 3,826 | $ 3,826 | $ 4,247 | 4,247 |
| 22 | $ 3,848 | $ 3,848 | $ 4,271 | 4,271 |
| 23 | $ 3,869 | $ 3,869 | $ 4,295 | 4,295 |
| 24 | $ 3,891 | $ 3,891 | $ 4,319 | 4,319 |
| 25 | $ 3,912 | $ 3,912 | $ 4,421 | 4,421 |
| 26 | $ 3,934 | $ 3,934 | $ 4,445 | 4,445 |
| 27 | $ 3,955 | $ 3,955 | $ 4,470 | 4,470 |
| 28 | $ 3,977 | $ 3,977 | $ 4,494 | 4,494 |
| 29 | $ 3,999 | $ 3,999 | $ 4,518 | 4,518 |

| Age | Avg. QALY | Computed |
|---|---|---|
| 20 | | 0.92 |
| 21 | | 0.92 |
| 22 | | 0.92 |
| 23 | | 0.92 |
| 24 | | 0.92 |
| 25 | | 0.92 |
| 26 | | 0.92 |
| 27 | | 0.92 |
| 28 | | 0.92 |
| 29 | | 0.92 |

**Exhibit 5 (continued). Sample Screen Shot of "AgeRelatedInput" Worksheet with Definitions (Partial)**

Percent of health care costs by age paid by Medicare (and similarly for Medicaid, out-of-pocket expenditures, and "other"). Note: Out-of-pocket values are not used by this version of the model.

| Age | Medicare | Medicare Interpolated | Medicaid | Medicaid Interpolated | Out of Pocket | Out of Pocket Interpolated | Other | Other Interpolated |
|---|---|---|---|---|---|---|---|---|
| 20 | 3.5% | 3.5% | 24.7% | 24.7% | 9.0% | 9.0% | 15.5% | 15.5% |
| 21 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 22 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 23 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 24 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 25 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 26 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 27 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 28 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |
| 29 | | 3.5% | | 24.7% | | 9.0% | | 15.5% |

Some of these inputs require further explanation. Data describing morbidity levels in the model (measured in QALYs) are computed using a relationship between health care costs and morbidity. Inputs for this relationship include the “QALY lost per $HC” parameter on the BasicInput worksheet, which represents the amount by which QALYs are reduced per additional dollar of annual health care spending on behalf of an individual. QALY levels by age for the base group (the population to which the intervention is applied) can be input directly on the AgeRelatedInput worksheet, or it can be calculated by the model using this relationship. Differences in QALY levels by age for the alternate group (the population that does not benefit from the intervention) compared with the base group are not input, but are calculated based on the difference between that group’s age-specific health care costs and those of the base group.

The Alternative Group Adjustments on the BasicInput worksheet are available for use in sensitivity analysis. Each of these is a number between 0 and 1, where 0 implies no adjustment to the alternative group’s baseline mortality rates, earnings, or costs, 1 implies no difference between the base group’s and alternative group’s values, and an intermediate number proportionally reduces the difference between the two populations. Thus, for any of these three sets of data, let $a$ be the adjustment parameter, $h$ be the value of the data representing the base group for a given age, $s$ represent the value of the data for the alternative group for that age, and $s'$ be the adjusted value of $s$. Then $s' = s+a(h-s)$.

The “Other Share” of health spending under federal and state parameters on the BasicInput worksheet represents the government share of health spending other than Medicare, Medicaid/CHIP, out-of-pocket, and private insurance. This includes spending on behalf of the Department of Defense, Department of Veterans Affairs, worksite health care, other private revenues, Indian Health Services, workers’ compensation, general assistance, maternal and child health, vocational rehabilitation, other federal programs, Substance Abuse and Mental Health Services Administration, other state and local programs, and school health. This other share is attributed to the population by age in the “Other” column of the AgeRelatedInput worksheet.

Sources and methods for generating all of these data for the two applications of the model that have been developed to date are described in the next chapter.

## 4.3 Valuation Tool Details

The valuation tool as a functioning unit comprises two Microsoft Excel workbooks, one containing user-supplied input pertaining to a particular prevention intervention (as described in the previous section), and another containing a generic mathematical model that processes this input and produces read-only output in the form of tables and charts. The two workbooks communicate with each other via a standard Excel workbook link. This documentation will henceforth refer to these two model components as the input workbook (IW) and output workbook (OW).

Common to both workbooks are two worksheets representing two kinds of input:

- The “BasicInput” worksheet contains global parameters and input data not related to the age of the cohort undergoing the intervention. Descriptions of the variables are given in the previous section.
- The “AgeRelatedInput” worksheet contains data dependent on the age of the cohort in the form of input vectors. Again, details are described in the previous section.

These input-oriented worksheets are nearly identical in both the IW and OW, the main difference being that the worksheets in the OW simply repeat the data supplied in the IW and are read-only and protected (they may be used for quick reference to input parameters but not to change their values). Additionally, the BasicInput worksheet in the IW provides a column to store preferred or “default” values for parameters, whereas the OW only displays the values in active use.

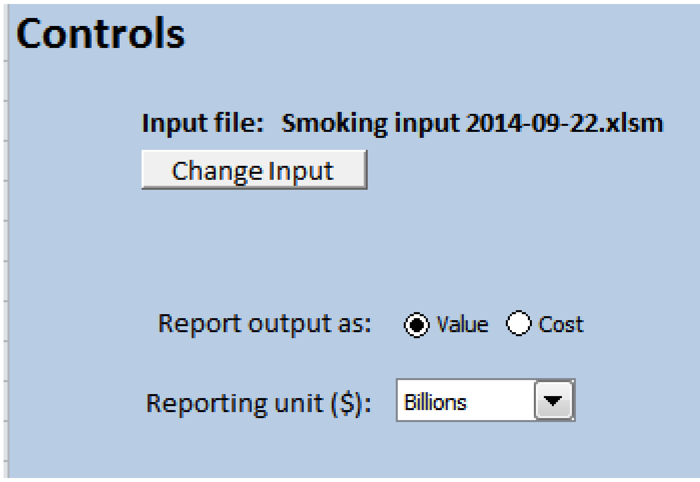
In both worksheets of the IW, values changeable by the user are located in white-colored cells. In the AgeRelatedInput sheet, the blue cells (the cells actually used by the model) calculate linearly interpolated values if any corresponding white cells are left blank. Additionally, blue columns for the alternate group may show values adjusted toward the base group values if any of the adjustment parameters are used (see previous section). The AgeRelatedInput sheet also optionally displays graphs comparing the vector values of variables for the base vs. alternate groups.

In the IW, it may be useful to attach auxiliary worksheets to assist in calculations leading to the input values. Such additional sheets do not affect how the IW communicates information to the OW so long as the two sheets described above are included with the names given.

The OW has ten additional sheets:

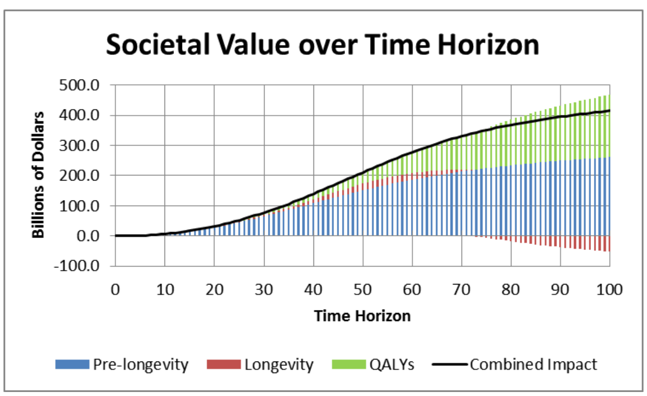
- “Controls” provides some overall model controls that can be manipulated by the user. It is the only worksheet in the OW that can be edited. Specifically, one can change the input file linked to the model, indicate whether outputs should be reported as values or costs (i.e., flip the sign of the output), and declare in what units dollar values should be reported (thousands, millions, billions, or trillions). Reporting the output as cost could be useful if studying an intervention whose costs exceed the resultant savings, or if studying a “negative” intervention, i.e., an undesirable change that worsens health.

**Exhibit 6. Sample Screen Shot of Controls Worksheet**




- The "Model" worksheet is where all model calculations are carried out. This section will be discussed in detail below.
- "AllComponentsCharts" and "AllComponentsTables" show model output for the societal, federal, and state overall cumulative and discounted values (or costs) of the intervention over the supplied time horizon in chart and table form, respectively.

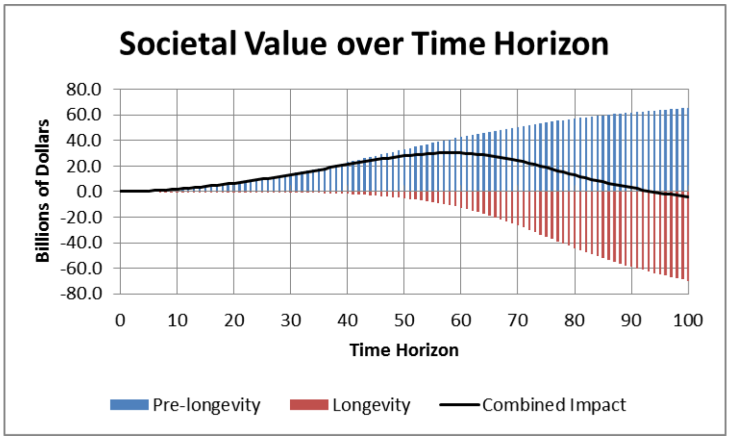
**Exhibit 7. Sample Screen Shot of AllComponents Output Worksheets (Partial)**




| Societal Value ($Billion) | | | | |
|---|---|---|---|---|
| Year | Base | Longevity | QALY $ | Total |
| 1 | 0.08 | 0.00 | 0.01 | 0.09 |
| 2 | 0.26 | 0.00 | 0.03 | 0.29 |
| 3 | 0.53 | 0.00 | 0.06 | 0.60 |
| 4 | 0.93 | 0.00 | 0.10 | 1.03 |
| 5 | 1.45 | 0.00 | 0.15 | 1.61 |
| 6 | 2.13 | 0.00 | 0.21 | 2.34 |
| 7 | 2.97 | 0.00 | 0.29 | 3.26 |
| 8 | 3.97 | 0.00 | 0.37 | 4.34 |
| 9 | 5.13 | 0.01 | 0.47 | 5.61 |
| 10 | 6.44 | 0.03 | 0.59 | 7.06 |
| 11 | 7.91 | 0.05 | 0.72 | 8.68 |
| 12 | 9.53 | 0.08 | 0.88 | 10.48 |
| 13 | 11.29 | 0.12 | 1.05 | 12.45 |

- "HealthCareOnlyCharts" and "HealthCareOnlyTables" provide the same information as above, applied only to health care dollars.

**Exhibit 8. Sample Screen Shot of HealthCareOnly Output Worksheets (Partial)**




| Societal Value ($Billion) | | | |
|---|---|---|---|
| Year | Base | Longevity | Total |
| 1 | 0.04 | 0.00 | 0.04 |
| 2 | 0.12 | 0.00 | 0.12 |
| 3 | 0.24 | 0.00 | 0.24 |
| 4 | 0.38 | 0.00 | 0.38 |
| 5 | 0.57 | 0.00 | 0.57 |
| 6 | 0.79 | 0.00 | 0.79 |
| 7 | 1.04 | 0.00 | 1.04 |
| 8 | 1.33 | 0.00 | 1.33 |
| 9 | 1.65 | 0.00 | 1.64 |
| 10 | 1.99 | 0.00 | 1.99 |
| 11 | 2.37 | -0.01 | 2.36 |
| 12 | 2.77 | -0.01 | 2.76 |
| 13 | 3.19 | -0.02 | 3.18 |

- “HealthCareYearByYearCharts” and “HealthCareYearByYearTables” provide the same information as in the HealthCareOnly sheets, but displays year-by-year results without discounting future values, rather than cumulative discounted results.
- “InvestmentThresholdCharts” and “InvestmentThresholdTables” show the maximum investment, for different time horizons, leading to the inputted desired rate of return for federal and state government stakeholders as well as society as a whole. Additionally, they show the maximum investment allowable in achieving a user-supplied desired cost per QALY for different time horizons for the societal view. InvestmentThresholdTables also gives the Health Adjusted Life Expectancy (HALE) increase.

**Exhibit 9. Sample Screen Shot of InvestmentThreshold Output Worksheets (Partial)**

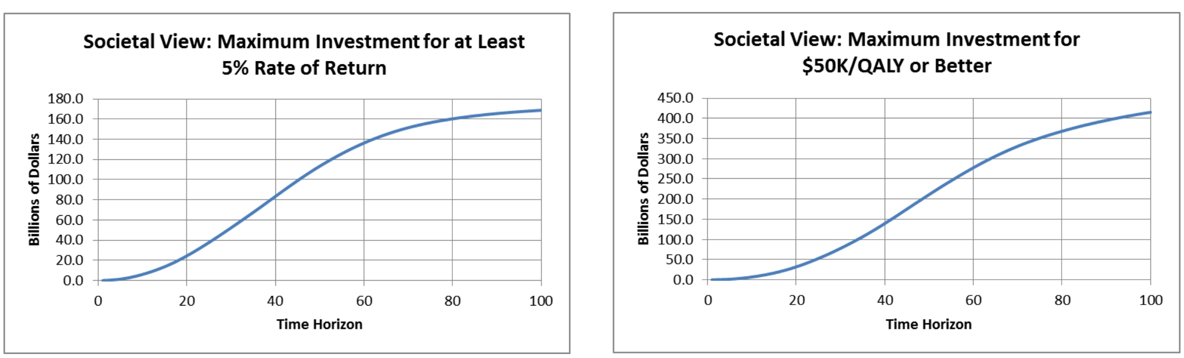


**Exhibit 9 (continued). Sample Screen Shot of Investment Threshold Output Worksheets (Partial)**

| | |
|---|---|
| Increase in HALE: | 7.87 |
| Age of intervention: | 20 |

| Maximum Investment for at Least 5% Rate of Return ($Billion) | | | |
|---|---|---|---|
| Time Horizon | Societal View | Federal View | State View |
| 100 | 168.8 | 76.0 | 71.4 |
| 1 | 0.1 | 0.0 | 0.0 |
| 2 | 0.3 | 0.1 | 0.1 |
| 3 | 0.6 | 0.2 | 0.1 |
| 4 | 1.0 | 0.3 | 0.2 |
| 5 | 1.5 | 0.5 | 0.3 |
| 6 | 2.2 | 0.6 | 0.4 |

| Time Horizon | Societal View: Maximum Investment for $50K/QALY or Better ($Billion) |
|---|---|
| 100 | 415.1 |
| 1 | 0.1 |
| 2 | 0.3 |
| 3 | 0.6 |
| 4 | 1.0 |
| 5 | 1.6 |
| 6 | 2.3 |

We now discuss in detail the heart of the valuation tool, the "Model" worksheet of the OW. The model takes the form of one large (86-column by 200-row) table. Rather than refer to arbitrary Excel column letters, we will use a more robust and informative convention of referring to column titles and using the form **[Title | Subtitle | Sub-subtitle]** (to the subtitle depth necessary), where quotes (**"**) indicate columns recently described, as in **[ " | Subtitle]**, and periods (**.**) indicate unnamed, non-specific, or multiple subtitles, as in **[Title | . ]**. When a column name is given in [blue text] or [red text], it refers to the vector of data given in that column (two colors are used to more easily see separation of variables within formulas—there is no difference implied between the two colors). Sometimes subscripts will be appended (in a non-mathematically-rigorous fashion) to make more complicated vector operations more clear.

As can been seen in the first column, **[Year]**, the model begins in year 0 and moves forward in time 200 years, one year at a time (though output only uses model data generated within the user-specified time horizon). Let *n* stand for a given year. The second column shows the age of the first cohort throughout the model years. The age of the first cohort during year one is specified in input, corresponding to the year the effects of the prevention intervention begin. Let age(*n*) specify the age of the cohort at year *n*.

The next six columns **[Per capita health care costs | . ]**, **[Per capita earnings | . ]**, and **[Probability of death | . ]**, give average per capita health care costs, earnings/wages, and mortality rates for the base and alternate groups by age (of the first cohort). These values come directly from the AgeRelatedInput sheet. Note that these columns, like the age column, only extend down until the first cohort reaches the age of 99. The model makes the simplifying assumption that contributions to value/cost from the very few people living beyond this age are negligible and therefore does not track any effects beyond it (this is enforced in the model by 100% mortality at age 99).

The first two **[Average life years | . ]** columns show the average number of years lived at a given age by members of the base and alternate groups. The difference between these columns, given in **[Average life years | Longevity]**, represents the longevity (in fractional years) achieved in one year by the base group over the alternate group at a given age (typically a positive number, given a health-beneficial intervention).

The **[Earnings gained | Single cohort | . ]** columns show the average rise in earnings for a member of a cohort resulting from moving from the alternate group to the base group. This increase is due to working as base member instead of an alternate member during the time an alternate member would have been alive (given in the **[ " | " | Base]** column), and also working longer due to living longer as a base member vs. an alternative member (**[ " | " | Longevity]**). These are calculated as follows:

[Earnings gained | Single cohort | Base] = [Average life years | Alt] * ([Per Capita Earnings | Base] – [Per Capita Earnings | Alt])

[Earnings gained | Single cohort | Longevity] = [Average life years | Longevity] * [Per Capita Earnings | Base]

[Earnings gained | Single cohort | Total] = [Earnings gained | Single cohort | Base] + [Earnings gained | Single cohort | Longevity]

Columns **[Earnings gained | All cohorts, with real growth | . ]** introduce the idea of multiple cohorts existing simultaneously, each cohort staggered one year behind the one previous, beginning with the first cohort in year one. These columns therefore extend all the way to year 200, the last year represented in the model, because in each year a fresh cohort starts up at the intervention age specified in input. For a given annual EarningsGrowthRate value provided in input, the total increase in earnings in year *n* across all cohorts is given by $[\text{Earnings gained | All cohorts… | Base}]_n = (1 + \text{EarningsGrowthRate})^n + \sum [\text{Earnings gained | Single cohort | Base}]_{1..n}$. Formulas of this form are used many times in the model, so we present a named function to denote it:

$F(v, r, n) = (1 + r)^n * \sum_{i=1..n} v_i$, where *v* is a vector. Note that $F(v, 0, n)$ simplifies to $\sum_{i=1..n} v_i$ . Let us define another function, denoted by *G*, that will also be used often:

$$G(v, r, n) = G(v, r, n\text{-}1) + [1 / (1 + r)^n] * v_n, \text{ where } G(v, r, 0) = 0, \text{ and } v \text{ is a vector.}$$

Using this notation, $[\text{Earnings gained | All cohorts…| Longevity}]_n = F([\text{Earnings gained | Single cohort | Base}], \text{EarningsGrowthRate}, n)$. Finally, [Earnings gained | All cohorts…|Total] = [ " | " | Base] + [ " | " | Longevity].

The **[GDP Gained | Single Cohort | . ]** columns give the gain in GDP as a multiple of **[Earnings gained | Single cohort | . ]** for base and longevity (the scalar multiplier GDPEarnings is provided as input). The data in **[GDP Gained | All cohorts… | . ]** are calculated by $[\text{GDP Gained | All cohorts | . }]_n = F([\text{GDP Gained | Single Cohort | . }], \text{EarningsGrowthRate}, n)$. [GDP gained | All cohorts…|Total] = [ " | " | Base] + [ " | " | Longevity].

The **[QALYs gained | Single cohort | . ]** columns give the number of QALYs generated by the average cohort member for each age. [ " | " | Base] = QALYLostPerHC * [Average life years | Alt] * ( [Per capita health care costs | Alt] – [Per capita health care costs | Base] ), where QALYLostPerHC is given in input and represents a conversion from health care dollars spent into negative QALYs. $[\text{ " | " | Longevity}]_n = \text{QALYByAge}_n * [\text{Average life years | Longevity}]$, where $\text{QALYByAge}_n$ represents the

average number of QALYs generated at age *n* by a base member and is given in the AgeRelatedInput worksheet.

Lastly, **[ " | " | Total]** just sums the base and longevity columns. The base, longevity, and total columns of **[QALYs gained | All cohorts | . ]** are computed by applying an *F*(*v*, 0, *n*) function for each corresponding single cohort column. Then [QALYs gained | All cohorts | Cum. Total, discounted]$_n$ = [QALYs gained | All cohorts | Cum. Total, discounted]$_{n-1}$ + [1 / (1 + DiscountRate)$^n$] * [QALYs gained | All cohorts | Total]$_n$ = *G*([QALYs gained | All cohorts | Total], DiscountRate, *n*), where DiscountRate is the overall discount rate given in input.

The **[Health care dollars saved | Single cohort | . ]** columns describe how health care dollars are saved due to the average cohort member's shift from the alternate group to the base group. [ " | " | Base] = [Average life years | Alt] * ( [Per capita health care costs | Alt] - [Per capita health care costs | Base] ). [ " | " | Longevity] = -[Average life years | Longevity] * [Per capita health care costs | Base]. **[ " | " | Total]** is obtained by summing these two columns. **[Health care dollars saved | All cohorts… | . ]** are computed with *F*(*v*, HealthCareCostsGrowth, *n*) functions, where HealthCareCostsGrowth is specified in input. Multiplying the values in these columns by the cohort size (given in input) and displayed in the dollar units and sign requested in the Controls sheet provides the data used to generate the output in the HealthCareByYear worksheets.

**[Longevity cost of living | . ]** show the average living cost of extended life based on the intervention. They are computed as [Longevity cost of living | Single cohort ] = -CostPerLifeYear * [Average life years | longevity], where CostPerLifeYear is specified in input. [Longevity cost of living | All cohorts… ]$_n$ = *F*([Longevity cost of living | Single cohort ], CostOfLivingGrowth, *n*), where CostOfLivingGrowth is an annual rate provided as input.

The **[Net offsets, with real growth | All components | . ]** columns are used to generate the ROI charts in InvestmentThresholdCharts output worksheet. **[ " | " | Base]** is computed as [Health care dollars saved | All components, with real growth | Base] + [GDP Gained | All components, with real growth | Base]. [ " | " | Longevity] is computed similarly, with one additional term: [Health care dollars saved | All components, with real growth | Longevity] + [GDP Gained | All components, with real growth | Longevity] + [Longevity cost of living | All cohorts, with real growth]. The **[ " | " | Total]** columns is the sum of these two columns.

To compute the net offsets for each model year in the **[Cumulative discounted net offsets, with real growth | All components | . ]** columns, we use the health care dollars saved and GDP gained in the base case: [ " | " | Base]$_n$ = *G*{([Health care dollars saved | All cohorts… | Base] + [GDP gained | All cohorts… | Base]), DiscountRate, *n*}. A similar formula holds for longevity, except that cost of living in extended life must be included: [ " | " | Longevity]$_n$ = G{([Health care dollars saved | All cohorts… |Longevity] + [GDP gained | All cohorts… | Longevity] + [Longevity Cost of Living | All cohorts…]), DiscountRate, *n*}. The **[Cumulative discounted net offsets, with real growth | Health care only | . ]** columns are computed the same way, but only using **[Health care dollars saved | All cohorts… | . ]** columns in the first argument of the *G* function.

The **[Societal view | . | . ]** columns process the above into overall dollars of value the intervention provides to society by multiplying by the cohort size and displaying in the requested dollars units and sign (parameters set in the Controls worksheet). These columns are used to generate the output in the Societal View portion of the AllComponents and HealthCareOnly output sheets.

The next set of columns concerns the federal government stakeholder. **[Total federal share of health care spending]** is computed from the input worksheets for each age and is used as a multiplier for the subsequent **[Federal healthcare dollars saved | Single cohort | . ]** columns: [Federal healthcare dollars saved | Single cohort | . ] = [Total federal share of health care spending] * [Healthcare dollars saved | Single cohort | . ] (this is just element-wise multiplication, not vector multiplication). Then [Federal healthcare dollars saved | All cohorts… | . ]$_n$ = *F*([Federal healthcare dollars saved | Single cohort | . ], HealthCareCostsGrowth, *n*).

The **[Discounted cumulative federal healthcare dollars saved | All cohorts, with real growth | . ]** columns are computed as [“ | “ | . ]$_n$ = *G*([Federal healthcare dollars saved | All cohorts… | . ], DiscountRate, *n*).

The **[Discounted cumulative federal safety net dollars saved | All cohorts, with real growth | . ]** columns are computed as [“|” | . ]$_n$ = *G*([Earnings Gained | All cohorts… | . ] * FedShareExtra, DiscountRate, *n*), where FedShareExtra is the percent of increased earnings by which federal safety net expenditures are reduced and is set in BasicInput.

The **[Discounted cumulative federal tax revenues gained via GDP | All cohorts, with real growth | . ]** columns are computed as [ “ | “ | . ]$_n$ = G( [GDP Gained | All cohorts… | . ]$_n$ * FedTaxShare, DiscountRate, *n*), where FedTaxShare is the percentage of GDP increase collected in federal taxes and is set in BasicInput.

**[Longevity Social Security payouts | Single cohort]** gives the extra social security funds paid out to an average member of the cohort due to extra life resulting from the intervention. It is computed as [ “ | “ ] = -SocialSecurityAmount * [Average life years | Longevity] * SocialSecurityMultiplier, where SocialSecurityAmount is defined in input as the average social security income for those receiving it and SocialSecurityMultiplier is given in BasicInput as the fraction of individuals who receive Social Security payments by age. To calculate this for all cohorts we compute [ “ | All cohorts, with growth]$_n$ = *F*([Longevity Social Security payouts | Single cohort], SocialSecurityGrowth, *n*). Finally, [ “ | Discounted, cumulative]$_n$ = G([Longevity Social Security payouts | All cohorts, with growth], DiscountRate, *n*).

**[Longevity exchange subsidy payments | Single cohort]** is the average per-capita exchange subsidy, paid to those between the ages of 18 and 64 and computed as [ “ | “ ]$_n$ = -[Average life years | Longevity] * ExchangeSubsidy * $I_{18 \le \text{age}(n) \le 64}$, where *I* is an indicator function. Then [ “| All cohorts… ]$_n$ = F([Longevity exchange subsidy payments | Single cohort], ExchangeSubsidyGrowth, *n*), where ExchangeSubsidyGrowth is an annual growth rate and is given in input. Lastly, [Longevity exchange subsidy payments| Discounted, cumulative]$_n$ = G([Longevity exchange subsidy payments | All cohorts, with growth], DiscountRate, *n*).

**[Discounted cumulative federal net offsets | All cohorts, with real growth | Base]** is then computed as [Discounted cumulative federal healthcare dollars saved | All cohorts… | Base] + [Discounted cumulative federal safety net dollars saved | All cohorts | Base] + [Discounted cumulative federal tax revenues gained via GDP | All cohorts… | Base]. For longevity we use [Discounted cumulative federal healthcare dollars saved | All cohorts… | Longevity] + [Discounted cumulative federal safety net dollars saved | All cohorts | Longevity] + [Discounted cumulative federal tax revenues gained via GDP | All cohorts… | Longevity] + [Longevity Social Security payouts | Discounted, cumulative] + [Longevity exchange subsidy payments | Discounted, cumulative]. **[ " | " | Total]** is the sum of these columns.

Finally, the **[Federal View | . | . ]** columns populate the charts and tables in the output worksheets. [Federal view | All Components | . ] = CohortSize * [Discounted cumulative federal net offsets | All cohorts… | . ] / DollarsUnits for base and longevity. Then [Federal view | All Components | Total ] = [Federal view | All Components | Base ] + [Federal view | All Components | Longevity] + [Societal view | All Components | $QALYs ]. Then for health care only, [Federal view | Health care only | . ] = CohortSize * [Discounted cumulative federal healthcare dollars saved | All cohorts… | . ] / DollarsUnits for base and longevity, with [Federal view | Health care only | Total ] being the sum of the two.

The final columns apply to the states, and are very similar to the federal columns. **[Total state share of health care spending]** is computed from the input worksheets for each age and is used as a multiplier for the subsequent **[State healthcare dollars saved | Single cohort | . ]** columns: [State healthcare dollars saved | Single cohort | . ] = [Total state share of health care spending] * [Healthcare dollars saved | Single cohort | . ] (this is just element-wise multiplication, not vector multiplication). Then [State healthcare dollars saved | All cohorts… | . ]$_n$ = $F$([State healthcare dollars saved | Single cohort | . ], HealthCareCostsGrowth, $n$).

The **[Discounted cumulative state healthcare dollars saved | All cohorts, with real growth | . ]** columns are computed as [" | " | . ]$_n$ = $G$([State healthcare dollars saved | All cohorts… | . ], DiscountRate, $n$).

The **[Discounted cumulative state safety net dollars saved | All cohorts, with real growth | . ]** columns are computed as ["|" | . ]$_n$ = $G$([Earnings Gained | All cohorts… | . ] * StateShareExtra, DiscountRate, $n$), where StateShareExtra is the percent of increased earnings by which state safety net expenditures are reduced and is set in BasicInput.

The **[Discounted cumulative state tax revenues gained via GDP | All cohorts, with real growth | . ]** columns are computed as [ " | " | . ]$_n$ = G( [GDP Gained | All cohorts… | . ]$_n$ *StateTaxShare, DiscountRate, $n$), where StateTaxShare is the percentage of GDP increase collected in state taxes and is set in BasicInput.

**[Discounted cumulative state net offsets | All cohorts, with real growth | . ]** is then computed as [Discounted cumulative state healthcare dollars saved | All cohorts… | . ] + [Discounted cumulative state safety net dollars saved | All cohorts | . ] + [Discounted cumulative state tax revenues gained via GDP | All cohorts… | . ] for base and longevity. **[ " | " | Total]** is the sum of these columns.

The **[State View | . | . ]** columns populate the charts and tables in the output worksheets. [State view | All Components | . ] = CohortSize * [Discounted cumulative state net offsets | All cohorts… | . ] / DollarsUnits for base and longevity. Then [State view | All Components | Total ] = [State view | All Components | Base ] + [State view | All Components | Longevity] + [Societal view | All Components | $QALYs ]. Then for health care only, [State view | Health care only | . ] = CohortSize * [Discounted cumulative state healthcare dollars saved | All cohorts… | . ] / DollarsUnits for base and longevity, with [State view | Health care only | Total ] being the sum of the two.

Finally, two columns that at the present time do not generate output are included in the model. The **[Societal minus federal and state | . ]** columns are computed as [Societal view | . | Total] – [Federal view | . | Total] – [State view | . | Total] for both "All components" and "Health care only."

# 5.0 Applications of Prototype Valuation Tool

We have applied the valuation tool to two types of prevention interventions related to smoking and obesity to test the tool and demonstrate its utility.

In recent years, the number of smokers in the US within each cohort of 20-year-olds has been about 800,000. Suppose a smoking intervention were to reduce this number by 100,000, so that new cohorts would produce only 700,000 smokers. Similarly, approximately 17% (or 12.7 million) of children and adolescents aged 2-19 years were obese, or approximately 700,000 in each single-age cohort. Suppose we were able to reduce the number in each cohort by 100,000. For each of these applications, we first estimate the impact this would have on health, longevity, health care costs, and productivity. Then we apply the valuation tool to examine the societal value of this achievement, the value in terms of the federal budget, and the value in terms of overall state budgets.

## 5.1 Data Sources and Methods

Exhibit 10 summarizes the principal data sources used in these two applications. For inputs describing health care costs, earnings, and mortality, we begin with baseline data describing these values for the overall population in the absence of a new smoking or obesity intervention. These values are used as a baseline and are modified to represent a 100,000-person cohort consisting entirely of non-smokers or non-obese individuals – i.e., a cohort that has been successfully subject to the intervention of interest. We also modify the values to represent 100,000-person cohorts consisting entirely of smokers or obese persons. These modified values are used to describe the effects of smoking or obesity in each cohort in the absence of the intervention. Age-specific morbidity impacts are based on a relationship between health care costs and QALYs, as noted earlier. Finally, we rely on data produced by the Centers for Medicare and Medicaid Services (CMS) to allocate total health care costs to the payers represented in the model (which consist of the federal government and state governments in the current prototype model). Details of the associated computations are presented in the next section.

**Exhibit 10. Principal Data Sources for Illustrative Applications**

| Type of Data | Baseline Values | Modifications for… | |
|---|---|---|---|
| | | Smoking | Obesity |
| Health Care Costs | National Health Expenditure (NHE) Data from CMS: (1) Historical NHE, (2) Personal Health Care Spending by Age | CBO, *Raising the Excise Tax on Cigarettes: Effects on Health and the Federal Budget,* June 2012 | CBO, *How Does Obesity in Adults Affect Spending on Health Care?* September 2010 |
| Earnings | American Community Survey from US Census Bureau | | Dor et al., A Heavy Burden: The Individual Costs of Being Overweight and Obese in the United States, GW University, 2010 |
| Mortality | CDC, *United States Life Tables, 2009*, January 2014 | | Borrell and Samuel, Body Mass Index Categories and Mortality Risk in US Adults…, *AJPH*, 2014 |
| Morbidity | Altarum estimates relating QALYs to health spending based on Sullivan and Ghushchyan, Preference-Based EQ-5D Index Scores for Chronic Conditions in the United States, *Med Decis Making*. 2006 | | |
| Sources of Funds for Health Care | National Health Expenditure (NHE) Data from CMS: (1) Historical NHE, (2) NHE Projections, (3) Personal Health Care Spending by Age | | |

### 5.1.1 Baseline Values

Per-capita baseline health care costs by age for the US population were inferred from data produced by the CMS Office of the Actuary (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Age-and-Gender.html). We used per-capita personal health care expenditures by age group for 2010 (the latest year for which these age-specific data were available), and updated them to 2012 values using the overall growth in personal health care expenditures between 2010 and 2012 from the official CMS national health expenditure data for 2010 and 2012 (http://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html). We increased the results by 3%, concentrated in ages 19 to 64, to account for the impact of new enrollees under the ACA. The results thus represent future spending (including ACA impacts) expressed in 2012 dollars. These results were then interpolated among ages within each age group to provide baseline age-specific annual expenditures per capita.

Baseline per-capita earnings by age (also broken out by gender for some uses) were extracted from results of the Census Bureau's American Community Survey (http://www.census.gov/acs/www/) for 2011 (the latest year available) and were updated to 2012 values using a 1.8% growth rate. Mean earnings by age were used, but we excluded the top 1% of earners from the calculations to avoid an upward distortion from typical wage levels.

Baseline mortality data (the probability of dying at a given age) came from 2009 US life tables produced by the National Center for Health Statistics of the Centers for Disease Control and Prevention (http://www.cdc.gov/nchs/data/nvsr/nvsr62/nvsr62_07.pdf).

Morbidity data are used to characterize the difference in QALYs accumulated in the base group and the alternate group. For this purpose, we developed a relationship between health care spending and QALYs experienced by an individual in a year using results presented by Sullivan and Ghushchyan (2006). This paper tabulates QALY values by age group for US adults. These were combined with per-capita personal health expenditures by age group from CMS (as referenced above) to generate a ratio of overall decline in QALY values to growth in health spending across age groups. The resultant value of .0000054475 QALYs per health care dollar is entered on the BasicInput worksheet.

Finally, sources of funds for health care spending are estimated in two steps. First, we allocate expenditures across payers by age (with the results input in the AgeRelatedInput worksheet), then allocate each payer's costs across stakeholders (entered on the BasicInput worksheet). For the first step, we use data on the payer mix by age group from CMS for 2010 (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/Age-and-Gender.html). These data are not appropriate for long term forecasts, because they will be changing over time due to the effects of the ACA and other factors. We therefore combine these age-specific data from 2010 with CMS projections for a later year (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsProjected.html) to estimate future year payer shares by age. The CMS projections include payer shares by year, but are not age-specific. We use 2018 for the future year, since the impact of ACA expanded coverage will be complete in that year. The analysis proceeds in the following steps:

- Generate estimates of personal health spending by age in 2018 by applying CMS per-capita rates for 2010 to 2018 population projections.
- Distribute these across payers using CMS personal health spending by age and payment category in 2010.
- Compare these results to the CMS projections in 2018 by payer and adjust to be consistent with the CMS projections.

The result is a set of estimates of the fraction of expenditures for each age group that are paid by Medicare, Medicaid/CHIP, private health insurance, out-of-pocket, and "other" (where "other" is as defined in Section 4.2).

In this version of the model, only the estimates for the Medicare, Medicaid/CHIP and "other" categories are used. The second step involves allocating government spending for each of these three payers between federal and state governments. Medicare expenditures are paid entirely by the federal government. For the federal share of Medicaid/CHIP, we begin with historical CMS expenditure data by source of funds. We use 2007 historical data to estimate federal government contributions to Medicaid and

CHIP to avoid the impact of the great recession on the estimated shares. We then adjust these results to reflect the impact of Medicaid expansion under the ACA for adults under 65 (assumed to add 12 million recipients to the 50 million that would otherwise receive Medicaid in 2018, with 90% of the expansion paid by the federal government). Separate estimates are developed for children under 19, adults under 65 and adults 65 years of age or older. The remaining share of Medicaid/CHIP for each age group is paid for by state governments. Federal and state shares of "other" expenditures are inferred from CMS expenditure data by source of funds for 2012 (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.html).

In addition to these inputs, a number of baseline values are used to discount future costs and health benefits; convert earnings to their impact on GDP, tax revenues, and safety net expenditures; and to capture the effect of longevity on cost-of-living expenditures, ACA exchange subsidies, and Social Security expenditures. All of these parameter values are input via the BasicInput worksheet. A number of them are preliminary and will be refined as the model and its use mature.

- Discount Rate: We use the standard recommended discount rate of 3% (Gold et al. 1996), which is applied both to future dollar values and future QALYs.
- GDP/Earnings: Our assumption that a given increase in earnings will increase GDP by a factor of 1.92 of the increase is based on data from the Bureau of Economic Analysis (http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=3&isuri=1&903=51). Table 1.10, Gross Domestic Income by Type of Income shows the ratio of GDP to wages, salaries, and proprietors' income to be 1.92 in 2011. This ratio has been fairly stable since 2007, ranging from a low of 1.87 to a high of 1.93.
- Cost of Living per Year: Our estimated value of $20,000 is intended to represent the minimum expenditure level to sustain an individual for a year. This subjectively-determined value is approximately twice the poverty level for a single person. It can be viewed roughly as a societal version of Social Security. This parameter requires more research to develop a precise definition and better estimation of its value.
- Share of Extra Earnings as Safety Net Offset: We assume that both federal and state safety net expenditures decline by 5% of the value of extra earnings achieved through better health. Additional research is needed to improve the precision if this estimate.
- Tax Share of GDP: We assume that, over the long run, the US government will adjust its tax structure such that federal income taxes remain at 19% of GDP overall, regardless of the mix of income that leads to any GDP increase that is associated with an increase in earnings resulting from better health. This is slightly larger than the historical long-run rate of 18.5%, because the aging population will result in an increase in the portion of the population that is not generating taxable income while still requiring government services. State tax revenues as a whole have been close to

5% of GDP in recent years. See http://knowledgecenter.csg.org/kc/content/tax-revenue-recovering-fiscal-stress-continues.

- Exchange Subsidy Spending: The Congressional Budget Office estimates that, by 2018, $100 billion per year will be spent by the federal government on subsidies for insurance purchased via ACA exchanges (http://www.cbo.gov/sites/default/files/45231-ACA_Estimates.pdf). This would be roughly equivalent to $80 billion in 2012, assuming 4% annual inflation. In 2012, the population aged 18-64 years was roughly 180 million, resulting in exchange subsidies of $420 per person per year for this subpopulation. Until better data are available, we assess $400 per person per year in federal spending for exchange subsidies.

- Social Security Amount: From published data from the Social Security Administration, we estimate that annual per capita Social Security payments are approximately $12,000 per year.

- Social Security Multipliers: The fraction of the population by age that receives Social Security payments is based on published statistics from the Social Security Administration. We adopt the following fractions:
    - Age 62: 0.5
    - Age 63: 0.7
    - Age 64: 0.8
    - Age 65: 0.9
    - Age 66+: 1.0

### 5.1.2 Modifications to Baseline Values for Smoking

Data representing the impacts of smoking on health care costs, earnings, and mortality are taken primarily from a report by the Congressional Budget Office on the impact of an increased excise tax on cigarettes (CBO 2012). According to this report, smokers and former smokers have 11-16% higher health care costs than never smokers, depending on age. Furthermore, if the whole population alive today were never smokers, CBO estimates that health care costs would be approximately 7% less. So we reduce overall population expenditures for all ages in the baseline data by 7% to estimate spending by never smokers. We then inflate these numbers by 11-16%, depending on age, to represent spending by smokers.

The CBO report also estimates the percent by age group by which never or former smokers earn more than current smokers. We combine these estimates with smoking prevalence rates by age from the 2014 Surgeon General's report (http://www.surgeongeneral.gov/library/reports/50-years-of-progress/sgr50-chap-13.pdf) to get the overall average earnings by age for smokers and for non-smokers using the relationship $S = A/[(1\text{-}F)(1+P)+F]$, and $N = S(1\text{-}P)$, where $N$ = non-smoker's wage, $S$ = smoker's wage, $F$ = fraction of the age group that smokes, $A$ = average age-specific wage

(from the baseline data), and *P* = non-smoking wage premium by age group, which ranges between 4% and 7% (from the CBO report).

Finally, the CBO report provides mortality estimates (the probability of dying in the next year) by age group for never smokers and for current smokers. We use these values to adjust the population-wide baseline age-specific mortality rates to generate rates for smokers and for non-smokers.

### 5.1.3 Modifications to Baseline Values for Obesity

Our analysis of obesity prevention uses the common definition of an obese individual as one with a body mass index (BMI) greater than or equal to 30. To estimate the impact of obesity on health care costs, we use a study conducted by the Congressional Budget Office (CBO 2010). This study concludes that obese individuals incur health care costs that average 38% higher than those of normal weight, but that 25% of this difference is attributable to factors other than obesity, so that preventing obesity will reduce average expenditures for an obese individual by .75·38% = 28.5% of that of the average normal weight individual. Combining this result with CBO's tabulation of the population distribution and of health spending by weight category, we compute that a normal weight individual has an average health spending that is 88.4% of the average health spending across the entire population, and that the expenditure savings associated with preventing obesity is 28.5% of this. To capture this differential in the model, we use an average spending level for a would-be obese person of 1.285·88.4% = 114% of overall average spending. (This value is lower than the actual relative weight of an obese person, but allows the model to properly compute the appropriate expenditure savings associated with obesity prevention.) The values of 88.4% and 114% are multiplied by the baseline age-specific expenditure values to generate age-specific spending associated with normal weight and obese individual, respectively.

Adjustments to baseline earnings values are based on results summarized by Dor et al. (2010), who assume that lost wages amount to 6% of the annual salary for an obese woman of any age compared with a normal weight woman and that the annual wage loss for men is not statistically different from zero. To apply this earnings penalty to computation of average earnings for women for a given age, let *O* = obese wage, *N* = non-obese wage, *F* = fraction of women that is obese (computed from statistics tabulated by Borrell and Samuel 2014)), *A* = average wage for the entire cohort of women (from the baseline data), and *P* = obese earnings penalty (6%). Then $N = A/[F(1-P)+(1-F)]$, and $O = N(1-P)$. We then weight the results across the age-specific population of men and women (from the Census Bureau) to get an average wage for all obese and all non-obese individuals by age.

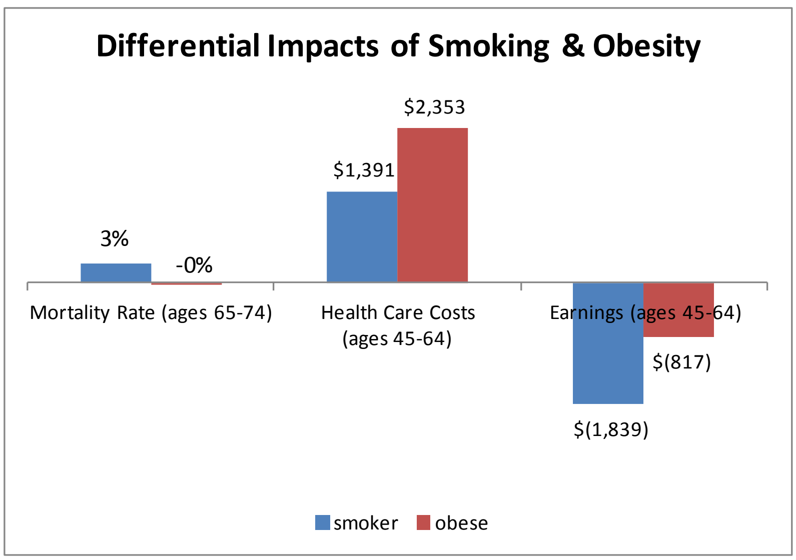
Mortality impacts are based on results presented by Borrell and Samuel (2014). For various age groups, this source estimates the ratio of death rates for various BMI categories to that of normal weight. These estimates combine smoking and exercise behaviors as a single variable, so we must control for both or neither. We control for both, which means we assume a reduction in obesity without altering smoking or exercise. Combining these death rate ratios with the paper's tabulation of population

shares of the BMI categories over age groups, we compute the ratios of death rates for obese individuals and for normal weight individuals to the overall death rate for each age group. We then multiply the baseline overall age-specific death rates by these ratios to get age-specific death rates for normal weight and for obese individuals.

## 5.2 Results

Results of the application of the valuation tool to smoking and obesity prevention are presented in this section. Most of the graphical presentations are extracted directly from the tool. Comparable graphs for the smoking and obesity applications are presented side-by-side to highlight similarities and differences between the two types of interventions. Exhibit 11 highlights the major differences: Smoking has a significant impact on mortality (illustrated here as the difference in mortality rates for 65 to 74-year-old smokers versus non-smokers), whereas obesity, while increasing morbidity, has comparatively little impact on mortality. Obese individuals, however, incur a greater increase in health care costs compared with non-obese individuals than do smokers compared with non-smokers (shown here for 45 to 64-year-olds). Finally, the earnings impact of smoking is greater than that of obesity (illustrated here for individuals between 45 and 54 years of age). These differences drive many of the differences in results that are described below.

**Exhibit 11. Differential Impact of Smoking and Obesity**

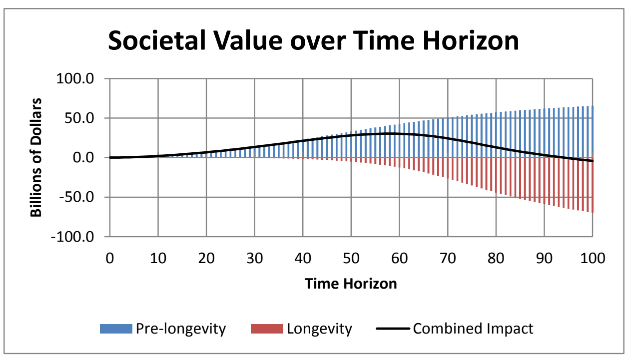



We begin with a comparison of the impact of prevention on health care costs. Exhibit 12 shows the change in overall cumulative health care costs (i.e., from a societal perspective, discounted at 3% per year) associated with preventing 100,000 20-year-olds per year from becoming smokers, or from becoming obese, for up to a 100 year time horizon. The blue areas in the graphs represent the cost impact during the pre-longevity period (the period in which a smoker or obese individual is still alive), while the red areas represent cost impacts during the longevity period (i.e., as a result of a smoker or obese individual dying sooner than one for whom smoking or obesity has been prevented). The black line

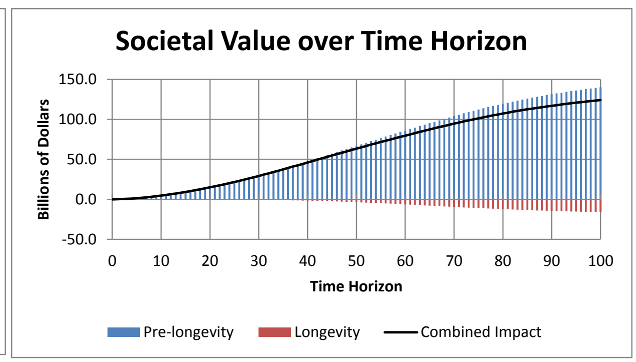
summarizes the overall impact of these two components of cost savings. The blue portion of each graph shows significant overall savings in health care costs during the pre-longevity period; the red portion shows additional costs associated with health care received by non-smokers or non-obese individuals during the longevity period. These additional costs are much greater for the smoking intervention than for the obesity one because of the greater impact of smoking on mortality. Pre-longevity savings for the obesity intervention are roughly double those for the smoking one because of the higher health care costs associated with obesity compared with those of smokers. While the net cost savings grow significantly over time for both interventions (peaking at 58 years for the smoking intervention), savings are also quite large in the early years after the intervention begins. For example, the obesity intervention results in savings of $1.2 billion after ten years. (The tool allows changing the scale of the abscissa to a smaller maximum number of years to show these nearer term impacts more clearly.)

**Exhibit 12. Health Care Costs – Societal Perspective**

**Smoking**



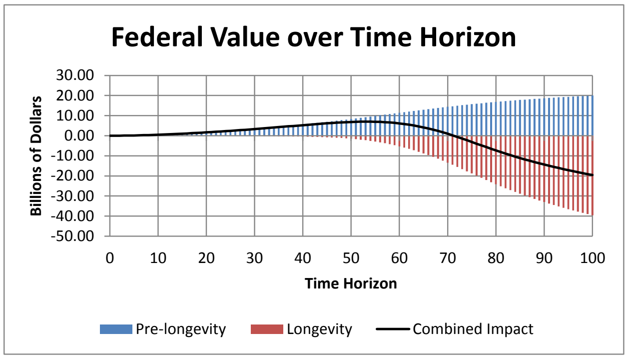

**Obesity**




Exhibits 13 and 14 display the portions of these health care cost savings that are realized by the federal government and state governments, respectively. This includes Medicare, Medicaid, exchange subsidies (which cause a small increase in federal government costs during the longevity period), and "other" savings. (The components of other savings are defined in Section 4.3.) For each of these stakeholders, the savings associated with obesity prevention are again large, while those for the smoking intervention are smaller and, for the federal government, become negative in the long term because of the larger longevity impact on Medicare spending and lower health care costs associated with smoking than with obesity.

**Exhibit 13. Health Care Costs – Federal Government Perspective**

**Smoking**




**Obesity**

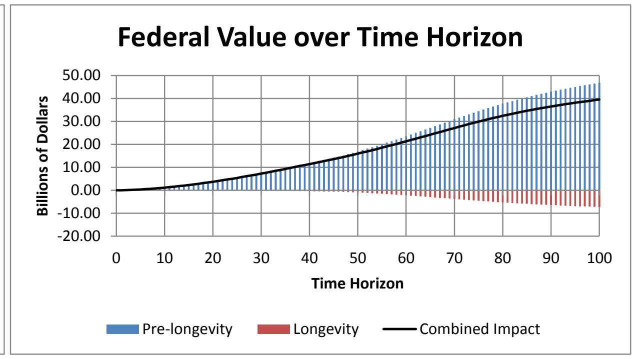
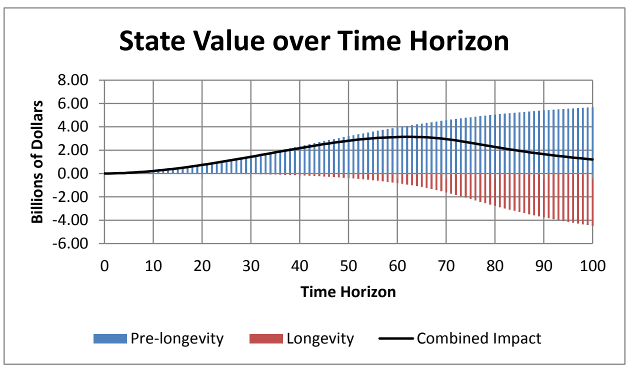



**Exhibit 14. Health Care Costs – State Government Perspective**

**Smoking**




**Obesity**

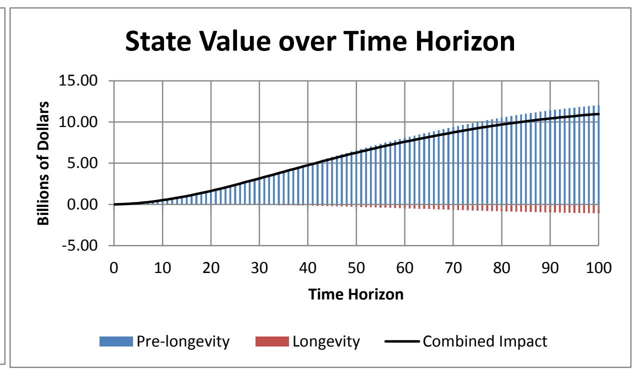
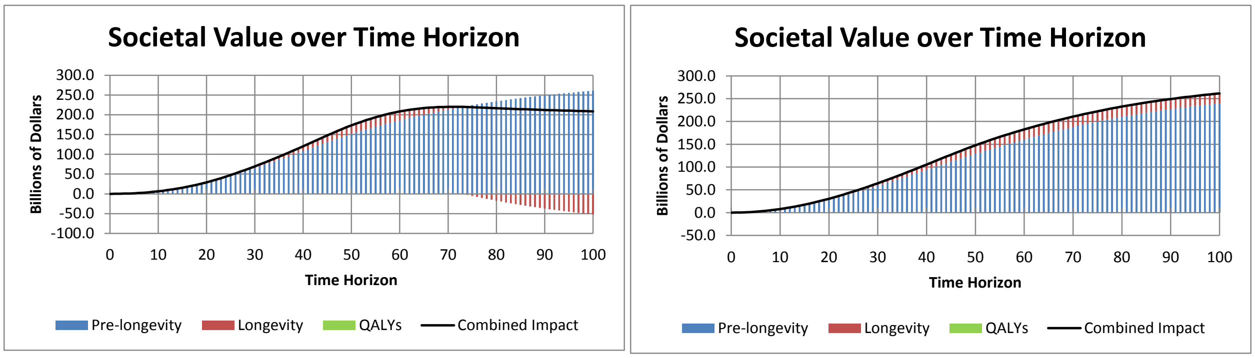



Exhibit 15 presents the overall economic value for each intervention from a societal perspective. From this perspective, obesity prevention shows greater value than smoking prevention over longer time horizons. In addition to the reduction in health care costs shown earlier, this value includes the increase in GDP associated with increased earnings for the base group (the individuals to whom the intervention has been applied) compared with the alternate group (smokers or obese individuals). It is also increased by the reduction in safety net spending associated with these increased earnings, and is reduced by the additional safety net spending during the longevity period. It is further reduced by the additional cost of living per year incurred by the base group during the longevity period. Note that a portion of the longevity impact for each intervention is an increase in value associated with greater earnings for the base group resulting from higher mortality rates in the alternate group during working years.

**Exhibit 15. Overall Economic Value – Societal Perspective**

Smoking | Obesity




Exhibits 16 and 17 present the overall economic value from the perspective of the federal and state governments (with lower earnings for obese individuals). In addition to the impact on government health care spending shown earlier, this includes increased tax revenues and reduced safety net spending associated with the additional earnings within the base group, which is partially offset during the longevity period by increased safety net spending and, for the federal government, by increased Social Security expenditures (especially for the smoking intervention). The absence of the Medicare and Social Security impacts on state government spending – both of which have large negative effects during the longevity period on the federal government value for the smoking intervention (causing a decline in overall value from the federal perspective after year 59) – causes the state government value of the two interventions to be very similar to each other. Note that these charts (and the corresponding tables in the tool) can also be used to estimate the payback period for an investment that produces the results shown here. For example, a $1.8 billion investment by the federal government in a smoking prevention campaign that produces these results would be paid back in 11 years.

**Exhibit 16. Overall Economic Value – Federal Government Perspective**

Smoking | Obesity

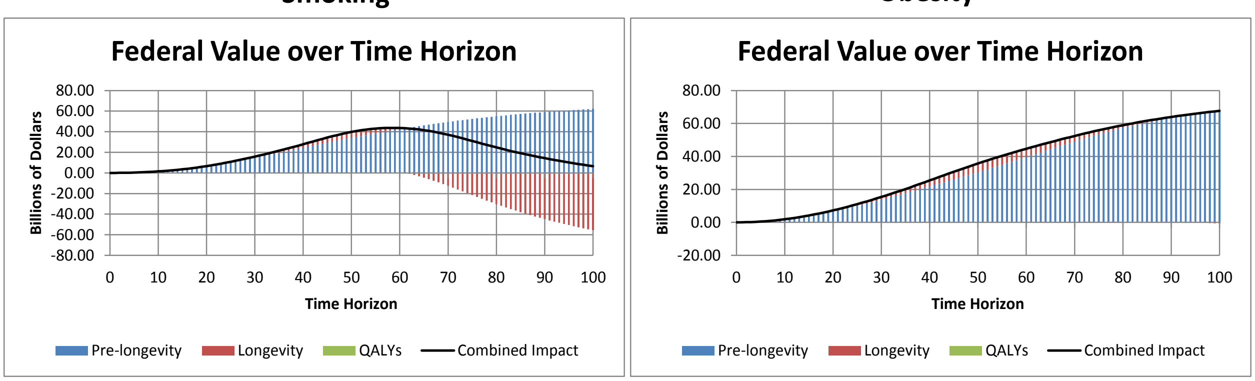
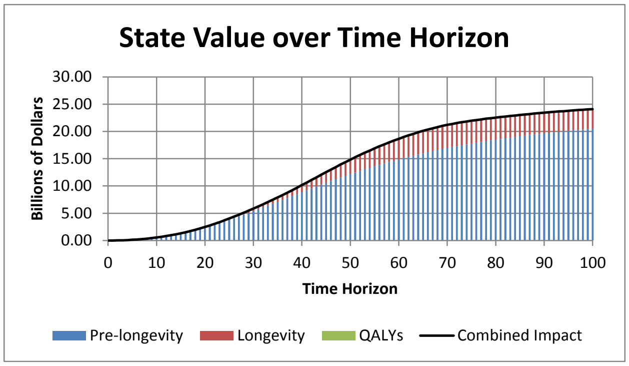
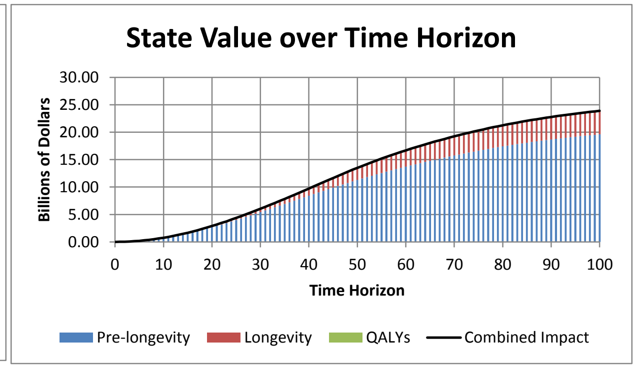


**Exhibit 17. Overall Economic Value – State Government Perspective**

**Smoking**



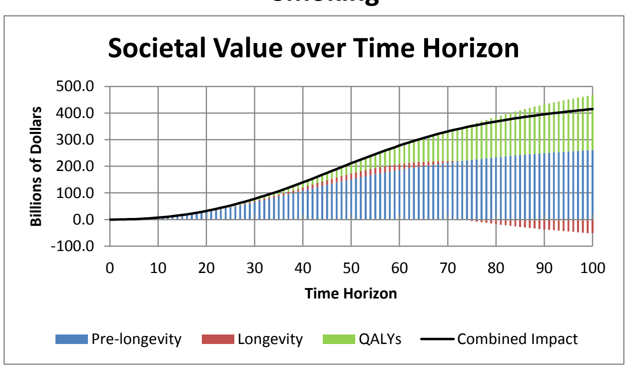

**Obesity**



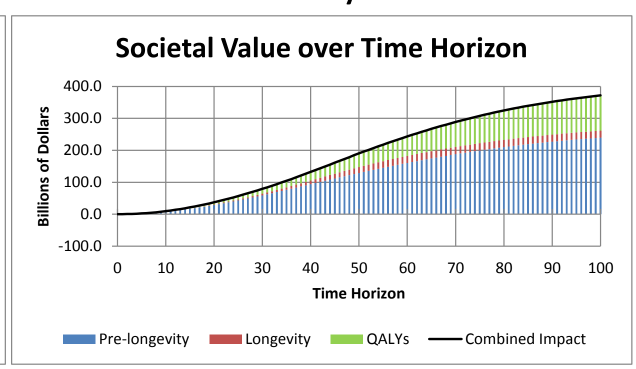

Results presented thus far include no monetary value for the decreased morbidity and mortality that result from an intervention. Such a value is sometimes used to reflect the argument that better health and longer life have value in themselves (in addition to their effects on expenditures and earnings) that can be expressed monetarily. Exhibit 18 presents the overall value of each intervention from a societal perspective if we add a conservative value of $50,000 per QALY saved to the other economic impacts shown earlier. The effect (shown in green) is a large increase in the value of each intervention in the later years, when the effects of smoking and obesity begin to have their largest impact on the health and mortality of the early cohorts as they age. This effect is greater for smoking because of its greater impact on mortality.

**Exhibit 18. Overall Economic Value with QALYs Valued at $50K – Societal Perspective**

**Smoking**




**Obesity**

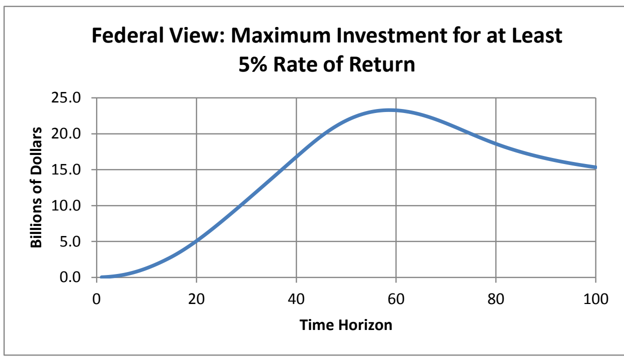



Estimating the ROI and cost-effectiveness of an intervention requires knowing the cost of the intervention, which is not included in the valuation tool. Instead, we provide threshold values corresponding to the largest investment that that will yield at least a desired ROI or cost effectiveness, given that the investment produces the economic and health effects estimated by the tool. Exhibits 19 and 20 are plots of 5% ROI threshold values for the smoking and obesity interventions as a function of the time horizon of interest. So, for example (from the first graph in Exhibit 19), an investment of $5 billion by the federal government that annually prevents 100,000 20-year olds from taking up

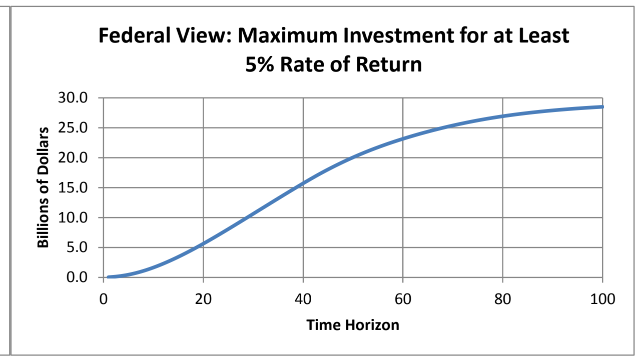
smoking will generate a 5% ROI in a 20-year horizon. A higher investment will produce a lower return in 20 years; a lower investment will result in an ROI greater than 5%. At the state level (from the first graph in Exhibit 20), the investment must be as low as $2 billion to provide a similar return to the states. Note that, except for the smoking intervention at the federal level, a longer time horizon will allow for a higher investment while still providing the desired return. The declining federal economic value of the smoking investment after year 59 (see Exhibit 16) causes that ROI threshold to tighten in the out years.

### Exhibit 19. Investment Threshold for 5% ROI – Federal Government Perspective

**Smoking**

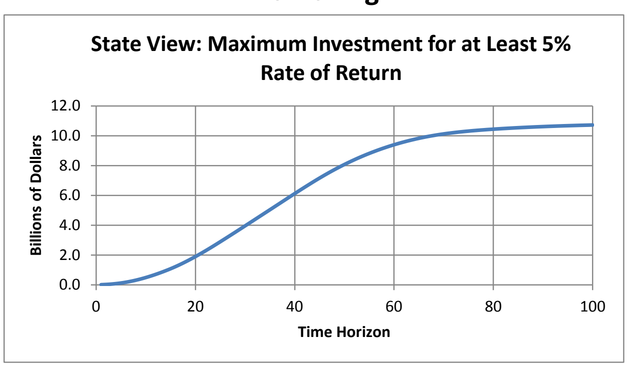



**Obesity**




### Exhibit 20. Investment Threshold for 5% ROI – State Government Perspective

**Smoking**




**Obesity**

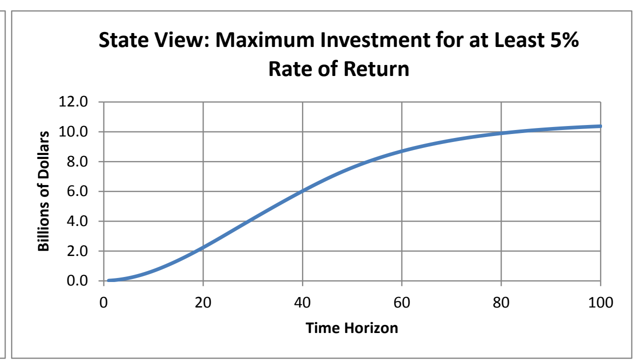
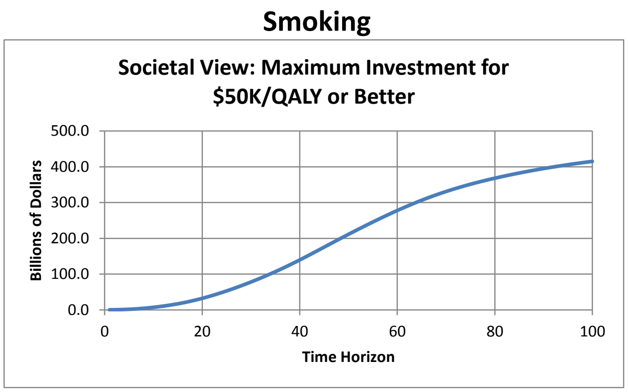
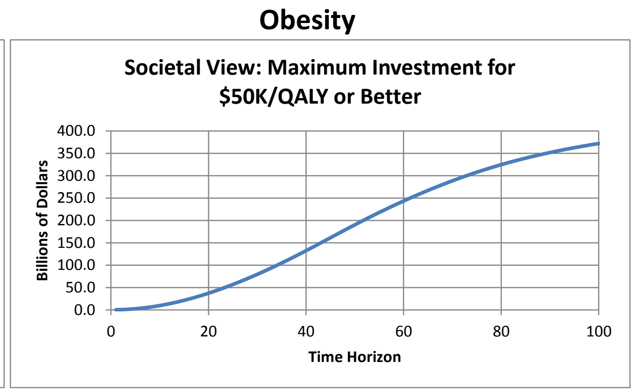



Exhibit 21 provides similar threshold plots at the societal level for a cost effectiveness value of at least $50,000 per QALY. For example, using this criterion, the maximum societal investment in the obesity intervention that achieves this cost per QALY result after 20 years is $37.2 billion. Any investment less than this amount that produces these results will generate a smaller (more favorable) cost effectiveness value.

**Exhibit 21. Investment Threshold for Cost Effectiveness of $50K per QALY – Societal Perspective**




In addition to these graphical results, the tool also estimates the impact of the intervention on health adjusted life expectancy (HALE), i.e., the impact of the intervention on lifetime QALYs. For the smoking intervention, the resultant value is 7.87 QALYs gained per would-be smoker who does not take up smoking. For the obesity intervention, HALE is increased by 2.64 QALYs – smaller than for the smoking intervention because of the smaller impact of obesity on mortality.

It is interesting to observe how changes in the cost and effectiveness of treatment affect the value of prevention. Obesity is a case in point – improved capabilities to treat conditions related to obesity has caused the value of preventing obesity to change over the past quarter century. New drugs to treat hypertension and hyperlipidemia, new surgical procedures such as bariatric surgery, and other clinical advances have caused spending on obesity-related conditions to grow dramatically over the past quarter century:

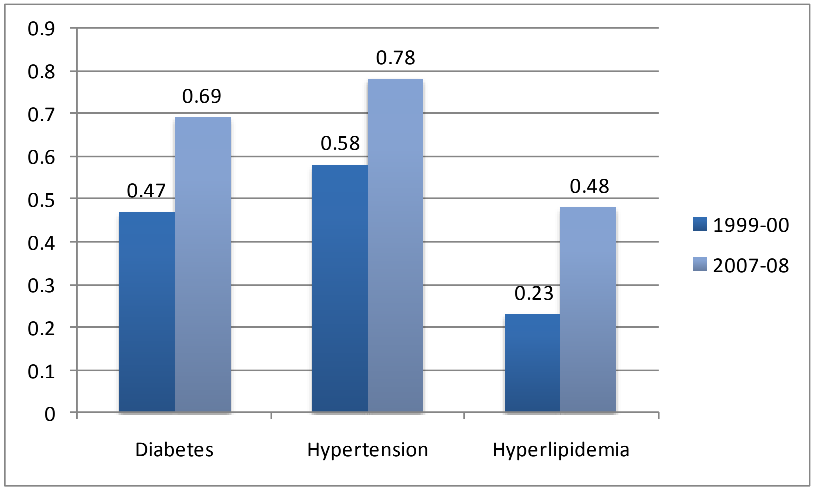
"Spending per capita for obese adults exceeded spending for adults of normal weight by about 8 percent in 1987 and by about 38 percent in 2007." (CBO 2010)

These clinical advances have also caused mortality attributable to obesity to decline significantly:

"Calculations show that approximately one-quarter of all deaths to middle-aged adults in 2003–2004 are attributable to obesity when the risks from NHANES I (1971–1987) are used. In contrast, if risks from the more recent NHANES III period (1988–2006) are used, only about one-tenth of all deaths are attributable to obesity in 2003–2004. Furthermore, mortality attributable to obesity drops to 5 percent if we use risks from the most recent period." (Mehta and Change 2011)

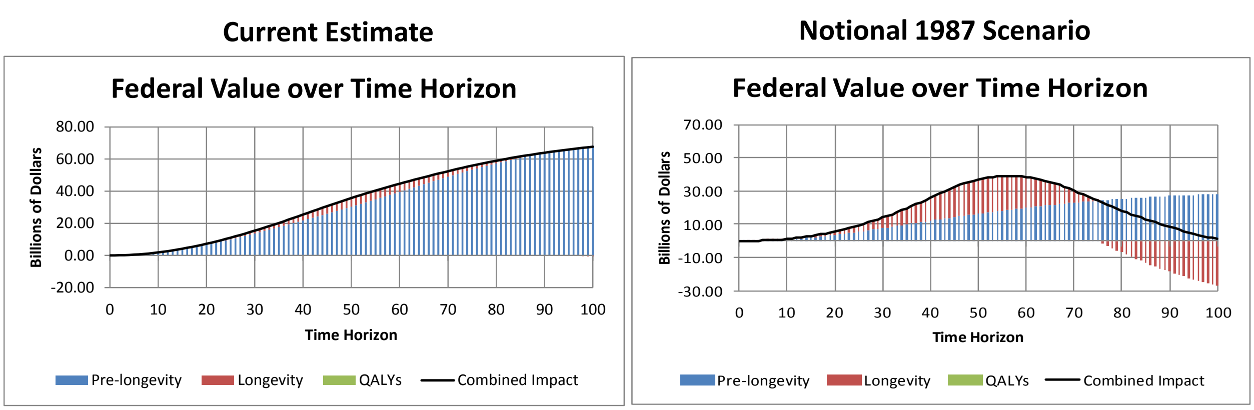
Furthermore, individuals with medical conditions associated with obesity are increasingly likely to receive treatment, as illustrated in Exhibit 22.

**Exhibit 22. Proportion of Those with an Obesity-Related Condition Who Receive Treatment**




To investigate the impact of these changes, we developed a scenario that approximated the mortality rate and health care spending associated with obesity in 1987 and compared the value of preventing obesity from a federal government perspective in 1987 with its value today (as previously shown in Exhibit 16). Results are shown in Exhibit 23. Because health care spending per obese person has increased significantly since 1987 and mortality from obesity has declined, the long-run financial returns to obesity prevention are much higher today, particularly for the federal government.

**Exhibit 23. The Changing Value of Obesity Prevention**




It is conceivable that smoking could be following the obesity example:

> "Screening older adults for lung cancer – the USA's leading cancer killer – has the potential to save thousands of lives, but at a cost of billions of dollars to the Medicare program, a new study shows."
> (http://www.usatoday.com/story/news/nation/2014/05/14/lung-cancer-screening-cost/9083125/)

If new, high cost treatments for smoking-related conditions result in lower mortality rates, these together could increase the financial value of smoking prevention. More

generally, by ignoring emerging advances in the treatment of many chronic conditions, we may be underestimating the value of preventing them.

## 5.3 Observations

The following are principal observations from these results:

- There is a large overall long-term positive monetary value for each of the interventions and for each of the three stakeholder groups.
- There is a significant monetary value even in the relatively short term.
- Valuing QALYs has a major positive impact on monetary value.
- Whether the intervention should be pursued also depends on its cost and on the stakeholder's threshold for ROI, cost-effectiveness, or payback period.
- The health benefit is greater for the smoking intervention.
- The economic impact of longevity is high for smoking, low for obesity, and most important from the federal government perspective.
- The impact on health care costs is generally positive (cost saving), except for smoking from the federal perspective in the out years.
- New, high cost treatments for obesity-related conditions have lowered related mortality. Together, these changes have greatly increased the value of preventing obesity. Ignoring the impacts of similar emerging treatments for smoking-related conditions and other chronic diseases might lead to undervaluing their prevention.

# 6.0 Future Work

Continued work on the valuation tool will be focused on three areas: enhancements to the tool itself, further applications of the tool, and development of standardized methods and data sets that can be used to quickly apply the model to new areas, levels of detail, and enhanced precision. These three research thrusts are described below.

## 6.1 Future Enhancements to the Valuation Tool

The valuation tool currently presents information on the impact of an intervention from the societal, federal government, and state government perspectives. A significant planned enhancement to the tool will be the addition of presentations of interest to other stakeholder groups. The list of important stakeholders will vary based on the specific intervention, but there are a number of additional stakeholder categories that will be important for many types of initiatives and will be useful to incorporate into the tool.

Stakeholders are individuals or groups who will be affected, either positively or negatively, by the initiative being considered. We are focused primarily on the information needs of stakeholders who may be investors or decision makers in prevention initiatives; however, we also recognize that decision makers may be influenced by

impacts on other stakeholders. For example, legislators may be influenced by the impact of an initiative on important political constituencies. It may also be important to understand possible sources of push back from stakeholders who could be negatively affected by the initiative.

Major stakeholder groups include federal, state, and local governments, particular agencies within governments (including public health departments), employers or the business community, philanthropic funders, public or private health care insurers, health care providers, faith-based organizations, and community coalitions that may include representation from some or all of these groups. In addition, initiative-specific stakeholders outside the health sector, such as entities involved in education, transportation, housing, recreation, or economic development, may be important stakeholders for some initiatives that address the social determinants of health. While potentially more difficult to quantify, demonstrating the impact on non-health sectors may be especially important in generating broad support for an initiative and for establishing the full economic benefits.

Different stakeholders may have different interests in terms of timeframe or discount rates. Rather than prescribing these dimensions for each type of stakeholder, we have chosen to parameterize these assumptions, or, in the case of timeframe, to compute the results across a 200-year time period, and allow users to view the output for any shorter time horizon they specify.

Having already represented the societal impact and the federal and state government impacts, the first additional stakeholder group we would likely address is the employer, or business, community. We describe here our initial thinking about measures of interest to this group and related issues.

There are several aspects of a healthier population that may be important to businesses. Perhaps the most straightforward is the need for a healthy, productive workforce. Most employers also care specifically about the health care costs of their employees, which can impact the costs of benefits such as health insurance, worker's compensation, and life or disability insurance. Employers also care about worker productivity, which can have several dimensions, including output per unit of time worked, absenteeism, and the quality of work performed.

In terms of the metrics currently computed within the valuation tool, the impact of the intervention on health care costs would be included in the presentation targeted to the employer community. The impact on productivity as measured by earnings would also be of interest. It may be appropriate to expand the measures of productivity for this stakeholder group to include costs associated with absenteeism or worker turnover and recruiting.

Workers in a competitive labor market should eventually be paid commensurate with their productivity. The degree to which savings in health care costs or gains due to increased productivity accrue to the employer versus the employees will depend on the competitiveness of the labor market, the degree to which other businesses in that industry adopt the same practices, and the timeframe. Even though the economic benefits may

accrue to the employees in the long run as compensation adjusts, in the short run, the employer may gain a competitive advantage or may improve their bottom line. One way to implement this variability in environment and timeframe in the tool would be to parameterize the proportion of each type of savings accruing to the employer, allowing the parameter to vary over time. For example, the user of the tool could assume that in the first year, all the savings in health care costs (except perhaps out-of-pocket costs borne by employees) and gains from productivity accrue to the employer, but the proportion drops from year to year until all gains are being passed along to employees. Employers may also want to see both the full economic benefits and their likely portion of the benefits. Note that if the investment required for the prevention initiative is mostly made up front, the savings to the employer in the short run may be enough to offset the investment costs and provide a positive return.

Employers may care about how they are perceived by their employees, prospective employees, and communities. Employee and prospective employee perceptions can impact turnover rates and the ability to attract high quality applicants. Within the community, employers have long invested in creating "good will," understanding that sales volume and market share may be affected by public perception of the business and the degree to which it invests in its employees or its community. In the long run, in addition to creating good will, a business investment in the health of a community may create a healthier, more productive, and therefore more affluent population that will have greater buying power to purchase goods or services. Retention rates and numbers of qualified applicants are metrics that can be monitored for a particular employer and could potentially be associated with monetary measures such as recruiting and training costs. Further exploration is needed to see if there is a sufficient evidence base to include such measures or costs as outputs of the tool.

Provider groups may be another stakeholder group addressed in future versions of the valuation tool. Providers will likely be interested in health care spending, including possible revenue losses. They may also be interested in the health of their attributed populations. Much will depend on the payment policies under which the providers are operating. Nonprofit hospitals or health care systems may care about a measure of their community benefit investment.

Health care payers will be interested in changes in total health care costs and in their portion of health care costs. Metrics such as the cost per member per month may communicate better than an annual cost. Measures of success that may be important to a health plan, such as market share and profitability, may be difficult to incorporate into the tool in a generic manner, but are worth further thought.

One of the more complex but important "stakeholders" to consider for future versions of the valuation tool is the community coalition, or similar multi-sector group investing in a prevention initiative. Adapting the methodology to produce results for individual members of such a coalition as well as for the community as a whole will be challenging. Will the impacts on separate coalition members be additive or will there be overlaps that are difficult to separate? Is the community-wide view of health, health care costs, productivity, and other economic measures that are currently included in the tool's

societal perspective sufficient? We will need to explore more about the decision making and governance processes to design presentations of results that will best serve these types of initiatives.

All stakeholders are likely to be interested in costs and benefits that may be difficult to monetize, or even to quantify. For example, in addition to levels of costs and of health, the distributional effects of an intervention may be of interest. Decision makers may take into consideration ideological concerns such as the role of government, or consistency with defined goals or missions, particularly for philanthropic or faith-based organizations. For place-based initiatives, building relationships and cohesion within a community is often considered a benefit of organizing around initiatives targeting upstream determinants of health and wellbeing. While these outcomes may be difficult to incorporate into the valuation tool, qualitative costs and benefits that are important for a particular intervention or stakeholder group should be identified and described along with the tool's metrics in evaluating a prevention initiative.

## 6.2 Future Applications of the Valuation Tool – Assessing the Value of Early Childhood Interventions

### 6.2.1 Background

We have begun work on a third application of the tool that assesses the value of programs aimed at early childhood. The early childhood period is generally considered the prenatal period through kindergarten entry; however, the time period over which the intervention takes place can and does vary. Though such programs differ in approach, they fall into one of three broad categories:

- Home visiting/parent education
- Early childhood education
- Home visiting/parent education combined with early childhood education

These programs vary in their methods; desired outcomes; eligibility criteria; whether they target the child, parents, or both; and the age of the target children (Karoly et al. 2005).

Home visiting programs employ trained professionals who regularly visit at-risk expectant and new parents to provide guidance, risk assessment, and referrals to other community services. Examples of major home visiting programs with national scope include the Nurse Family Partnership (NFP), Early Head Start – Home Visiting, and the Maternal, Infant, and Early Childhood Home Visiting (MIECHV) Program, which is funded through the Affordable Care Act. While not involving home visits, the ParentCorps program pursues similar objectives with a series of group sessions for parents and children held at school during early evening hours, and professional development for early childhood educators. A number of these programs have been extensively studied, and many have been shown to be effective on various dimensions (http://homvee.acf.hhs.gov/).

The Task Force on Community Preventive Services defines early childhood development programs as publicly funded comprehensive preschool programs designed to increase social competence in children, aged 3 to 5 years, at risk because of family poverty. Examples of such programs that have been studied extensively include Head Start, the Carolina Abecedarian Project, the HighScope Perry Preschool Study, and the Chicago Child-Parent Center Project.

Numerous quantitative measures have been used to capture the varied objectives of early childhood interventions. For example, Mathematica (2011) conducted a meta-analysis of home visiting programs across multiple measurable dimensions within eight domains: child health, child development and school readiness, family economic self-sufficiency, linkages and referrals, maternal health, positive parenting practices, reductions in child maltreatment, and reductions in juvenile delinquency, family violence, and crime. Nine of the evaluated programs were associated with studies having favorable, statistically significant impacts in multiple domains. The Task Force on Community Preventive Services conducted a systematic review of early childhood education programs using specific measures within four different categories of outcomes: cognitive, social, health, and family (Anderson et al. 2003). The review concluded that such programs are effective in preventing developmental delay, but found insufficient evidence for benefits within the other three outcome categories, suggesting the need for further research.

A number of programs have been shown to produce savings that exceed program costs (http://www.rand.org/pubs/research_briefs/RB9352/index1.html). For example, the Washington State Institute for Public Policy estimated per-capita costs for NFP of $9.842 and discounted long-term cost savings of $27,174, resulting in a net gain of $17,332 per family (http://www.wsipp.wa.gov/BenefitCost/Program/35). Heckman et al. (2010) analyzed the cost benefit and rate of return for the Perry Preschool Program. The authors estimated that the initial cost of the program was $17,759 per child (undiscounted year 2006 dollars). This included both operating costs (teacher salaries and administrative costs) and capital costs (classrooms and facilities). The authors estimated that the overall social rate of return to the Perry program was in the range of 7 to 10 percent. Governmental cost savings of such programs have been associated with outcomes that lead to lower medical and public health care costs, lower costs to the child welfare system, and lower costs for education.

Given the demonstrated cost savings, early childhood programs would appear to be potentially attractive to investors. However, many (though not all) of the identified savings and other benefits accrue with significant time delays after the time of the intervention. For example, Olds et al. (2014) concluded that NFP home visit programs were associated with reduced mortality of both women and children during the 20 years following registration in a trial. Assessment of the value of such programs with the valuation tool might contribute to an improved understanding of both the financial and health impacts of such investments from the perspectives of multiple stakeholders. We discuss our approach to this assessment below.

### 6.2.2 Approach

Our investigation of early childhood is meant to include a broad set of interventions that impact the life course prospects of children by the time they reach age 5. As suggested above, there are a large number of such interventions, and one of our objectives is to identify the most important ones and how they are being evaluated. From a modeling perspective, we will continue to recognize the important dividing line between how to accomplish an objective, e.g., how to accomplish improved life course prospects at age 5, and what that would be worth in the eyes of key stakeholders. Our model will demonstrate the value of accomplishing specific improvements in the life course prospects of a cohort of children. This information is not sufficient to show the value of any particular intervention, since that would require knowledge of the cost of the intervention and its impact on the life course. However, this information is essential to determining the value of a specific intervention or combination of interventions, since one must know the value of what these interventions accomplish. With this approach, the model will support assessment of the value of the many early childhood interventions currently being adopted and evaluated, as well as new combinations that will no doubt evolve.

Our initial step will be to create a series of alternative life courses that can be used to represent the impact of early childhood interventions. To assist with the creation of these life courses, we are using level of education as a proxy measure. Thus, we are initially developing 5 life course descriptions based upon the highest level of education achieved:

- Less than high school
- High school only
- Two years of post-high school education
- 4 year college degree
- Greater than 4 year college degree

These life courses will be described in terms of the key variables used in our model. Thus, for each life course, we will specify the age-specific estimates of:

- Mortality rates
- Health care costs
- Productivity/earnings
- Health (QALYs credited)
- Other stakeholder variables such as:
  - Taxes paid to federal and state and local governments
  - Reliance on transfer payments from federal, state and local governments
  - The share of health care costs borne by federal, state and local governments

One can think of these five life courses as ranging from lowest (less than high school education) to highest (greater than 4 year college degree). We can then help place a value on early childhood interventions by specifying their impact on expected life courses. For example, an intervention could be expected to move a certain proportion of children from one path to the next (or halfway to the next).

We have begun compiling the data needed to estimate these life courses. We are also in the early stages of developing ideas for how to estimate the impact of particular interventions on expected life courses. One approach links interventions to commonly used outcome measures that can, themselves, be connected to expected life courses. For example, the ParentCorps intervention cites improvements in Kindergarten achievement scores. Our goal would be to determine how these scores can be predictive of movements up our life course hierarchy.

## 6.3 Development of Comprehensive Data Set

### 6.3.1 Background

As described earlier, the valuation tool has been developed to provide estimates of the value of prevention (via the determinants of health) through the eyes of various stakeholders. The tool is based on a life course approach in which a prevention intervention alters the year-by-year life path of a given age-specific cohort from their current age through the rest of the lifespan. This path is defined, as cohort ages over time, by age-specific mortality rates, health care spending, earnings, morbidity (QALY credit), and other stakeholder costs and benefits. The tool computes the value of prevention by comparing the expected life courses with, and without, the prevention intervention.

For example, our smoking application hypothesizes a prevention intervention that causes a certain proportion of 20 year olds to remain non-smokers for life who would otherwise have been lifetime smokers. In order to apply the tool to this specific intervention, life courses were estimated for lifetime smokers and lifetime nonsmokers in terms of mortality, health care spending, earnings, QALY credit, and other selected costs and benefits. Similarly, the tool has been applied to obesity prevention with life course estimates developed for an obese life path and a normal weight life path.

Life path estimates for these two applications were derived from published research. This is a difficult process, because existing research may fail to cover all of the elements needed by the tool and, even if the focus is precisely what is needed by the tool, the results are typically not published in the desired detail. Another problem is timeliness, as some research is quickly outdated.

To solve this problem, and to open up the valuation tool to a much broader array of applications, we propose to develop an analytic data set, regularly updated from multiple sources, that is set up to quickly and efficiently produce the needed life course descriptions. This data set, referred to as VPAD (Value of Prevention Analysis Data), will eliminate the total reliance on previous research, and accelerate new research into the direct determinants of health.

### 6.3.2 Approach

Our approach is based, in large part, upon our existing knowledge of research in this area and the data sets that are commonly used. This is important because, in some instances, our first step may be to replicate existing research in order to place our subsequent research in the proper historical setting. The various available data sets tend to be strong in a particular area and weak in others. For example, the American Community Survey (ACS) is a very large data set (roughly 3 million respondents each year) that is particularly strong in data on earnings and on reliance on public assistance. It gathers some health status information in the form of the six standard disability questions, and also includes sources of health insurance. However, it contains no data on health care costs or mortality. The best survey in terms of health spending is the Medical Expenditure Panel Survey (MEPS). It also includes questions that have been used to compute QALYs, and has income and health insurance information. It is a relatively small data set (about 30,000 respondents per year) and is not yet available with linked mortality data. The National Health Interview Survey (NHIS) has been linked to mortality data and is currently the best source for examining the impact of prevention on mortality. It collects data on nearly 100,000 individuals each year. MEPS is a subsample of NHIS and can be linked to NHIS data (though we are not sure how well this has worked in practice).

While ACS, MEPS, and NHIS are likely to be the most important elements in constructing our analytic data set, two other data sets deserve special mention. First is the National Health and Nutrition Examination Survey (NHANES). The main advantage of this survey is that respondents undergo clinical examination, so that not all information is based upon patient responses to questions. For selected medical conditions such as diabetes, hypertension, and hyperlipidemia, it is therefore possible to track the true prevalence of the condition rather than the prevalence of individuals saying they have been diagnosed. Second is the Behavioral Risk Factor Surveillance System (BRFSS), which is a large survey (500,000 individuals) that collects data on health-related risk behaviors, chronic conditions, and use of preventive services. There are various longitudinal data sets that could also become important.

We envision the development of the data set to be incremental and driven, initially, by desired applications of the tool. For example, the next application will be for early childhood interventions, and (as discussed in the previous section) we are exploring the use of highest level of education as a means to develop a series of alternative life courses. We anticipate the use of ACS for the earnings analysis, MEPS for health care spending and QALY credit, and NHIS for mortality. As we convert the survey data into the data sets appropriate for the analysis questions, we will be thinking ahead to future applications so that, eventually, we will have data sets that can quickly and efficiently be applied to emerging needs.

In addition to supporting new applications of the valuation tool, we expect that VPAD will enable us to extend existing research into the direct determinants of health, how they interact, and the relative importance of these determinants (or combinations of determinants when they are highly inter-related) on health.

# 7.0 Summary

Under this grant, we have completed a review of evidence of the relative impact of determinants of health, developed a high-level framework for considering the impacts of an investment in one or more of the determinants, and developed the initial version of a tool for characterizing the value of such an investment from the perspectives of alternative stakeholders. The initial version of the tool includes societal, federal government, and state government perspectives. Demonstration applications of the tool to investments to reducing smoking and obesity have illustrated its potential utility. The tool's structure and the results of the demonstration applications suggest that it has a number of strengths:

- The tool computes the stakeholder value of achieving a specific prevention objective. This helps stakeholders determine how much they should be willing to invest toward achieving the objective. It also paves the way for shared investments, as it can demonstrate to multiple stakeholders the value to each of them of participating in funding an intervention. The tool avoids the complexities associated with designing and costing a particular approach to achieving the objective.
- Input requirements are standardized, well-defined, and simple, because they are tied to specific objectives rather than specific programs or approaches.
- Findings can be summarized in simple rules of thumb (e.g., the value to the federal government of keeping one person from becoming a smoker).
- Research requirements for new applications are well-defined and can be used to structure a future research agenda.
- The tool has a life course focus that is ideal for the valuation of early childhood interventions and improvements in HALE at birth.
- The tool includes productivity over the life course – a crucial determinant of value for early childhood interventions.
- For a given prevention objective, the tool provides the maximum investment under a desired ROI, a desired cost per QALY, or a desired payback period.
- The longevity effect can be particularly important for some types of prevention, and its effects are separately identified.
- Changes in the cost and effectiveness of treatment can have a major impact on the value of prevention. The tool is well suited to exploring alternative scenarios in this space.
- There is much uncertainty about the future rate of growth in health care costs, in average earnings, in basic costs of living, and even in the appropriate discount rate. The tool is also well suited to exploring alternative scenarios in this space.

Work continues toward enhancing the tool to address the interests of additional stakeholders, applying it to additional types of investments, and developing a comprehensive data set to facilitate its further application.

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# List of Acronyms

| | |
|---|---|
| **ACA** | Affordable Care Act |
| **ACS** | American Community Survey |
| **APHA** | American Public Health Association |
| **BRFSS** | Behavioral Risk Factor Surveillance System |
| **BMI** | Body Mass Index |
| **CBO** | Congressional Budget Office |
| **CDC** | Centers for Disease Control and Prevention |
| **CHIP** | Children's Health Insurance Plan |
| **CMS** | Centers for Medicaid and Medicare Services |
| **CSHS** | Center for Sustainable Health Spending |
| **GDP** | Gross Domestic Product |
| **HALE** | Health-adjusted Life Expectancy |
| **HiAP** | Health in All Policies |
| **HRR** | Hazard Rate Ratio |
| **IOM** | Institute of Medicine |
| **IW** | Input Workbook |
| **MEPS** | Medical Expenditure Panel Survey |
| **MIECHV** | Maternal, Infant, and Early Childhood Home Visiting |
| **NHANES** | National Health and Nutrition Examination Survey |
| **NHIS** | National Health Interview Survey |
| **NFP** | Nurse Family Partnership |
| **OW** | Output Workbook |
| **PCAC** | Prevention Cost Advisory Committee |
| **QALY** | Quality-adjusted Life Year |

| | |
|---|---|
| **ROI** | Return on Investment |
| **RWJF** | Robert Wood Johnson Foundation |
| **SDH** | Social Determinants of Health |
| **SES** | Socioeconomic Status |
| **SIB** | Social Impact Bond |
| **VPAD** | Value of Prevention Analysis Data |
| **WHO** | World Health Organization |