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A Penny-Per-Ounce Tax On Sugar-Sweetened Beverages Would Cut Health And Cost Burdens Of Diabetes

DOI: 10.1377/hlthaff.2011.0410
HEALTH AFFAIRS 31,
NO. 1 (2012): 199–207
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ABSTRACT Sugar-sweetened beverages are a major contributor to the US obesity and diabetes epidemics. Using the Coronary Heart Disease Policy Model, we examined the potential impact on health and health spending of a nationwide penny-per-ounce excise tax on these beverages. We found that the tax would reduce consumption of these beverages by 15 percent among adults ages 25–64. Over the period 2010–20, the tax was estimated to prevent 2.4 million diabetes person-years, 95,000 coronary heart events, 8,000 strokes, and 26,000 premature deaths, while avoiding more than \$17 billion in medical costs. In addition to generating approximately \$13 billion in annual tax revenue, a modest tax on sugar-sweetened beverages could reduce the adverse health and cost burdens of obesity, diabetes, and cardiovascular diseases.

According to industry data on the US nonalcoholic beverage market, Americans consumed 13.8 billion gallons of sugar-sweetened beverages in 2009, or approximately 45 gallons per capita annually of soda, fruit punch, sweetened tea, sports drinks, and all other beverages with added caloric sweeteners.¹ These drinks provided approximately 70,000 “empty calories” per person. Every twenty-ounce bottle of a typical sugar-sweetened beverage contains nearly seventeen teaspoons of sugar. These beverages represent the largest source of added sugar and excess calories in the American diet and have been linked to weight gain and type 2 diabetes.^{2,3}

Over the past decade, adults and children in the United States have dramatically increased their consumption of these beverages.^{4,5} Some researchers believe this trend to be the single largest contributor to the current obesity epidemic.^{6,7} In adults, a large body of literature has established the effect of consuming sugar-sweetened beverages on the risk of diabetes and metabolic syndrome.^{3,8} Women who consume at least one sugar-sweetened beverage per day may

have an 83–98 percent increase in the risk of developing diabetes.

The Centers for Disease Control and Prevention explicitly listed reducing the intake of sugar-sweetened beverages as one of its chief obesity prevention strategies in 2009.⁹ In the same year, the Institute of Medicine advocated fiscal policies and local ordinances to discourage the consumption of food and beverages, such as those sweetened with sugar, that are high in calories but poor in nutritional value.⁷

Forty states now impose sales taxes on all types of soda at an average rate of 5.2 percent. (See Exhibit A1.1 in the online Appendix¹⁰ for detailed state-by-state sales taxes, population size, and prevalence of obesity.) However, the association between soda sales taxes and the state-level prevalence of obesity has been found to be weak.^{11–14} This is probably because existing sales taxes on soda are too low to cause changes in calorie consumption that are substantial enough to change average body mass index.⁶

As of May 2011, fifteen states had discussed proposals to impose special taxes on sugar-sweetened beverages (in the range of 0.5 cents to 2.0 cents per ounce) during the 2011 legisla-

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tive session.¹⁵ However, none of the proposals had passed by mid-November. An excise tax of a penny per ounce (that is, twelve cents on a twelve-ounce can of regular soda, approximately a 15–25 percent increase) was the most common proposal and was frequently advocated as a public health strategy to prevent obesity and type 2 diabetes.^{6,7,16–18}

Past studies have estimated that taxes in this range would reduce consumption of sugar-sweetened beverages by 10–25 percent.^{1,6,7,16,17,19,20} Estimates exist for the potential of such taxes to curb the consumption of sugar-sweetened beverages^{21,22} and generate revenue.¹ However, no estimates exist for the downstream health benefits and savings on medical expenditures that might result from a tax-induced shift in consumption.

The study on which this article is based estimates potential reductions in obesity, diabetes, cardiovascular disease, and associated medical costs that would result if a penny-per-ounce tax were to be imposed on sugar-sweetened beverages in all US states. We project the impact of such a tax on the health and medical care costs among adults ages 25–64 over a ten-year period.

Study Data And Methods

CHOICE OF AGE COHORTS Despite the immense public attention focused on the sugar-sweetened beverage intake of children and adolescents, consistent evidence on their response to price disincentives and on the likely long-term health effects at these ages is lacking. Furthermore, taxation would coincide with many school-based nutrition policy initiatives, confounding inferences about its impact.²³

In contrast, young and middle-aged adults are most likely to be affected by the proposed tax. In addition, a sound knowledge base exists to inform projections of consumers' likely behavior and impacts on disease risks in this population as a result of such a tax.

INTAKE OF SUGAR-SWEETENED BEVERAGES Baseline consumption—before the proposed tax—of sugar-sweetened beverages was estimated using data from the National Health and Nutrition Examination Survey for the period 2003–06. We analyzed the self-reported food frequency questionnaire responses to obtain a nationally representative consumption pattern of sugar-sweetened beverages. Based on the average price of these beverages¹⁹ and published estimates of the price elasticity of demand,²⁴ we estimated the extent to which the proposed tax could reduce consumption.

PHYSIOLOGICAL IMPACT We modeled the health benefits of a tax-induced reduction in the con-

sumption of sugar-sweetened beverages via two pathways: weight reduction and reduction in the risk of type 2 diabetes, both of which reduce cardiovascular disease risk over time. To estimate the tax's potential impact on diabetes, we applied the relative risk estimates reported by Mathias Schulze and colleagues²⁵ to the baseline individual intake levels from the National Health and Nutrition Examination Survey data for 2003–06.²⁶

Following 91,249 nurses from 1991 to 1999, Schulze and colleagues estimated that people who consume at least one sugar-sweetened drink per day have an 83–98 percent higher incidence of diabetes compared with those who consumed fewer than one of these beverages per month.^{25,27} Only about half of this association was explained by weight gain. The other half was probably due to the high amount of rapidly absorbable carbohydrates in the drinks, which triggers pronounced spikes in blood sugar.^{25,28}

We calculated the potential differences in caloric intake with and without the proposed tax. Consistent with previous studies,²⁹ our base case assumed that the tax-induced reduction in sugar-sweetened beverage intake was likely to be replaced by a combination of water, diet drinks, and other nutritious caloric beverages (such as milk and juice) in equal measure.³⁰ This pattern of replacement assumes that approximately 40 percent of the calories “saved” by reducing sugar-sweetened beverage intake are compensated for, producing a net reduction of 60 calories for every 100 calories of sugar-sweetened beverage not consumed.

We then applied a validated conversion rule that, for average adults, each ten-calorie reduction in daily intake produces a one-pound reduction in body weight, assuming no other changes (for example, reduced physical activity). According to Kevin Hall and coauthors, approximately half of the weight loss will occur within one year, 90 percent within two years, and 100 percent within about three years. Weight loss from a fixed reduction in net calorie intake does not continue indefinitely. Rather, it ceases when energy intake once again reaches equilibrium with energy expenditures at a lower body weight.³¹

We next entered the estimated reduction in diabetes and mean body mass index associated with the projected weight change into the Coronary Heart Disease Policy Model to predict downstream reductions in cardiovascular disease burden over the ten-year period 2010–20. The Coronary Heart Disease Policy Model^{32–35} is a validated state-transition computer model that simulates coronary heart disease and stroke based on risk factors in the US adult population.³⁶

Confidence intervals were calculated using the Monte Carlo method, which repetitively ran the model (for 1,000 repetitions) using different parameter values drawn from predetermined distributions based on published ranges.³⁷

SENSITIVITY ANALYSIS The greatest uncertainty in our analysis is the extent to which a reduction in calories from sugar-sweetened beverages leads to a compensatory increase in calories from food or beverages that are not taxed.³⁸ Our base case, as previously noted, assumes 40 percent compensation. We conducted a separate sensitivity analysis on this parameter alone, assessing its impact over the full range—that is, from 0 percent (most optimistic) to 100 percent (most pessimistic, with no change in net calorie intake and thus no impact on body mass index).

In addition, we cross-validated our model projections against the estimates reported by Teresa Fung and coauthors, who followed 88,250 individuals for twenty-four years and found a 35 percent increase in heart attack rates among those who consumed more than two servings of sugar-sweetened beverages per day.^{39,40}

LIMITATIONS Although the National Health and Nutrition Examination Survey sample is designed to produce nationally representative estimates, the survey may overrepresent lower-income people living in the community.⁴¹ The self-reported food consumption patterns in its food frequency questionnaire are also subject to recall bias. In addition, we focused our estimates on cardiovascular diseases and diabetes, inevitably omitting other relevant disease outcomes such as osteoarthritis, some cancers, and dental

caries. Overall, our analysis produced conservative estimates for the full impact of the proposed tax on sugar-sweetened beverages.

Study Results

We estimated that a nationwide penny-per-ounce tax on sugar-sweetened beverages would reduce consumption of these beverages by 15 percent (95% confidence interval: 6, 24) among adults ages 25–64. This estimate is conservative but consistent with the findings of prior studies.^{6,7,16,17,19,20} Assuming that 40 percent of the reduction would be offset by increased consumption of other, nontaxed calorie sources,³⁸ the net caloric savings would be nine calories per day (95% confidence interval: 3, 16). This estimate closely matches the recent estimate by Eric Finkelstein and coauthors,²¹ who used different methods and data sources.

Applying the rule that ten fewer calories per day equals one pound of weight loss,³¹ the tax-induced net reduction in calories results in a net reduction of 0.9 pound (95% confidence interval: 0.4, 1.5) in mean weight at the population level. The tax would have a greater impact on consumption and weight among younger adults and men, who consume more sugar-sweetened beverages at baseline, than among older adults and women (Exhibit 1).

The resulting modest decline in expected body mass index would result in approximately 867,000 fewer obese adults ages 25–64—a 1.5 percent reduction. In addition, the shift in sugar-sweetened beverage consumption would reduce new cases of diabetes by 2.6 percent over-

EXHIBIT 1

Projections Of The Mean Downstream Health Effects Of A Penny-Per-Ounce Tax On Sugar-Sweetened Beverages, By Sex And Age

Group	Consumption of sugar-sweetened beverages (servings/day) ^a		Reduction in diabetes incidence (%)	Average reduction in weight (lbs.)	Reduction over 10 years in:				
	Baseline	Posttax			Diabetes person-years	Incidence of CHD	Myocardial infarctions	Strokes	Deaths
Both sexes, ages 25–64	0.56	0.47	2.6	0.9	2,377,000	95,000	30,000	8,000	26,000
Men									
Ages 25–44	0.79	0.67	3.4	1.3	497,000	22,000	4,000	500	4,000
Ages 45–64	0.49	0.42	2.3	0.7	1,044,000	54,000	20,000	4,000	15,000
Women									
Ages 25–44	0.63	0.53	2.8	0.9	268,000	5,000	800	500	2,000
Ages 45–64	0.33	0.28	1.6	0.4	568,000	14,000	4,700	3,000	5,000

SOURCE Authors' calculations. **NOTES** 95% confidence intervals have been omitted from this exhibit for brevity. A complete version of the exhibit is available in the online Appendix, as in Note 10. Assuming a penny-per-ounce tax reduces baseline consumption by 15 percent (6–24 percent). CHD is coronary heart disease. ^aBased on food frequency questionnaires in the National Health and Nutrition Examination Survey, 2003–06.

all, ranging from 1.6 percent in women age forty-five and older to 3.4 percent in men under age forty-five. The resulting medical cost savings (Exhibit 2) during these ten years are estimated to be \$17.1 billion.

If 100 percent of the tax-induced reduction in calorie intake from sugar-sweetened beverages was replaced by equivalent caloric intake from other beverages and foods,⁴² there would be no impact on population body weight, and only about half of the diabetes risk reduction expected at the 40 percent replacement level would be realized. As a result, the health care savings would be reduced to \$6.7 billion (approximately 40 percent of the base case). If none of the calories avoided by reducing sugar-sweetened beverage consumption were replaced by increases in other caloric beverages, the resulting medical savings would increase to \$20.1 billion.⁴³

Discussion

POTENTIAL HEALTH IMPACT In this study, we set out to fill a knowledge gap on the potential downstream impacts on health and health care cost burdens of a nationwide penny-per-ounce excise tax on sugar-sweetened beverages. If fully passed on to the consumer through a price increase, this tax would raise the price of a typical twenty-ounce bottle of regular soda by twenty cents, or 20–25 percent. In turn, it would discourage consumption of sugar-sweetened beverages by 6–24 percent among adults ages 25–64.

Even if 40 percent of the calorie reductions thus realized were offset by increased consumption of juice or milk, we estimate that such a tax could reduce new cases of type 2 diabetes by

2.6 percent and the prevalence of obesity by 1.5 percent. Although small, these percentage reductions would, over the course of ten years, result in 95,000 fewer instances of coronary heart disease, 8,000 fewer strokes, 26,000 fewer premature deaths (Exhibit 1), and more than \$17 billion in savings from medical expenditures averted across the US population (Exhibit 2).

Current consumption patterns indicate that the impact on consumption and body weight from the tax would be greatest among younger age groups. However, the ten-year health benefit in diabetes, coronary heart disease, and stroke prevented is expected to be greater among people ages 45–64. This difference is primarily driven by the higher incidence of cardiovascular disease and the higher per person diabetes treatment costs³⁷ in middle-aged adults.

For the same reasons, the anticipated health benefits and associated medical cost savings are greater among men than among women. Nevertheless, given the greater reductions in consumption among younger populations, the long-term health impacts would be far greater than the impacts during the first ten years modeled in our study.

THE TRUE COSTS OF SUGAR-SWEETENED BEVERAGES On the surface, sugar-sweetened beverages are sweet, cheap indulgences. In striking contrast with the average price of consumer goods (in particular, prices of fruit and vegetables),⁴⁴ the low price of these beverages, along with their mass marketing, has undoubtedly fueled their widespread overconsumption by both adults and children in the United States.⁶

The low purchase price of this “liquid candy,” unfortunately, does not reflect its full costs from a societal viewpoint. The United States spends \$174 billion a year to treat diabetes⁴⁵ and at least \$147 billion (9.1 percent of US health care expenditures) on health problems related to overweight and obesity⁴⁶—a dual epidemic exacerbated by a diet high in empty calories and added sugar. As a thought experiment, using our model we estimated that over ten years, \$82 billion in medical costs was attributable to excess sugar-sweetened beverage consumption (defined above as one beverage per week). Interestingly, on a per ounce basis, this amounts to approximately one penny, which is the proposed tax on these beverages.

UNCERTAINTIES AND METHODOLOGICAL CHALLENGES As with almost all policy impact assessments, our model-based calculations rely on several key assumptions for which empirical evidence is still lacking or inconclusive. Even before one considers external factors, such as pricing counterstrategy (often referred to as the “pass-through rate”), advertising, and prod-

EXHIBIT 2

Projected Ten-Year Savings in Medical Costs From A Penny-Per-Ounce Tax On Sugar-Sweetened Beverages

Group	Diabetes cost savings (\$ billions)	Cardiovascular disease cost savings unrelated to diabetes (\$ billions)	Total cost savings (\$ billions)
Both sexes, ages 25–64	9.6	7.4	17.1
Men			
Ages 25–44	1.6	1.5	3.2
Ages 45–64	4.6	3.5	8.1
Women			
Ages 25–44	0.9	0.9	1.8
Ages 45–64	2.5	1.6	4.1

SOURCE Authors' calculations. **NOTES** All amounts are in billions of US dollars, discounted by 3 percent a year. Numbers might not sum to totals because of rounding.

Whether a beverage tax would disproportionately affect low-income consumers is a matter of great debate.

uct reformulation, it is challenging to predict consumers' responses to the proposed tax.

The first major uncertainty concerns how much consumers would reduce their purchasing in response to each 1 percent increase in price (or "price elasticity"). Our base-case assumption, which is that each 10 percent increase in price results in an 8 percent reduction in consumption (a price elasticity of -0.8), was based on the most recent meta-analysis.²⁴ However, a wide range in elasticity estimates (-0.13 to -3.18) exists in the literature.²⁴ Inevitably, there is also a wide range in price elasticity among consumers.

Second, unlike the case of cigarettes, what consumers substitute in place of the sweetened beverages is a key determinant of the net impact of the tax.^{13,16,21,47} Some researchers have argued that the calories saved by cutting consumption of sugared soda might be completely offset by increased consumption of calories from whole milk and juice.¹³ Nevertheless, only part of the negative effects of sugar-sweetened beverages on diabetes²⁵ and heart disease³⁹ have been found to be mediated by weight gain.^{2,3}

Thus, even if all of the calories saved were replaced and there was no net impact on net body weight, cutting consumption of sugar-sweetened beverages would still reduce the incidence of diabetes and heart disease. Nonetheless, little is known about whether people will tend to substitute other sugary food for these beverages. More research is needed to eliminate these key uncertainties.

EFFECTS ON LOW-INCOME HOUSEHOLDS

Whether a sugar-sweetened beverage tax would disproportionately affect low-income consumers is a matter of great debate. Low-income households purchase more sugar-sweetened beverages than higher-income households, and they do so at lower prices.⁴⁸

However, lower-income consumers do not appear to be more price-sensitive than those with higher incomes.^{21,22} As a result, their share of the

tax burden may be lower than that of higher-income consumers, partly because lower-income consumers would be expected to shift their purchases to store-brand, bulk, or sale items to circumvent the price effects of the tax. Furthermore, even a 40 percent increase in the tax-induced price would have a modest impact on food expenditures—approximately \$30 per household per year.

More evidence and attention in policy discussions should be devoted to the size of downstream health benefits to lower-income consumers and racial and ethnic minorities. A recent study by Roland Sturm and colleagues¹⁴ found a significantly larger effect of a sales tax on soda among children who are heavier, from lower-income families, and African American. Because low-income people and racial and ethnic minorities bear a greater burden of obesity, cardiovascular disease, and diabetes, the potential savings from avoiding these conditions may disproportionately benefit these subpopulations.

ADDITIONAL BENEFITS OF ADDING THE TAX Not only does a per volume excise tax represent a larger increase in price, but it also has a number of additional benefits over a sales tax (when viewed as a fraction of price).

First, sales taxes encourage substitutions of lower-cost options, such as store brands or larger-serving-size containers (with lower cost per ounce), whereas a per ounce excise tax does not. Second, an excise tax is levied on producers and is therefore likely to be passed on to the consumer via the product's price tag. This sends a price signal at the point of purchase. In contrast, a sales tax is added at the checkout counter—after the purchase decision has been made.

Finally, an excise tax would be likely to have an impact on purchases made through the Supplemental Nutrition Assistance Program (formerly known as food stamps), which exempts its purchasers from state and local sales taxes.¹⁷

In addition to the potential health care cost savings examined in our analyses, a penny-per-ounce tax on sugar-sweetened beverages was estimated to generate approximately \$13 billion in new tax revenue in 2010 and \$79 billion over the period 2010–15.¹ How the tax revenues would be used has been a major driver of public opinion toward the tax.⁴⁹

In 2008 the Congressional Budget Office suggested that a federal beverage tax of three cents per twelve ounces could generate \$50 billion over ten years to help finance national health care reform.⁵⁰ Existing state soft drink taxes have been dedicated to a medical trust fund (Arkansas), state-funded medical schools (West Virginia), and litter control and recycling (Virginia). Given these examples, advocates have

voiced enthusiasm over the potential for additional revenues from higher taxes on sugar-sweetened beverages to support obesity prevention, health care, or school nutrition programs.¹⁶ Such uses would further enhance the tax's potential positive downstream health effects.

ARE SUGAR-SWEETENED BEVERAGES THE NEW TOBACCO? Tobacco taxes in the United States have played a monumental role in affecting purchasing behavior and promoting public health. The enormous health care burden from smoking—including cancer, heart disease, and chronic obstructive pulmonary disease—was well recognized to be an externality shouldered by taxpayers at large through Medicare and Medicaid and hence justifying government intervention. The large revenues generated through tobacco taxes have been used to support anti-smoking programs.

The unsurprising industry outcry against soft drink taxes seemed like *déjà vu*. In 2010, in opposition to then-governor David Paterson's effort to levy an excise tax on sugar-sweetened beverages in New York State, the beverage industry spent nearly \$13 million on a successful anti-tax campaign.⁵¹ The campaign focused on the message that the tax would unfairly hit low-income Americans, infringe on personal freedom, create a "nanny state," and cause job loss.

Considering that the societal burden of treating obesity, diabetes, and cardiovascular diseases is greater than ever, legislative and regulatory actions to support healthier behavior amount to acts of collective responsibility. A proposed tax on sugar-sweetened beverages would run in parallel with other policy strategies aimed at curbing unhealthy diets—such as school nutritional standards, menu labeling, and regulations

Actions to support healthier behavior amount to acts of collective responsibility.

on marketing practices. Yet the success or failure of the tax would still depend on individual choices.⁵²

Conclusion

Adam Smith wrote in *The Wealth of Nations*, "Sugar, rum, and tobacco are commodities which are nowhere necessities of life, [but] which are...objects of almost universal consumption, and which are therefore extremely proper subjects of taxation." If the tobacco tax history is any parallel, the current discussion of taxes on sugar-sweetened beverages could represent an early development in the broadened use of taxes to promote health and decrease health care costs.

In addition to generating substantial revenue, which can be used to fund health services or other infrastructure, the proposed penny-per-ounce excise tax on sugar-sweetened beverages is predicted to greatly reduce the adverse health and cost burdens of obesity, diabetes, and cardiovascular diseases among US adults. ■

Preliminary results from this study were presented orally at the 32nd Annual Meeting of the Society for Medical Decision Making, in Toronto, Ontario, October 25, 2010, as well as in an invited seminar at the Yale Rudd Center for Food Policy and Obesity, in New Haven, Connecticut, November 9, 2011. The study was partially supported by a grant-in-aid from the American Heart Association Western States Affiliate to

Kirsten Bibbins-Domingo (Grant No. 09GRNT2060096) and by a grant from the Robert Wood Johnson Foundation to Claire Wang (Grant No. 68162). The authors thank David Fairley, who developed the Monte Carlo simulation routine used in the study; Litsa Lambrakos, who performed the preliminary analysis; and Kevin Hall, who provided critical insight on the modeling of caloric imbalance on steady-state

body weight change. The authors also appreciate feedback from Miriam Laugesen, Stephen Lyman, Tatiana Andreyeva, and Michael Long on previous versions of this article. Claire Wang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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In this month's *Health Affairs*, Claire Wang and coauthors report on their examination of the potential impact on health and health spending of a nationwide penny-per-ounce excise tax on sugar-sweetened drinks. They found that over ten years, starting in 2010, the tax would reduce consumption of these beverages by

15 percent among adults ages 25–64. Other results would include substantial cuts in the number of heart attacks, strokes, and deaths, and more than \$17 billion in savings in reduced medical costs.

Wang is an assistant professor of health policy and management at Columbia University. Trained as an epidemiologist and decision scientist, she focuses her current research on the consequences of the obesity epidemic in adults and children and on the potential impact of policies to improve dietary intake and physical activity levels.

Wang earned her medical degree from National Taiwan University and both a master's degree in

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Yu-Ming Shen is a doctoral student in statistics at Virginia Tech University.

Yu-Ming Shen is a doctoral student in statistics at Virginia Tech University. At the time this work was conducted, he was an analyst in the College of Physicians and Surgeons at Columbia University. Originally a biophysicist conducting cellular research, he shifted his interests to health-related studies using statistical and simulation models—including the CHD Policy Model, which he has employed to explore the impacts of cardiovascular risk modification in the United States, China, Argentina, and India.

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Lee Goldman is the Harold and Margaret Hatch Professor, executive vice president for health and biomedical sciences, and dean of the faculties of health sciences and medicine, all at Columbia University. From 1978 to 2006 he held numerous positions at Harvard University, Brigham and Women's Hospital, and UCSF.

Trained in internal medicine and cardiology, and the lead editor of the *Cecil Textbook of Medicine*, Goldman holds master of public health and medical degrees from Yale University.



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Kirsten Bibbins-Domingo is an associate professor of medicine and of epidemiology and biostatistics at UCSF, as well as codirector of the UCSF Center for Vulnerable Populations and a practicing general internist at San Francisco General Hospital. She currently leads the UCSF team working on the CHD Policy Model, in close collaboration with investigators at Columbia University.

A member of the US Preventive Services Task Force, Bibbins-Domingo completed her master's degree in clinical research, her medical degree, and her doctorate in biochemistry at UCSF.