Estimating Health Care Costs in Minnesota for Certain Chronic Diseases & Risk Factors: A Status Update

REPORT TO THE MINNESOTA LEGISLATURE, July 2016

MDH Minnesota
Department *of* Health

HEALTH ECONOMICS PROGRAM

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HEALTH ECONOMICS PROGRAM

July 27, 2016

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To the Honorable Chairs:

As required by Minnesota Statutes, Section 62U.10, this report outlines MDH's work to date in developing estimates of the costs associated with selected chronic conditions and risk behaviors. The work described in this report will serve as the foundation for estimates of actual and projected spending that MDH will deliver to the Legislature in November of this year.

In requiring MDH to conduct this work, the Legislature recognized the toll that chronic disease continues to take on individuals, communities, and the state. In 2012, total health care costs for chronic disease in Minnesota were nearly $23 billion, representing more than 80 percent of total medical spending. Without a strong and continuing focus on preventing and managing chronic disease, both the costs and the impact on the quality of life for individuals and communities will only increase.

Our work in the coming months will focus on obtaining stakeholder input into the preliminary approach and findings, and making necessary improvements to the methodology, to ensure that the estimates and projections we produce in November rely on the best science available.

If you have any questions about this report, please direct them to Stefan Gildemeister at
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Sincerely,

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Introduction

In Minnesota, as in other states, chronic diseases increasingly take a toll on individuals, our community, and our state. While Minnesotans' overall rate of chronic disease is lower than the national average, about 35 percent of insured Minnesotans in 2012 had at least one chronic condition. More than half of those had multiple chronic conditions.

The burden of illness and cost associated with chronic disease is not evenly distributed among people in Minnesota. Older persons and populations of color and American Indians are disproportionately represented among those who suffer from chronic disease, for many reasons, including disproportionate rates of poverty and the burden of discrimination.[1] As people in Minnesota grow older, the costs associated with chronic disease will continue to rise unless attention is paid to the conditions that shape health in every community.

In 2012, Minnesota's total health care bill for chronic disease was $22.7 billion, representing more than 80 percent of total health care spending. That works out to an annual average for payers, insurers and individuals of $12,800 for each insured resident with one or more chronic diseases, such as diabetes, asthma or congestive heart failure,[2] and nearly eight times the $1,600 average spending associated with an insured resident without a chronic condition. While part of this difference may be due to individuals without chronic conditions being younger and having reduced health care costs because of age, having a chronic condition increases annual medical costs. Living with multiple chronic conditions adds, on average, an additional $4,000 to $6,000 in healthcare expenses per person per condition.

In the long term, these costs to individuals and communities associated with chronic conditions in Minnesota are large, increasing, and, ultimately, unsustainable.[3]

While health care providers have made great strides in improving the quality of care for individuals who experience one or more chronic diseases, we know that we can't treat our way out of this crisis. New approaches to address the occurrence of chronic disease, including through prevention efforts, need to be system-wide and persistent, recognizing that some change will be slow and benefits are realized not in the period of a few years, but over a lifetime.

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[1] See for example: Centers for Disease Control and Prevention. CDC Health Disparities and Inequalities Report – United States, 2013. MMWR 2013; 62 (Suppl 3).

[2] This estimate is derived from spending for chronic disease across the total population of Minnesota who holds insurance coverage. It spans approximately 116 chronic diseases and the age spectrum of Minnesota residents. Because it excludes certain groups of individuals, including the uninsured and people with coverage through the Veterans Administration, it constitutes a low estimates of the total cost burden associated with chronic disease.

[3] See for example: MDH/Health Economics Program, "Chronic Conditions in Minnesota: New Estimates of Prevalence, Cost, and Geographic Variation of Insured Minnesotans, 2012." Jan. 2016.

In recognition of these facts, Minnesota has made significant efforts to support community-based prevention efforts designed to engage schools, businesses, housing owners/managers, community groups, senior organizations, hospitals, clinics, local public health agencies, faith communities, and other community partners in making health a priority. Many of these efforts focus on changing structures and systems to support health across the lifespan, in the places that people live, work, play and learn. Neighborhoods, schools and workplaces environments all loom large in the shaping of health. Efforts to reduce obesity (which is linked to type 2 diabetes), tobacco use, and second-hand smoke exposure – all factors that contribute to increases in chronic disease prevalence, rising health care costs, and increasing levels of disability or lower quality of life – must focus on changing community conditions. This work is occurring not just in the public health space, but also through significant clinical activities focused on care delivery changes such as care coordination and patient-centered care, screening for chronic conditions and risk behaviors, and smoking and tobacco use cessation counseling.[4]

Increasingly, these efforts must also recognize that not everyone has the same opportunities to be healthy: alongside genetic and behavioral factors, social determinants of health, such as low income, lack of access to affordable healthy food within the neighborhood, unstable housing, and lack of access to reliable transportation increase the likelihood that individuals and communities will experience poorer health and quality of life.

The fruits of the many focused policy, systems and environmental change efforts in selected communities are beginning to emerge. For example, the percentage of adult Minnesotans who smoke cigarettes is 14.4 percent, down from 22.1 percent in 1999.[5] A variety of broad-based state and local policy, systems, and environmental changes have increased tobacco-free environments, raised the price of commercial tobacco, and reduced access to commercial tobacco products. These population-level initiatives helped reduce commercial tobacco use rates for all populations.

The challenges, however, remain daunting. More than a quarter of Minnesota adults are obese and 14.4 percent still smoke. Cancer, heart disease, and stroke - all associated with tobacco use - remain among the top causes of death in Minnesota. Nearly 15 percent of Minnesota's children are growing up in poverty (2014),[6] unemployment and underemployment remain high for populations of color and American Indians, and many people, in both rural and urban areas, lack access to adequate nutrition, stable homes, and meaningful work. Disparities and inequities in commercial tobacco use and exposure continue to persist across several

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[4] For the example, the public-private Million Hearts initiative aims to reduce heart attacks and strokes by working with partners on a range of public and population health and clinical activities. http://wayback.archive-it.org/3926/20140108162043/http://www.hhs.gov/news/press/2011pres/09/20110913a.html; accessed: July 18, 2016, 10:09:00am.

[5] ClearWay Minnesota, Minnesota Department and Westat, "Minnesota Adult Tobacco Survey, Tobacco Use in Minnesota: 2014 Update," January 2015.

[6] Children's Defense Fund analysis of data from the U.S. Census Bureau, "2014 American Community Survey 1-Year Estimates," Tables B1700, 2015. http://www.childrensdefense.org/library/data/state-data-repository/cits/2015/2015-minnesota-children-in-the-states.pdf

sociodemographic characteristics, including, but not limited to, race, ethnicity, sexual orientation, gender identity, income, education, age, geography, and mental health. Those who still smoke are more likely to have mental health issues, and lower levels of income and education. Given these realities, policymakers, health care providers and public health professionals need to employ multi-sectoral efforts to impact spending for chronic disease.

In response to these trends, the Minnesota Legislature directed the Minnesota Department of Health (MDH) to report the projected impact on spending over a ten-year time frame for five health indicators:

- Obesity (including obesity-related cancers, coronary heart disease, stroke, and arthritis);
- Utilization of tobacco products;
- Hypertension;
- Diabetes or prediabetes; and
- Dementia and chronic disease among the population aged 60 or older, including long-term care costs.

The Legislature authorized MDH to use the Minnesota All Payer Claims Database (MN APCD), a secure state repository of more than one billion medical and pharmacy claims for insured Minnesotans. The MN APCD is derived from medical providers' billing records sent to insurance companies, plan administrators and public payers and represents roughly 90 percent of the Minnesota population.

This report briefly describes work conducted to date, including (1) a review of the relevant literature published from 2005 through 2015 related to each health condition; (2) the development of data and methods to estimate the cost associated with each health condition and risk factor; (3) the production of preliminary cost estimates for 2009; and (4) the development of a stakeholder input plan to assist in prioritizing improvements in methods before finalizing a report to the legislature in November 2016. Because the preliminary cost estimates that were developed in this first phase of work are likely to change substantially after implementing of some of the methodological enhancements described in this report, preliminary estimates are not included here.

The work described in this report will form the basis of a report to the Minnesota Legislature in November 2016 that will present:

- Actual estimates of spending for the most recent available period based on a refined methodological approach;
- Projections of spending for a ten-year period, starting with 2009, that reflect changes in medical and pharmacy prices, demographic change in the population, and historic changes in the incidence of the conditions documented in survey data; and
- A comparison between the most recent actual health care spending and spending projected from the baseline model.

Review of the Literature

Mathematica Policy Research, the analytic vendor MDH retained to support this work, conducted a review of the published literature since 2005, as well as several seminal studies published since 2000, to identify estimates of the cost of the selected conditions. The analysis identified approximately 35 studies summarized in a full literature review. Twenty-eight of these studies (summarized in Appendix A) offered per-person cost estimates, which were presented either as the average total cost for all health care among people with the condition or average cost of health care specifically due to having the condition.

Not all of the studies reviewed produced estimates that are directly comparable to this work. Of those that estimated the average health care costs specifically due to having a specific condition, relatively few took into account the presence of other chronic conditions that may have contributed to overall costs; even those that did often failed to use precise methods. In addition, most focused on specific subpopulations or excluded institutionalized persons, making it difficult to generalize their results to the broader population as the current work requires.

Two observations about these studies are of particular relevance. First, studies that statistically adjusted cost estimates to remove the effect of concurrent but unrelated chronic conditions produced much lower estimates of cost than studies that did not.[7] However, too few studies controlled for specific chronic conditions to help us understand how appropriate statistical controls would change estimates produced without such controls.

Second, when reported by age and age-by-gender population subgroups, the cost estimates varied widely across the subgroups. For example, estimates of costs associated with obesity (all uncontrolled for comorbidities) varied by orders of magnitude by age (Moriarty et al. 2012). Among workers age 60 or older, cost estimates for women were approximately twice those for men (Finkelstein et al. 2010). In addition, cost estimates for diabetes differed substantially for diagnoses of Type I diabetes versus Type II (e.g., Tunceli et al. 2010), although challenges concerning the availability of data that reliably permit identifying type 1 and type 2 diabetes are partly responsible for this variation.

Taken together this means the work pursued by Minnesota is methodologically complex and substantially innovative. But there are also limited opportunities for benchmarking this work to existing estimates, either locally or nationally.

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[7] For example, in a given year, hypertensive patients might receive care for hypertension and care for a trauma injury. While the care might occur concurrently, the treatment of the injury is unrelated to the hypertension diagnoses, and cost estimates for hypertension would be inaccurate if the cost for injury care were not removed.

Data and Methods

Estimating the costs of medical services and prescription drugs associated with specific conditions or risk factors generally requires knowledge about three components:

- How many people had a given condition;
- How much health care spending occurred for people with the condition; and
- What share of spending was <u>not</u> attributable to a given condition.

For example, to assess the volume of spending for asthma care, analysts need to understand how many people in a given period have asthma (diagnosed or undiagnosed), how much health care these individuals consumed, and what share of spending was associated with health care use *unrelated* to asthma (for instance, inpatient care associated with a skiing accident). Generally speaking, these types of questions can be answered with the help of health care transaction records data, also known as claims data. Analysis of spending associated with risk factors, such as obesity or tobacco use, generally requires a different approach.

More specifically, claims data, such as the MN APCD, are well-suited to estimating the costs of conditions that have clearly understood diagnoses, and widely-used treatments, and corresponding codes that providers use to bill for services. However, it is challenging to use these data to estimate costs for sub-populations for whom claims are not generated or present (e.g., the uninsured); risk behaviors that are not associated with a diagnosis or treatment code; or conditions with diagnosis codes that do not affect reimbursement, so are not widely used.

Survey data, such as the Behavioral Risk Factor Surveillance System (BRFSS) can be useful for estimating diagnosed conditions or disease prevalence across an entire population; however, they are limited by the questions that are asked of respondents, the populations that are part of the survey, and respondents' ability for recall. Data like the Household Component of the Medical Expenditure Panel Survey (MEPS-HC) permit the estimation of national and regional prevalence rates and overall health care spending. However, they do not support either state-level estimates or estimates for institutionalized persons; and like BRFSS, they are limited by the questions asked of respondents.

The approach used by the contractor draws on the existing literature and pairs the estimation of costs for specific conditions and risk factors with the best-suited data source or multiple data sources. Where necessary, the data are benchmarked to represent total population estimates for Minnesota using a variety of data sources. For some conditions like diabetes, where claims data are robust and fit for the purpose, the MN APCD underlies the analytical models. For conditions like tobacco use, estimates are derived using survey data that provide a more comprehensive picture of current use patterns and cost than claims data can provide at this time.

Generally, the data captures approaches to health care that is typically offered in health care settings and, in the case of the MN APCD, is covered by an insurance policy. The data do not

typically include types of care that include many complementary or alternative therapies such as acupuncture; massage therapy; meditation, imagery, or relaxation techniques; homeopathic treatment; spiritual healing; or traditional (ethnic) medicine.

Data sources included in the development of the preliminary estimates were:

- The MN APCD was used to estimate 2009 costs associated with diabetes, hypertension, and dementia for the commercially-insured population and for residents enrolled in fee-for-service Medicare, Medicare risk or cost contracts, Medical Assistance, MinnesotaCare, or other public health insurance programs. The treated incidence of diabetes, hypertension, and dementia – or the incidence of people with the condition who were seen in the health care system in a year – across the population (by age, sex, and primary coverage category) were estimated from the MN APCD.

- The 2009 Household Component of the Medical Expenditure Panel Survey (MEPS-HC) was used for two purposes: First, the MEPS was used to estimate the cost of care among Minnesotans who are current smokers or obese, as these conditions are typically unreported in claims data and, therefore, cannot be observed accurately in the MN APCD. Second, for all chronic conditions of interest, the MEPS was used to estimate costs among persons in insurance coverage categories that are not reflected in the MN APCD—specifically, TRICARE enrollees and the uninsured, the latter including those who rely on the Veterans Administration or Indian Health Service for care.

- The Minnesota Behavioral Risk Factor Surveillance System (BRFSS) was used to estimate the prevalence of smoking and obesity in 2009. In addition, multiple years of the BRFSS were used to inform cost projections with changes in the incidence of smoking and obesity, as well as diabetes and hypertension, in later years.

- Multiple years of the Minnesota Health Access Survey (MNHA) were used to adjust the cost estimates so that they are reflective of the distribution of insurance coverage among Minnesota's total population for 2009 and later years. This approach recognizes that service use and cost differ by type of insurance coverage and ensures that the final estimates align with Minnesota's actual distribution.

- Total population estimates (by age and gender) provided by the Minnesota State Demographic Center were used to align study estimates with population totals (including institutionalized persons) in 2009 and projections through 2019.

Preliminary estimates of the treatment cost associated with each condition, i.e., costs for medical services and drugs, were produced using a regression framework. To estimate the cost of care for persons identified as having a specific condition, the model controlled for other health conditions that experts consider unrelated to the main condition of interest.[8]

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[8] As noted earlier, controlling for unrelated conditions ensures that cost estimates are specifically attributable to a condition in question. For example, to understand the opportunity embedded in reducing the prevalence of diabetes among children, we need to identify and disregard spending for treatment of unrelated conditions such as the cost of treating an acute ear infection.

The estimates also controlled for the patient's age and sex, and the average income in the patient's community (defined by zip code area). The estimates do not control for diagnoses that are clinically related to the condition because these diagnoses would be expected to rise or fall with a change in the prevalence of the risk behavior or condition. For example, the estimated cost of tobacco use does not control for cancers related to tobacco use.[9] To estimate the cost of smoking and obesity, the regression models used the MEPS-HC data, and the estimates were adjusted to be consistent with both health care spending reported in the MN APCD and prevalence reported in the Minnesota BRFSS.

The development of preliminary estimates revealed a number of data limitations and methodological challenges to be addressed in the development of final estimates. For example:

- Because of the limited information in MEPS-HC on the current and former use of tobacco products, preliminary estimates include only costs associated with adults who were smokers at the time of the survey. Research shows that not accounting for other forms of tobacco use or former smoking status biases cost estimates and yields artificially high estimates for "non-smokers".

- For some groups— including those that roughly correspond to disabled and dual-eligible persons enrolled in Medicare or Medical Assistance—cost patterns are very different from those among other Minnesotans. In addition, costs among children under age 18 diagnosed with hypertension are markedly higher than those among adults diagnosed with hypertension. In both cases, the reasons for higher costs appear to be associated with the challenge of predicting low-cost cases or outliers at the low end of the cost distribution.

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[9] These methods are similar to those incorporated in the Centers for Disease Control and Prevention Chronic Disease Calculator, which measures the medical cost associated with arthritis, asthma, cancer, cardiovascular diseases, depression, and diabetes. See: [http://www.cdc.gov/chronicdisease/calculator/resources.html], accessed November 30, 2015. A detailed description of methods underlying the estimates is reported in: Chollet, D. and S. Liu. "Estimating the Impact of Chronic Disease and Certain Risk Factors: Methods." Revised report submitted to the Minnesota Department of Health (March 2016).

Next Steps

The work that the Minnesota Legislature directed MDH to perform is breaking new ground in its scope and potential impact to inform future statewide and local efforts to prevent chronic diseases, lower the incidence of certain risk behaviors, and reduce healthcare costs. Other studies, in Minnesota and elsewhere, have attempted to estimate the impact of select chronic conditions or risk behaviors on health care costs, and to model how future costs would increase under different scenarios of growth in prevalence of the condition.[10] However, this work is unique in that it relies to a significant extent on data observed for Minnesota residents, focuses on a number of conditions and risk factors that account for a substantial part of disease burden and spending, and aims to control more rigorously for unrelated conditions.

During the summer of 2016, MDH will seek additional input from both internal and external advisors on the analysis and methods employed so far to identify ways to refine the approach and address known limitations or challenges as part of completing final estimates and projections in November. In particular, MDH will work with stakeholders and advisors to:

1) Identify strategies to address the bias in cost estimates for current smokers by augmenting existing data to more effectively identify former smokers.

2) Seek to refine the cost estimates associated with birth outcomes so that they consider smoking status of pregnant women.

3) Explore whether alternative methods to identify chronic disease may improve the balance between over-identifying and under-counting individuals with a given chronic disease.

4) Consider enhanced modeling to account for the impact of complex conditions among the disabled and/or dual-eligible populations, some children, and persons under age 60 with dementia (to strengthen face-validity).

5) Address modeling challenges associated with estimating costs for patients with extremely low spending.

6) Explore improvements to the projection methods to account for changes in the use of health care services and the availability and use of prescription drugs.

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[10] "Obesity and Future Health Care Costs: A Portrait of Two Minnesotas." Blue Cross and Blue Shield of Minnesota, Minnesota Department of Health, 2008. http://archive.leg.state.mn.us/docs/2008/other/080146.pdf

APPENDIX A

SUMMARY COMPARISON OF ANNUAL PER-PERSON COST FINDINGS FROM RECENT LITERATURE: SMOKING, OBESITY, DIABETES, HYPERTENSION, AND DEMENTIA

TABLE A.1: COMPARISON OF ANNUAL PER-PERSON COST FINDINGS FROM RECENT LITERATURE: SMOKING, OBESITY, DIABETES, HYPERTENSION, AND DEMENTIA

Condition	Ref. #	Time period	Reference population	Per person total cost	Per person cost associated with the condition		Payer
					Estimate is not controlled for comorbidities	Estimate is controlled for comorbidities	
Smoking	1	1998-2008 (2008 $)	Current and former smokers age 18+	$6,170 (age 45-64) - $11,580 (age 75+)	--	$1,000 (age 45-64) - $1,300 (age 75+)	All payers
	2	1999-2002 (2007 $)	Mayo Clinic employees, retirees, and dependents (Rochester, MN), current and former smokers	--	--	$1,274 (< age 65) - $1,401 (age 65+)	Private insurance
	3	2009	California adults and adolescents, current and former smokers	--	$2,505	--	All payers
Obesity	4	1999-2002	Mayo Clinic employees, retirees, and dependents by extent of obesity	--	$382 - $5,530 (< age 65) $2,907 - $5,467 (age 65+)	--	Private insurance
	5	2006 (2008 $)	Noninstitutionalized adults age 18+	--	$1,429	--	All payers
	6	2006	Full-time workers age 60+ by extent of obesity	--	$475 - $1,269 (men) $1,269 - $2,395 (women)	--	All payers
	7	2004-2013 (2013 $)	Adult members of Geisinger Health Plan: Northern PA	$4,166	-$1,305	--	Private insurance
	8	2007-2010	Children age 3-17 in integrated health system: MN and CO		$937	$897	Private insurance
	9	2007-2012	Noninstitutionalized adults age 18+	--	$941 (moderate obesity) to $1,980 (severe obesity)	--	All payers
Diabetes	10	2001-2006	Adults age 65+	$9,061	$6,414 - $6,649	--	All payers
	11	2006	Privately insured adults age 19-65	$13,466 (Type 1I) $7,648 (Type 2)	$10,442 (Type 1) $4,186 (Type 2)	$4,372 - $6,526 (Type 1) $1,980 - $2,297 (Type 2)	Private insurance

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	12	2006-2009 (2011 $)	All non-Medicaid insured persons	$1,565 (Medicare FFS) $1,090 (Private ins.)	$879 (Medicare FFS) $1,042 (Private ins.)	--	Medicare FFS and private insurance
	13	2006-2009	Adults age 30+ not on insulin therapy before age 30	--	--	$3,900 - $6,800	All payers
	14	2006-2010	All non-Medicaid insured persons	$19,612	--	$2,866	Private insurance and Medicare Supplement plans
	15	2008-2009	Medicare Advantage enrollees	--	--	$11,739	Medicare
	16	2009-2011	Noninstitutionalized adults	--	$4,394 (age 18-44) $5,611 (age 45-64) $11,825 (age 65+)	--	All payers
	17	2010-2011	Medicare Advantage plan members	$10,896	--	--	Medicare
	18	2010-2012	Privately insured persons, 59% in South U.S.	$6,736 - $7,195	--	$2,671 - $3,246	Private insurance
	19	2012	Adults > age 17 enrolled in employer plans	$12,299 - $13,162	--	--	Private insurance
	20	2012	Total U.S. population	--		Mean = $7,888 $4,394 (< age 45) $5,611 (age 45-64) $11.825 (age 65+)	All payers
	21	2010-2011	Noninstitutionalized population age 18+	--		$5,378	All payers
Hypertension	22	1996-2006 (2008 $)	Noninstitutionalized adults age 18+	--	--	$832	All payers
	23	2003-2009 (2009 $)	Adults age 18+ enrolled in Kaiser Permanente (Portland, OR)	--	--	$550	Private insurance

Dementia	24	1998	Noninstitutionalized patients with Alzheimers or other diagnosed dementia	$12,081 (Alzheimers) $8,027 (Other dementia)	--	--	All payers
	25	1997-2005 (2005 $)	Medicare beneficiaries age 65-101	--	--	$10,814 (Medicare) $6,234 (Medicaid)	Medicare
	26	2001-2002	Patients age 65+ enrolled in large commercial managed care plan	--	--	$2,062	All payers
	27	2004	Medicare beneficiaries age 65+ with employer-sponsored supplemental	--	--	$1,475	Medicare and private insurance
	28	1998-2011 (2004 $)	Nonrepresentative sample of dementia patients, baseline average age 76	$8,753	--	--	Self-reported, all payers
	29	2000-2004 (2010 $)	National sample age 70+	--	--	$10,039	All payers
	30	2000-2008 (2010 $)	Persons age 70+	$33,329	$28,501	--	Medicare and out of pocket

Source: Mathematica Policy Research.

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APPENDIX B

STUDY METHODOLOGY,
MATHEMATICA POLICY RESEARCH, JANUARY 2016

This appendix describes the methods used to produce estimates of health care spending for the four chronic diseases (diabetes, hypertension, obesity and obesity-related conditions, and dementia) and one risk behavior (tobacco use). The following sections describe our general approach—including methods and data—and then offer detail on the estimation of medical and prescription drug (Rx) costs for each chronic disease and for tobacco use. The same methods are used to estimate costs among the entire Minnesota population, and then among the population over age 60. All analyses are conducted at the unique person level.

A.   General approach

We estimate spending related to diabetes (type 1 and type 2 combined, since claims data cannot reliably distinguish the two conditions), hypertension, and dementia for medical services and Rx (respectively) in 2009 using methods analogous to those that underlie the CDC/RTI cost estimation model[11] with several key distinctions. Similar to the CDC/RTI model, we use data from the Medical Expenditure Panel Survey (2009 MEPS)—specifically, the self-reported screening questions for diabetes and hypertension—to measure the percentage of persons with each condition (by source of coverage, age, and sex) that use medical services and, of those, the percent that use Rx. Unlike the CDC/RTI model, we use the 2009 Minnesota MN APCD to (1) identify Minnesotans with each condition (when observable, based on the diagnosis codes on their medical claims) who are service users, and (2) calculate medical and Rx spending among service users controlling for other conditions that contribute to spending. Because no survey asks screening questions that would identify dementia, we assume that all persons with dementia are service users.

Based only on diagnostic coding in the MN APCD, the prevalence of either obesity or smoking in Minnesota would appear much lower than estimates from either MEPS or the Minnesota Behavioral Risk Factor Surveillance Survey (BRFSS) (Table 1). Therefore, for obesity and tobacco use (necessarily defined as smoking, but not other use of tobacco products), we calculate medical service/Rx rates using national MEPS data adjusted to the Midwest region using questions about BMI and, among respondents aged 18 or older, whether they currently smoke to estimate relative rates of service use among persons who smoke or are obese and, among service users, relative spending per member per month. (In contrast the CDC/RTI model relies on the non-public Minnesota population sample in MEPS to make these calculations.) These factors are used to estimate the marginal spending associated with (respectively) obesity and tobacco use, compared with average spending among service users calculated from the MN APCD by source of coverage, age, and sex.

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[11] The Chronic Disease Calculator measures the medical cost (and, separately, the cost of absenteeism) associated with arthritis, asthma, cancer, cardiovascular diseases (specifically, congestive heart failure, coronary heart disease, hypertension, stroke, and other cerebrovascular disease), depression, and diabetes. See technical documentation available at [http://www.cdc.gov/chronicdisease/calculator/resources.html], accessed November 30, 2015.

Table 1: Estimated Incidence of Obesity, Diabetes, Hypertension, Tobacco Use, and Dementia from BRFSS, MEPS and the MN APCD

	BRFSS 2009 – age 18+, excluding institutionalized persons, service users and nonusers (based on screening questions	MEPS 2009 – Midwest region, excluding institutionalized persons (based on ICD9 coding and screening questions if asked)			MN APCD 2009 – all ages, including institutionalized persons, service users only (based on ICD9 coding) *Revised preliminary estimates*
		Total – all ages, service users and nonusers	Total – age 18+, service users and nonusers	Total – all ages, service users only	
Obesity	24.9%	23.6%	30.1%	23.9%	4.5%
Diabetes (type 1 and 2)	6.4%	6.6%	8.6%	7.4%	7.3%
Hypertension	21.6%	19.9%**	26.2%**	22.1%**	14.9%***
Dementia	--	0.2%	0.2%	0.2%	1.4%
Tobacco use	16.7%*	16.5%*	21.7%	14.8%*	5.8%

Note: Conditions are identified in MEPS by reference to screening variables (when asked) and use of ICD9 codes. Conditions are identified in the MN APCD solely by use of ICD9 codes. Conditions are identified in BRFSS solely by reference to self-reported information to broad questions about ever having been diagnosed with a condition or whether the respondent currently smokes.

*Tobacco use estimate is reflects questioning about current smoking status among persons age 18 or older; persons under age 18 are included as nonusers in the "all ages" estimates.

** Identified in the MEPS Conditions file as two or more diagnoses of hypertension.

*** Identified as at least two claims coded with hypertension as either primary or secondary. Any diagnosis of hypertension (more comparable to BRFSS) produces an estimate of 19.9 percent.

B. Definitions

1.   Conditions

The screening variables and ICD9 codes used to identify the key diagnoses/risk factor and other diagnoses in MEPS (which reports abbreviated ICD9 diagnosis codes) and in the MN APCD (which reports full ICD9 diagnosis codes) are reported in Table 2. Estimates rely on medical claims exclusive of lab claims, which might code for conditions being tested—although lab claims, exclusive of a medical service claim coded with the condition, accounted for very few or none of the persons identified with any of the conditions.

Table 2: ICD9 Codes Used to Define Conditions in MEPS and the Minnesota MN APCD

Condition	MEPS	MN APCD
1. Diabetes (DIAB)	250, not 648	(362.0, 357.2, 366.41, 250), not 648
2. Obesity (OBES)	Reported BMI or 278, 649	278, 649.1, 649.2, v85.30 - v85.45
3. Hypertension (HPER)	Among adults age 18+, reported having been told 2+ times, or 401 – 405 twice or more	401 – 405 reported twice or more

4.	Dementia (DEMT)	290, 331	290, 331
5.	Tobacco use (TBCO)	Reported current smoker (age 18+)	305.1, 649.0, 649.2, v15.82
6.	Arthritis (ARTH)	714-716	714-716
7.	Asthma (ASTH):	493	493
8.	Any cancer (CANC)	140-210, 230-239	140-210, 230-239
9.	Cancers associated with obesity (CANC_OBES)[12]	150, 157, 153, 209, 230, 174 (if AGE>50), 182, 189, 193, 156	150, 157, 153, 209, 230, 174 (if AGE>50), 182, 189, 193, 156
10.	Cancers not associated with obesity (OTH_CANC_O)	140-210, 230-239 and CANC_OBES = 0	140-210, 230-239 and CANC_OBES = 0
11.	Cancers associated with smoking (CANC_TBCO)[13]	140-149, 150, 151, 157, 160 – 162, 170, 180, 182, 183, 188, 189, 205, 230, 231, 235	140-149, 150, 151, 157, 160 – 162, 170, 180, 182, 183, 188, 189, 205, 230, 231, 235
12.	Cancers not associated with smoking (OTH_CANC_T)	140-210, 230-239 and CANC_TBCO = 0	140-210, 230-239 and CANC_TBCO = 0
13.	Cancers not associated with either obesity or smoking (OTH_CANC)	140-210, 230-239 and CANC_OBES = 0 and CANC_TBCO = 0	140-210, 230-239 and CANC_OBES = 0 and CANC_TBCO = 0
14.	Congestive heart failure (CHF)	428	428
15.	Coronary artery disease (CAD)	414	414
16.	Stroke (STRO):	433-435	433-435
17.	Other cerebrovascular disease (OCVD)	402-438	402-438
18.	Depression (DEPR)	296, 300, 309, 311	296, 300, 309, 311
19.	Injuries (INJR)	800-998	800-998
20.	Dyslipidemia (DYSL)	272	272
21.	HIV/AIDS (HIVA)	42	42, V08
22.	Pneumonia (PNEU)	480-486	480-486
23.	Chronic obstructive pulmonary disease (COPD)	490-496	490-496
24.	Other mental health/substance abuse (MHSA)	291-295, 297-299, 301-308, 310, 312-314	291-295, 297-299, 301-308, 310, 312-314, v40
25.	Back problems (BACK)	720-724	720-724
26.	Skin disorders (SKIN)	216, 680-686, 690-698, 700-702, 705-709, 782	216, 680-686, 690-698, 700-702, 705-709, 782

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[12] Obesity-related cancers are those reported in: http://www.cancer.gov/about-cancer/causes-prevention/risk/obesity/obesity-fact-sheet#q3.

[13] Tobacco-related cancers are those reported by the CDC and augmented to further include uterine cancer, nasal and paranasal sinus cancers, and cerebrovascular disease (stroke).

27.	Renal failure (RENL)	584-586	584-586
28.	Pregnancy (PREG)	630-679, 760-779	630-679, 760-779, V22, V23
29.	Rheumatic heart disease (RHEU)	390-393, 395, 398	390-393, 395, 398
30.	Diseases of mitral and aortic valves & other endocardial structures (VALV)	93, 394, 396, 424, 725, 745, 746	93, 394, 396, 424, 725, 745, 746
31.	Acute and chronic pulmonary heart disease (PULM)	415-416	415-416
32.	Acute and other pericardial & endocardial disease (PERI)	397	397
33.	Cardiomyopathy (CARM)	425	425
34.	Conduction disorders (COND)	426	426
35.	Cardiac dysrhythmias (CDYS)	427	427
36.	Other or ill-defined heart disease (OTHH)	410-413, 429	410-413, 429

2.   Coverage

Common definitions of coverage are used across the MEPS and MN APCD analyses. Persons in MEPS are assigned to unique coverage categories by arraying their sources of coverage by month and selecting the coverage status that corresponds to the greatest number of months during the year (that is, their modal coverage status). For persons with equal months of coverage from two or more sources during most of the year, coverage is assigned hierarchically, giving precedence to Medicare, then commercial insurance or TRICARE, then Medicaid or other public coverage, and then uninsured. For persons in the MN APCD, sources of coverage by month are similarly arrayed and, when two or more sources account for most months during the year, the same hierarchy is used to assign coverage: first Medicare, then commercial insurance, then Medicaid or other public coverage. This process results in unique assignment of persons to a primary coverage status, although they may have claims paid from multiple sources of coverage during the year.

Where coverage sources are merged (that is, TRICARE and the uninsured, respectively, merged with commercial and for other public coverage merged with Medicaid), each analysis flags the smaller category of coverage (that is, uses indicator variables for TRICARE, uninsured, or other public) to develop separate estimates for that category independent of the larger coverage category (commercial coverage or Medicaid).

After developing marginal cost estimates for each condition and risk factor for persons (by age and sex) in each coverage category, the estimates are weighted to reflect the distribution of coverage (by age and sex) reported in 2009 in the Minnesota Health Access Survey.

3.   Age

Age categories are defined as: 0-17, 18-29, 30-44, 45-59, 60-64, 65-74, 75. To the extent possible, these age categories are defined as age in January 2009 across all analyses using BRFSS, MEPS, or the MN APCD. MEPS age, which is reported as age in December, is reduced by one year to calculate the incidence and relative cost of obesity and tobacco use.

4.   Household income

Household income deciles are assigned based on 2009 Minnesota population-weighted mean household income by ZIP Code Tabulation Areas (ZCTA) as reported in the American Community Survey and rounded to the nearest $100:

Household income decile	Household income range *Preliminary*
1	$0 - $54,400
2	$54,500 - $58,300
3	$58,400 - $61,500
4	$61,600 - $65,400
5	$65,500 - $70,000
6	$70,100 - $78,000
7	$78,100 - $84,100
8	$84,200 - $92,100
9	$92,200 – 110,800
10	> $110,800

Income deciles are assigned to unique persons in the MN APCD by mapping (1) the person's zip code to the ACS ZCTA and then (2) the ACS ZCTA to the corresponding household income decile. In effect, this process assumes each person in the MN APCD has household income approximately at his/her community mean defined as mean household income by ZCTA.

Having estimated acute care spending related to each condition/behavior from the MN APCD, we use Mathematica's annual estimates of long-term care spending in Minnesota to proportionately adjust the acute care estimates to include long-term care spending. By necessity, this method assumes that acute care spending and long term care spending are correlated.

The 2009 cost estimates for diabetes, hypertension, obesity, and tobacco use (smoking) are projected to 2014 using the annual rates of change in the incidence of the condition reported by age and sex in the Minnesota BRFSS (irrespective of coverage) and changes in coverage reported in the Minnesota Health Access Survey. The 2014 estimates are projected to 2019 assuming population change by age and sex as projected by the Minnesota Demographic Center, but no further change in the mix of coverage or the incidence of the condition/risk factor within age and sex categories. The 2009 cost estimates dementia are projected to 2014 based only on changes in coverage mix by population age and

sex, assuming no change in the incidence of dementia within age and sex categories; the 2014 estimates are then projected to 2019 based only on population change.

C. Estimation of 2009 acute care spending for residents represented in the MN APCD

The methods used to estimate spending for each chronic condition and risk factor are described below for populations represented in the MN APCD—specifically, residents covered by Medicare, commercial insurance, or Medicaid and other public programs. Estimates for populations not represented in the MN APCD—primarily residents with coverage from TRICARE or who are uninsured are estimated separately.

1. Diabetes

Medical and Rx spending (per member per month) associated with a diagnosis of diabetes (type 1 and type 2 combined) is estimated from the MN APCD among persons (by coverage category) who use services. The estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of diabetes. Because the models do not control for diagnoses that are clinically linked to diabetes,[14] the coefficient estimated for diabetes captures the impact on spending of clinically related conditions.

Estimated by coverage category among, respectively, service and Rx users, the spending models are specified as follows:

(1) Total medical spending pmpm = f (age category, sex, household income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, DEPR, INJR, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN, RENL, PREG)

(2) Total Rx spending pmpm = f (age category, sex, household income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, DEPR, INJR, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN, RENL, PREG)

We calculate five values associated with diabetes:

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[14] The diagnoses linked to diabetes are:
- congestive heart failure (CHF)
- coronary artery disease (CAD)
- stroke (STRO)
- other cerebrovascular disease (OCVD)
- rheumatic heart disease (RHEU),
- diseases of mitral and aortic valves & other endocardial structures (VALV)
- acute and chronic pulmonary heart disease (PULM)
- acute and other pericardial & endocardial disease (PERI)
- cardiomyopathy (CARM)
- conduction disorders (COND)
- cardiac dysrhythmias (CDYS)
- other or ill-defined heart disease (OTHH)

- Separately, medical and Rx spending for diabetes, estimated by age/sex category as the difference between the sum of expected medical/Rx spending (estimated with DIAB = 2009 values) and the spending that would occur if no Minnesota resident were diagnosed with diabetes (estimated with DIAB = 0).

- Total spending for diabetes, estimated as the sum of total medical and total Rx spending for diabetes, as described in the bullet above

- Direct medical spending, tabulated from the MN APCD as spending on medical claims with a primary diagnosis of diabetes.

- Indirect medical spending, estimated as the difference between total medical spending (as described in the first bullet) and direct medical spending.

2.   Hypertension

Medical and Rx spending (per member per month) associated with a diagnosis of hypertension is estimated from the MN APCD among persons (by coverage category) who use services. The estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of hypertension and excluding controls for diagnoses that are clinically linked to hypertension.[15]

Estimated by coverage category among, respectively, service and Rx users, the spending models are specified as follows:

(1) Total medical spending pmpm = f (age category, sex, community income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, STRO, OCVD, DEPR, INJR, HIVA, PNEU, COPD, MHSA, BACK, SKIN, PREG)

(2) Total Rx spending pmpm = f (age category, sex, community income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, STRO, OCVD, DEPR, INJR, HIVA, PNEU, COPD, MHSA, BACK, SKIN, PREG)

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[15] The diagnoses linked to hypertension are:
- congestive heart failure (CHF)
- coronary artery disease (CAD)
- dyslipidemia (DYSL)
- renal disease (RENL)
- rheumatic heart disease (RHEU),
- diseases of mitral and aortic valves & other endocardial structures (VALV)
- acute and chronic pulmonary heart disease (PULM)
- acute and other pericardial & endocardial disease (PERI)
- cardiomyopathy (CARM)
- conduction disorders (COND)
- cardiac dysrhythmias (CDYS)
- other or ill-defined heart disease (OTHH)

We calculate five values associated with hypertension:

- Separately, total medical and total Rx spending for hypertension, estimated by age/sex category as the difference between the sum of expected medical/Rx spending (estimated with HPER = 2009 values) and the spending that would occur if no Minnesota resident were diagnosed with hypertension (estimated with HPER = 0).

- Total spending, estimated as the sum of total medical and total Rx spending on hypertension

- Direct medical spending for hypertension, tabulated from the MN APCD as spending on medical claims with a primary diagnosis of hypertension.

- Indirect medical spending, estimated as the difference between total medical spending and direct medical spending.

3. Dementia

We assume that all persons with dementia are service users, so for this condition do not estimate an equation to estimate the probability of service use. Medical and Rx spending (per member per month) associated with a diagnosis of dementia is estimated from the MN APCD based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of dementia and excluding controls for diagnoses that are clinically linked to dementia.[16]

Estimated by coverage category among, respectively, service and Rx users, the spending models are specified as follows:

(1) Total medical spending pmpm = f (age category, sex, community income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, DEPR, INJR, DYSL, PNEU, COPD, MHSA, BACK, SKIN, RENL, PREG)

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[16] The diagnoses linked to dementia are:
- congestive heart failure (CHF)
- coronary artery disease (CAD)
- stroke (STRO)
- other cardiovascular disease (OCVD)
- HIV/AIDS
- rheumatic heart disease (RHEU)
- diseases of mitral and aortic valves & other endocardial structures (VALV)
- acute and chronic pulmonary heart disease (PULM)
- acute and other pericardial & endocardial disease (PERI)
- cardiomyopathy (CARM)
- conduction disorders (COND)
- cardiac dysrhythmias (CDYS)
- other or ill-defined heart disease (OTHH)

(2) Total Rx spending pmpm = f (age category, sex, community income decile, DIAB, OBES, HPER, DEMT, TBCO, ARTH, ASTH, CANC, DEPR, INJR, DYSL, PNEU, COPD, MHSA, BACK, SKIN, RENL, PREG)

As for diabetes and hypertension, we calculate five values associated with dementia:

- Separately, total medical and total Rx spending for dementia, estimated by age/sex category as the difference between the sum of expected medical/Rx spending (estimated with DEMT = 2009 values) and the spending that would occur if no Minnesota resident were diagnosed with dementia (estimated with DEMT = 0).

- Total spending for dementia, estimated as the sum of total medical and total Rx spending for dementia

- Direct medical spending for dementia, tabulated from the MN APCD as spending on medical claims with a primary diagnosis of dementia.

- Indirect medical spending for dementia, estimated as the difference between total medical spending and direct medical spending.

4.   Obesity

We use MEPS data statistically adjusted to the Midwest region to estimate the probability of service use among persons who (1) report BMI of 30.0 or more (for adults) or BMI at or above the 95th percentile for the person's age and sex (for children 6-17); or (2) who have spending for medical care coded with a diagnosis of obesity. The relative probability of medical service and Rx use, respectively, is estimated within coverage category using a logit regression model, specified as:

(1) P (medical service use) = f (age category, sex, household income decile, Midwest region flag, OBES flag)

(2) P (Rx use) = f (age category, sex, household income decile, Midwest region flag, OBES flag)

Relativity factors for the probability of medical service and Rx use, respectively, are calculated as:

- $R_{PMED \sim OBES}$ = the ratio of the probability of medical spending estimated with OBES = 1 to the probability of medical spending estimated with OBES = 0

- $R_{PRX \sim OBES}$ = the ratio of the probability of Rx spending estimated with OBES = 1 to the probability of Rx spending estimated with OBES = 0

The probability of medical service and Rx use, respectively, among Minnesotans who are non-obese is calculated by solving the following equation for P_MED$_{MN\ APCD}$, defined as is the unobserved probability of any service use among non-obese persons in the MN APCD:

- P_MED$_{MN\ APCD}$ = P_OBES * R$_{PMED \sim OBES}$ * P_MED$_{\sim OBES}$ + (1 − P_OBES) * P_MED$_{\sim OBES}$

- P_MED$_{\sim OBES}$ = P_MED$_{MN\ APCD}$ / (P_OBES * R$_{PMED \sim OBES}$ + 1 − P_OBES)

where $P\_MED_{MN\ APCD}$ is the probability of any service use in the MN APCD, whether or not among persons who are obese; P_OBES is the probability of obesity estimated from BRFSS; and $R_{PMED\text{-}OBES}$ is estimated from MEPS as described above.

A probability-of use estimate for Rx adjusted to the MN APCD and BRFSS rates of obesity in Minnesota is calculated analogously, to produce:

(1) $P\_RX_{\sim OBES} = P\_RX_{MN\ APCD} / (P\_OBES * R_{PRX\sim OBES} + 1 - P\_OBES)$

Medical and Rx spending (per member per month) associated with obesity among medical service/Rx users is also estimated in MEPS by coverage category, relative to the non-obese population who use medical services/Rx for any condition. The estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of obesity and excluding controls for diagnoses that are clinically linked to obesity.[17]

Estimated by coverage category among (respectively) medical service and Rx users, the spending models are specified as follows:

(3) Total medical spending pmpm = f (age category, sex, community income decile, Midwest region flag, OBES, HPER, DEMT, TBCO, ASTH, OTH_CANC_O, INJR, HIVA, PNEU, COPD, MHSA, RENL, PREG, RHEU, VALV, PULM, PERI, CARM, COND, CDYS)

(4) Total Rx spending pmpm = f (age category, sex, community income decile, Midwest region flag, OBES, HPER, DEMT, TBCO, ASTH, OTH_CANC_O, INJR, HIVA, PNEU, COPD,MHSA, RENL, PREG, RHEU, VALV, PULM, PERI, CARM, COND, CDYS)

From these equations, we calculate a spending relativity factors (by coverage, age, and sex category) for medical services and Rx associated with obesity among persons with spending > 0:

- $R_{MED\sim OBES}$ = the ratio of expected medical service spending per member per month if all Minnesotans were obese (estimated with OBES = 1) and the medical spending per member per month that would occur if none were obese (estimated with OBES = 0)

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[17] The diagnoses linked to obesity are:
- diabetes (DIAB)
- arthritis (ARTH)
- cancers associated with obesity (CANC_OBES)
- congestive heart failure (CHF)
- coronary artery disease (CAD)
- stroke (STRO)
- other cardiovascular disease (OCVD)
- depression (DEPR)
- dyslipidemia (DYSL)
- back problems (BACK)
- skin problems (SKIN)
- other or ill-defined heart disease (OTHH)

- $R_{RX \sim OBES}$ = the ratio of expected Rx spending per member per month if all Minnesotans were obese (estimated with OBES = 1) and Rx spending per member per month that would occur if all were obese (estimated with OBES = 0)

We use these relativity factors to medical and Rx spending, respectively, that would occur in each age/sex by coverage category among persons who have any spending for health care, if no Minnesota resident were obese as follows:

- $MED_{MN\ APCD} = (P\_OBES * R_{MED \sim OBES} * MED_{\sim OBES}) + (1 - P\_OBES) * MED_{\sim OBES}$

  $MED_{\sim OBES} = MED_{MN\ APCD} / (P\_OBES * R_{MED \sim OBES} + 1 - P\_OBES)$

- $Rx_{MN\ APCD} = (P\_OBES * R_{RX \sim OBES} * Rx_{\sim OBES}) + (1 - P\_OBES) * Rx_{\sim OBES}$

  $Rx_{\sim OBES} = Rx_{MN\ APCD} / (P\_OBES * R_{RX \sim OBES} + 1 - P\_OBES)$

where $MED_{MN\ APCD}$ and $Rx_{MN\ APCD}$ are actual medical and Rx spending per member per month among service users in the MN APCD, whether or not obese; P_OBE is the probability of an individual being obese, estimated from BRFSS; and $R_{MED \sim OBES}$ and $R_{RX \sim OBES}$ are defined as above.

Total medical and Rx spending pmpm, respectively, associated with obesity is then calculated as the difference between estimated spending if no Minnesotan were obese and actual spending in 2009:

- $(P\_MED_{MN\ APCD} * MED_{MN\ APCD}) - (P\_MED_{\sim OBES} * MED_{\sim OBES})$

- $(P\_Rx_{MN\ APCD} * Rx_{MN\ APCD}) - (P\_Rx_{\sim OBES} * Rx_{\sim OBES})$

These values are added and multiplied by total member months to calculate the total cost of obesity.

5. Tobacco use

Estimates for the probability of medical service and Rx use, and level of medical service and Rx spending if no Minnesotan smoked, are developed in the same way as estimates for obesity. The probability of medical service and Rx use, respectively, among smokers is estimated as:

(1) P (medical service use) = f (age category, sex, household income decile, Midwest region flag, TBCO flag)

(2) P (Rx use) = f (age category, sex, household income decile, Midwest region flag, TBCO flag)

Relativity factors for the probability of medical service and Rx use associated with smoking are calculated as:

- $R_{PMED \sim TBCO}$ = the ratio of the probability of medical spending estimated with TBCO = 1 to the probability of medical spending estimated with TBCO = 0

- $R_{PRX \sim TBCO}$ = the ratio of the probability of Rx spending estimated with TBCO = 1 to the probability of Rx spending estimated with TBCO = 0

The probabilities of medical service and Rx use among Minnesotans who are nonsmokers (respectively, P_MED$_{\sim TBCO}$ and P_RX$_{\sim TBCO}$) are calculated by age, sex, and coverage category as:

- P_MED$_{\sim TBCO}$ = P_MED$_{MN\ APCD}$ / (P_TBCO * R$_{PMED\sim TBCO}$ + 1 – P_TBCO)

- P_RX$_{\sim TBCOS}$ = P_RX$_{MN\ APCD}$ / (P_TBCO * R$_{PRX\sim TBCO}$ + 1 – P_TBCO)

where P_MED$_{MN\ APCD}$ and P_RX$_{MN\ APCD}$ are the probabilities of medical service use and Rx use, respectively, among all persons in the MN APCD in that age/sex/coverage category irrespective of smoking status, and P_TBCO is the probability of smoking estimated from BRFSS.

Medical service and Rx spending (per member per month) associated with smoking is estimated in MEPS by coverage category, relative to nonsmokers who use services/Rx for any condition. The estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of smoking and excluding controls for diagnoses that are clinically linked to smoking.[18]

Estimated by coverage category among, respectively, service and Rx users, the spending models are specified as follows:

(3) Total medical spending pmpm = f (age category, sex, family income decile, Midwest region flag, TBCO, DIAB, OBES, HPER, DEMT, ARTH, ASTH, OTH_CANC_T, CAD, OCVD, DEPR, INJ, DYSL, HIVA, MHSA, BACK, SKIN, RENL, PREG, RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH)

(4) Total Rx spending pmpm = f (age category, sex, family income decile, Midwest region flag, TBCO, DIAB, OBES, HPER, DEMT, ARTH, ASTH, OTH_CANC_T, CAD, OCVD, DEPR, INJ, DYSL, HIVA, MHSA, BACK, SKIN, RENL, PREG, RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH)

From these equations, we calculate medical service and Rx spending relativity factors (by coverage, age, and sex category) for tobacco among persons with spending > 0:

- R$_{MED\sim TBCO}$ = the ratio of expected medical service spending per member per month if all Minnesotans smoked tobacco (estimated with TBCO = 1) to the medical spending per member per month that would occur if none smoked (estimated with TBCO = 0)

- R$_{RX\sim TBCO}$ = the ratio of expected Rx spending per member per month if all Minnesotans smoked tobacco (estimated with TBCO = 1) and Rx spending per member per month that would occur if none smoked (estimated with TBCO = 0)

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[18] The diagnoses linked to smoking are:
- cancers associated with smoking (CANC_TBCO)
- congestive heart failure (CHF)
- stroke (STRO)
- pneumonia (PNEU)
- chronic obstructive pulmonary disease (COPD)

We use these relativity factors to medical and Rx spending, respectively, that would occur in each age/sex by coverage category among persons who have any spending for health care, if no Minnesotan smoked tobacco:

- $MED_{\sim TBCO} = MED_{MN\ APCD} / (P\_TBCO * R_{MED \sim TBCO} + 1 - P\_TBCO)$

- $Rx_{\sim TBCO} = Rx_{MN\ APCD} / (P\_TBCO * R_{RX \sim TBCO} + 1 - P\_OBES)$

where $MED_{MN\ APCD}$ and $Rx_{MN\ APCD}$ are actual medical and Rx spending per member per month among service users in the MN APCD, whether or not a smoker; P_TBCO is the probability of that an individual smokes tobacco, estimated from BRFSS; and $R_{MED \sim TBCO}$ and $R_{RX \sim TBCO}$ are defined as above.

Total medical and Rx spending pmpm, respectively, associated with tobacco is then calculated as:

- $(P\_MED_{MN\ APCD} * MED_{MN\ APCD}) - (P\_MED_{\sim TBCO} * MED_{\sim TBCO})$

- $(P\_Rx_{MN\ APCD} * Rx_{MN\ APCD}) - (P\_Rx_{\sim TBCO} * Rx_{\sim TBCO})$

These values are added and multiplied by total member months to calculate the total cost of smoking tobacco.

D.   Estimation of 2009 acute care spending for residents in TRICARE or uninsured

Several significant sources of financing for medical care and prescription drugs do not report to the MN APCD. These include, in particular, TRICARE and programs such as the Indian Health Service (IHS) and the Veterans Administration (VA) that help finance care for the uninsured. We estimate spending for Minnesota residents who were enrolled in TRICARE or who were uninsured in 2009 (separately).

Using MEPS, we estimate the probability of spending among TRICARE enrollees and the uninsured (respectively) relative to the commercially insured population for each condition identified by diagnosis in the MN APCD—diabetes, hypertension, and dementia .

To estimate the probability of use among persons with a diagnosis of diabetes or hypertension, we estimate the following models for each condition using logit regression:

(1) P (medical service use) = f (TRICARE, age category, sex, household income decile, Midwest region flag)

(2) P (medical service use) = f (UNINS, age category, sex, household income decile, Midwest region flag)

(3) P (Rx use) = f (TRICARE, age category, sex, household income decile, Midwest region flag)

(4) P (Rx use) = f (UNINS, age category, sex, household income decile, Midwest region flag)

For those with a diagnosis of dementia (all of whom we assume have medical spending > 0), we estimate:

(5) P (Rx use) = f (TRICARE, age category, sex, household income decile, Midwest region flag)

(6) P (Rx use) = f (UNINS, age category, sex, household income decile, Midwest region flag)

These models are used to calculate the expected probability of medical service and Rx spending among TRICARE enrollees and the uninsured (respectively) by age and sex for each condition.

Among medical service/Rx users with diabetes, hypertension, or dementia, we estimate the level of spending pmpm by age and sex each condition, we estimate generalized least squares (log-linked, gamma distribution) models as described in Sections C.1., C.2., and C.2., merging TRICARE enrollees and the uninsured (respectively) with the commercial population and adding indicator variables for TRICARE or uninsured. These models are used to calculate expected medical service and Rx spending pmpm among TRICARE enrollees and the uninsured for each condition relative to the commercially insured population.

For each condition, the ratio of expected spending pmpm among TRICARE enrollees and uninsured service users (respectively) to expected spending among the commercially insured population multiplied by MN APCD spending among the commercially insured population to produce MN APCD-adjusted estimates of spending pmpm for TRICARE and the uninsured, among service users. These estimates are weighted by the probability of medical service/Rx for TRICARE enrollees to arrive at total spending estimates for these populations and to the marginal spending estimates for populations included in the MN APCD to arrive at total marginal spending for each condition among all Minnesotans (both those included in the MN APCD and those not included).

Estimates of spending associated with obesity and tobacco use are produced analogously. The models specified in Sections C.3. and C.4. are estimated across the commercially insured population in MEPS including indicator variables for TRICARE and the uninsured, respectively. These models are used to calculate expected medical service and Rx spending among TRICARE enrollees and the uninsured who are obese or who smoke, relative to commercially insured service users in the MN APCD.

E.   Long-term care spending

For persons insured by Medicare, commercial insurance, or Medicaid or other public coverage, the MN APCD captures the use of covered acute and post-acute services, as well as covered long-term services and supports. We estimate total spending for each chronic condition to include these long-term care services, not differentiating estimates for acute/post-acute services versus long-term care.

This method distinguishes our estimates from the CDC/RTI model, which relies on MEPS expenditure data that exclude institutionalized persons. While the CDC/RTI model assumes that the uninsured account for no long term care spending, our estimates pick up differential acute and long-term care spending combined for the uninsured relative to the commercially insured population, controlling for age, sex, and household income.

F.   **Estimation of spending for chronic conditions among residents age 60 or older**

The estimates for each of the chronic conditions described in Section C include estimates for individuals age 60-64, 65-74, and 75 or older. Consequently, we are able to report medical service and Rx spending estimates for each condition among persons age 60 or older. However, because any individual might have more than one chronic condition, these estimates cannot be added to produce a combined spending estimate across the conditions.

We use the MN APCD is used to estimate a combined spending equation for diabetes, hypertension, and dementia among persons age 60 or older. The models (excluding all conditions interdependent with any of the chronic conditions of interest) are specified as:

   (1) Total medical spending pmpm = f (age category, sex, community income decile, DIAB, HPER, DEMT, ASTH, OTH_CANC, DEPR, INJR, MHSA)

   (2) Total Rx spending pmpm = f (age category, sex, community income decile, DIAB, HPER, DEMT, ASTH, OTH_CANC, DEPR, INJR, MHSA)

We calculate three values associated with the cost of diabetes, hypertension, and dementia:

- Separately, total medical service spending and total Rx spending, estimated as the difference between the sum of expected medical/Rx spending (estimated with actual 2009 values) and the spending that would occur if no Minnesota resident were diagnosed any of the conditions (estimated with DIAB, HPER, and DEMT = 0).

- Total spending, estimated as the sum of total medical and total Rx spending

Estimates of the marginal cost of obesity and tobacco use rely on the relativity factors developed for those conditions in Sections C.4. and C.5. Using BRFSS, the percentage of persons age 60+ are estimated in three categories: those who are obese but do not smoke, those who smoke but are not obese, and those who are both obese and smoke. Because the number of persons aged 60+ who are obese and also smoke is quite small (approximately 2 percent), their relative cost is assumed to be the higher of the relative costs for tobacco or obesity in each age category. As described in Section E, long-term care spending is included in all total spending estimates.

G.   **Projecting 2009 spending estimates to 2019**

The cost estimates for each condition/risk behavior in each age/sex cell are reweighted by coverage status to project the estimates to 2019 to reflect Census estimates of the Minnesota population by age and sex; these estimates are provided by the Minnesota State Demographic Center. Coverage status also is reweighted to MNHAS estimates through 2014, and assumed to remain at 2014 levels through 2019.

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