Treated Chronic Disease Costs in Minnesota – a Look Back and a Look Forward

Developing Estimates for 2009 and 2014 and Projecting 2023 Costs

REPORT TO THE MINNESOTA LEGISLATURE, December 2017

Treated Chronic Disease Costs in Minnesota – a Look Back and a Look Forward

Developing Estimates for 2009 and 2014 and Projecting 2023 Costs

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As requested by Minnesota Statute 3.197: The cost of producing this annual legislatively required report was approximately $426,000. This estimate includes staff time and contractor effort. In includes expenditures that were reported for the preparation of the status update report in July 2016.

DEPARTMENT OF HEALTH

Protecting, Maintaining and Improving the Health of All Minnesotans

December 4, 2017

The Honorable Michelle Benson
Chair, Health and Human Services Finance and Policy Committee
Minnesota Senate
3109 Minnesota Senate Building
95 University Ave. W.
Saint Paul, MN 55155-1606

The Honorable Matt Dean
Chair, Health and Human Services Finance Committee
Minnesota House of Representatives
401 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.
Saint Paul, MN 55155

The Honorable Joe Schomacker
Chair, Health and Human Services Reform Committee
Minnesota House of Representatives
509 State Office Building
100 Rev. Dr. Martin Luther King Jr. Blvd.
Saint Paul, MN 55155

To the Honorable Chairs:

As required by Minnesota Statutes, Section 62U.10, this report describes the results of the Minnesota Department of Health's (MDH) work in developing estimates of the health care costs directly associated with selected chronic conditions and smoking. Key findings of the analysis include:

- Spending on chronic disease, particularly for the elderly, accounts for significant share of total current and future total health care spending;
- Health care spending for all conditions rose from 2009 to 2014
    - Prevalence growth beyond the impact of aging contributed to the spending increase
    - Per-person spending for a number of categories actually fell;
- Ten-year projections of health care spending show considerable growth (24.8 percent to 65.1 percent) in costs;
- Compared to baseline projections, 2014 trends in health care spending are lower for some and higher for other conditions.

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. The dramatic projected growth in treatment costs and the contribution of increase in treated prevalence to this trend illustrated by this analysis reinforce the fact that Minnesota will not be able to treat its way out of this crisis. Without a strong and continuing focus on evidence-based strategies for preventing and managing chronic disease, the costs and the impact on the quality of life for individuals and communities will increase.

As required by statute, MDH also calculated the difference between actual and projected health care spending for 2014 for these conditions, and estimated the percentage of this difference that accrues to state-administrated health care programs. The analysis results indicate that the portion of the difference accruing to state-administered health care programs, as defined in section 62U.10, subdivision 8, will exceed $50 million. This will result in the required certification and transfer of $50 million in funding to the Health Care Access Fund on July 1, 2018. I have certified this finding in correspondence with Minnesota Management and Budget (MMB) Commissioner Myron Frans.

The enclosed report includes a copy of MMB certification, detailed findings from the analysis, the methodology that was used and actuarial certification of the approach used.

If you have any questions about this report, please direct them to Stefan Gildemeister at Stefan.Gildemeister@state.mn.us or 651-201-3554.

Sincerely,

Edward P. Ehlinger, M.D., M.S.P.H.
Commissioner
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St. Paul, MN 55164-0975

Contents

Executive Summary and Key Findings

This report analyzes treated chronic disease costs in Minnesota for a subset of chronic diseases and risk factors. Those include directly attributed costs for diabetes, hypertension, dementia, obesity, smoking and secondhand smoke exposure, and all chronic disease costs for those older than 60. The Legislature directed the Minnesota Department of Health (MDH) to conduct this analysis to provide another lens for understanding the extent to which certain chronic conditions and risk behaviors, which may be preventable through improved community health and healthier lifestyles, contribute to rising health care costs in Minnesota.

Other studies in Minnesota and elsewhere have attempted to estimate the impact of selected chronic conditions on total health care costs and to model how future costs might change under different scenarios. This work is unique in that it relies to a significant extent on Minnesota-specific data, focuses on a subset of conditions and risk factors that, together, account for a substantial share of disease burden, and hones in on medical expenditures that can be tied to the chronic conditions themselves, as opposed to looking at total health care spending for people with chronic conditions.

The key findings for this report include the following:

- Both the number of Minnesotans with one of these chronic conditions, and the prevalence rate, increased between 2009 and 2014 for all of the focus areas except for smoking and secondhand smoke exposure, which declined.
- Spending associated with these chronic conditions contributes substantially to total per-person health care spending.
- There is significant concentration of chronic conditions in the elderly population, raising long-term concerns for both costs and overall health for this population. More than 80 percent of people age 60 or over had at least one diagnosed chronic condition in 2014.
- Per-person spending associated with most of the studied conditions decreased between 2009 and 2014.
- Ten-year projections of spending show alarming levels of cost growth between 2014 and 2023, with prescription drug spending growing more quickly than medical spending for most conditions. For the conditions studied in this report, projected increases range from 24.8 percent (smoking exposure) to 65.1 percent (all chronic conditions, age 60+).
- Compared to projections, 2014 actual spending was lower than expected by $209 million. Actual spending in 2014 was below projections for diabetes, hypertension, obesity and dementia and higher than expected for chronic disease in the 60+ population and smoking and secondhand smoke exposure.

- State-administered health care programs accounted for more than $50 million of the difference between actual and projected spending in 2014. Per statute, this will trigger a transfer of $50 million from the state's General Fund to the Health Care Access Fund in 2018.

The key findings of this report reinforce the fact that Minnesota will not be able to treat its way out of rising costs associated with chronic conditions as our population grows and ages. By investing in a wide range of prevention activities, supporting care delivery and payment reform efforts, improving community health, and promoting healthier lifestyles, Minnesota is starting to see some signs of progress. However, even if Minnesota continued to reduce per-person health care costs for these conditions, it will not be enough. If we do not pair our ongoing efforts to create a more efficient health care delivery system with a public health approach that focuses on both individual and community-based strategies for reducing the prevalence of chronic disease, the state will continue to see health care costs for chronic conditions rise to a point where they become unsustainable.

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 for which they received treatment that year.[1] 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. There are many reasons for this, including disproportionate rates of poverty and the burden of discrimination.[2] Many chronic conditions, such as dementia and hypertension, become more common as people age. That means that as Minnesota's population becomes older on average, the costs associated with chronic disease will continue to rise. The trajectory of this growth will depend on many factors, but unless we are comfortable with absorbing the growth in spending and the related necessary shift in spending priorities for families, businesses, and government, we need to pay greater attention to what builds and sustains health in every community.

The Minnesota Department of Health (MDH) conducts a range of work to better understand trends in chronic disease and to identify ways to help prevent disease onset or delay progression. Previously we also conducted analyses to estimate the costs associated with health care spending for people with chronic disease. The 2016 analysis cited above used data from the Minnesota All Payer Claims Database (MN APCD) and found that in 2012, Minnesota's total health care spending on chronic disease-related treatment was $22.7 billion, representing more than 80 percent of the state's 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[3] 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 age—

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[1] Minnesota Department of Health, Health Economics Program, "Chronic Conditions in Minnesota: New Estimates of Prevalence, Cost and Geographic Variation for Insured Minnesotans, 2012" January 2016

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

[3] This estimate is derived from spending for chronic disease across the total population of Minnesotans who hold 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 estimate of the total cost burden associated with chronic disease.

i.e., young people are less likely to have a chronic condition and more likely to have lower health care costs— having a chronic condition increases annual medical costs. Living with multiple chronic conditions adds on average an additional $4,000 to $6,000 in total health care expenses per person.

In order to measure the fiscal opportunity associated with reducing likely trends in disease prevalence and spending, and to assess existing progress towards that goal in Minnesota, the Legislature directed MDH to conduct this analysis by focusing on health care spending directly related to a set of conditions and risk factors.[4] Specifically, the Minnesota Legislature directed MDH to:

1. Identify health care spending directly attributable to diabetes, hypertension, dementia, obesity, smoking and secondhand smoke exposure, and all chronic disease costs for those older than 60;
2. Project how condition-attributable spending would rise, taking demographic and price changes into account;
3. Compare the latest actual, observable health care spending for the conditions and risk factors with the projection baseline; and
4. Estimate the share of the difference between actual and projected spending attributable to state-administered programs.[5]

To conduct this work, an interdisciplinary team at MDH worked with Mathematica Policy Research, an independent and nationally known research firm, to review the literature, develop the methodology and analytic approach, model actual and projected spending estimates and obtain actuarial certification of data, methods and assumptions. MDH also sought input from stakeholders and a content expert group with members from Minnesota and beyond.

The previous analysis in 2016 focused on a wider range of conditions and estimated all health care costs associated with persons who had one or more chronic conditions, whether or not the costs were associated with the chronic conditions. In contrast, this report offers our first opportunity to examine more closely only those health care costs directly associated with six specific conditions and risk factors. This targeted approach will produce important new information for Minnesota in a number of areas.

- It helps us understand the trend in treated disease prevalence – how many patients with a diagnosed condition received medical care in a calendar year;

[4] Minnesota Statutes, section 62U.10, subd. 6 to 8.

[5] This includes the State Employee Group Insurance Program (SEGIP) and Medicaid and MinnesotaCare.

- It allows us to begin to track per-person health care spending for people with these conditions, as well as the share of total spending attributable to selected conditions and risk factors;
- It gives us a new metric of statewide, annual spending in disease-attributable health care costs;
- By projecting the expected growth in medical spending in Minnesota for the six categories over 10 years, it allows us to more effectively plan for a sustainable approach to health care spending; and
- It gives us important new insight into the contribution of medical and pharmacy spending to overall trends.

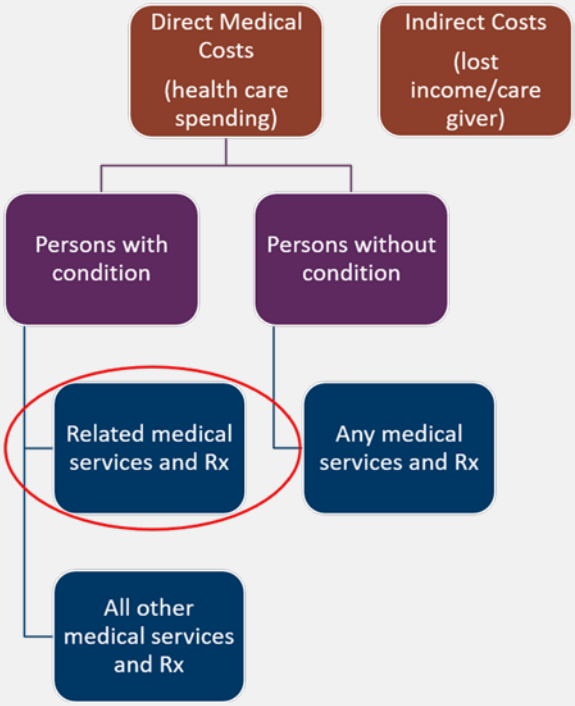
As with any study, it's important to understand the research questions and the data and methods in order to understand what it can and cannot tell us. By focusing on health care costs - medical and pharmacy spending – directly associated with chronic conditions rather than *all* health care costs for someone with a chronic condition or considering non-medical costs, this study looks at a specific slice of the impact of disease or risk factors (see sidebar). This allows us to more effectively hone in on how these specific conditions are treated, and track changes over time. But the estimates do

WHAT IS DISEASE-ATTRIBUTABLE HEALTH CARE SPENDING?

There are a range of ways to measure the cost impact of disease and risk factors, such as tobacco.Direct health effects typically measure the cost of treating the condition, while indirect effects aim to quantify larger economic impacts like lost income to the patient, years of life lost, or time away from work.

Direct cost impacts distinguish between the cost of health care spending devoted on individuals with a condition compared to those without, for example to assess, on average, how much health care spending diabetics experience, compared to people who do not have diabetes.

The finer distinction made in this report is to separate spending for people with a certain condition that is a direct outcome of the condition from the cost of care that is unrelated. For example we would count hypoglycemia for diabetes, but not pneumonia. As noted elsewhere, this distinction presents methodological challenges and does not capture the potentially complicating impact of disease on unrelated care.



not include the indirect costs of disease associated with, for example, lost work or income, changes in quality of life, need for caregiver support, or other non-medical costs. Importantly, in attributing spending to a specific chronic condition or risk factor, the research team did not aim to consider the spill-over effects from the presence of a disease on treatment costs of an unrelated condition.[6]

The Minnesota estimates in this report should not be directly compared to other studies that used different methodologies or data sources. There are also a number of methodological features used in this analysis that result in more robust, but lower estimates of attributable spending, making direct comparison with certain national or local estimates not particularly meaningful. These include:

- As much as possible developing direct estimates based on information about chronic disease and spending for Minnesota residents, rather than relying on research studies for specific populations or in particular settings.
- Estimates were carefully adjusted for unrelated health care.[7]

As with all empirical studies, estimates developed for this report are associated with estimation errors – observed differences in estimates over time or across comparison groups may not, in fact, be different at a statistically significant level. Further, estimates based on a small set of observations – mostly obesity and tobacco – are likely less robust than estimates derived from broader data. Finally, limitations in the data prevented us from developing estimates for all population groups; as a result, our spending estimates are likely low.[8]

Additional detail on how these estimates compare with existing estimates in the literature, the methodological approach to modeling spending estimates and projections, and limitations associated with the estimates are available in the Appendix Sections of this report.

[6] In other words, the study didn't capture the effect of diabetes or obesity, for example, on the intensity of care required for unrelated conditions, such as acute care needs. While it is feasible that the prescence of these chronic conditions would complicate and potential increase spending for unrelated health care services, capturing them as part of this study was out of scope.

[7] Detailed specifications for each condition and risk factor can be found in Appendix xx.

[8] For example, the analysis of obesity and tobacco-attributable spending did not include people 65 years or older, because draft estimates did not meet tests of reliability.

Summary of Findings

Treated prevalence in 2009 and 2014 rose: Both the number of Minnesotans with one of the chronic conditions and the prevalence of chronic conditions increased from 2009 to 2014 for diabetes, hypertension, dementia, obesity, and chronic conditions for people age 60 or older. The one exception was smoking and secondhand smoke exposure. Despite the decrease in the number of people exposed to smoking, smoking exposure was the most prevalent condition for the population groups and conditions and risk factors studied in 2009 and 2014, followed by hypertension and obesity.

The accumulation of chronic conditions among the elderly raises longer-term concerns: In 2014, nearly 900,000 adults age 60 or older (81.2 percent) had at least one diagnosed chronic condition (an increase from about 700,000 and 77.8 percent in 2009).

Chronic disease contributed substantially to health care spending. Condition-attributable spending accounted for a sizable share of total per-person spending in 2014. This was the case particularly for elderly Minnesotans with one or more chronic conditions (83.0 percent). However, the share of total spending contributed by chronic disease spending was large for other persons as well: people with diabetes (19.7 percent), adults with dementia (13.2 percent), and people of any age with hypertension (29.4 percent).

Estimated total spending increased for all of the conditions and smoking exposure. Despite decreases in per-person spending for a number of conditions from 2009 to 2014 (diabetes, hypertension and dementia), attributable health spending grew for all categories studied.

Condition-attributable health care spending is projected to rise steadily for all conditions and risk factors: Between 2014 and 2023, health care spending attributable to selected chronic conditions and smoking exposure is projected to grow between 24.8 percent and 65.1 percent.

Prescription drug spending shows high rates of growth: For most conditions and smoking exposure, prescription drug spending is growing more quickly than spending for medical services. Still, most of the projected growth in attributable spending in Minnesota is estimated to be due to changes in spending for medical services.

Actual spending in 2014 was below baseline projections by about $209 million: Actual spending in 2014 was below projections for most conditions, with the exception of spending among Minnesotans 60 years and older with chronic conditions and the projections for costs attributable to smoking and secondhand smoke exposure. Across all conditions, but not counting smoking exposure, actual spending in 2014 was about $209 million below what the baseline projected.

State-administered programs accounted for more than $50 million of the difference between actual and projected spending in 2014: Based on available data, we used two different methods to approximate the share of the difference between actual and projected spending that can be attributed to state-administered programs (Medicaid, MinnesotaCare and the State Employee Group Insurance Program). Using these two methods, we estimate that the public program share of the difference between actual and projected spending was between $54.6 million and $68.1 million.

Estimates of Condition-Attributable Health Care Spending

In this section we present results from the estimation process to identify health care spending directly attributable to selected chronic conditions and smoking exposure. We focus here on prevalence of treated conditions, as well as per-person and total condition-attributable spending for the years 2009 and 2014. Projections are presented in the next section.

Diabetes

Our analysis of health care spending that is attributable to diabetes is designed to:

- Include spending for diabetes-related health care conditions, such as kidney disease and hypoglycemia (low blood sugars), and
- Exclude spending for unrelated conditions or conditions not directly caused by diabetes, like pneumonia.

A portion of the costs was attributed to diabetes if a condition such as hypertension was made worse by a person also having diabetes. The estimates use health care administrative data derived from payers of health care in Minnesota, including insurers, pharmacy benefit managers (PBM) and third-party administrators (TPA). To account for health care spending for people who are not typically part of these data sets (e.g., the uninsured and some federal payers), the data are adjusted using the Midwestern sample of the Medical Expenditure Panel Survey, adjusted to reflect Minnesota's distribution of health insurance coverage. Estimates for diabetes-attributable spending for this report are calculated for people of all ages.

Treated Diabetes Prevalence

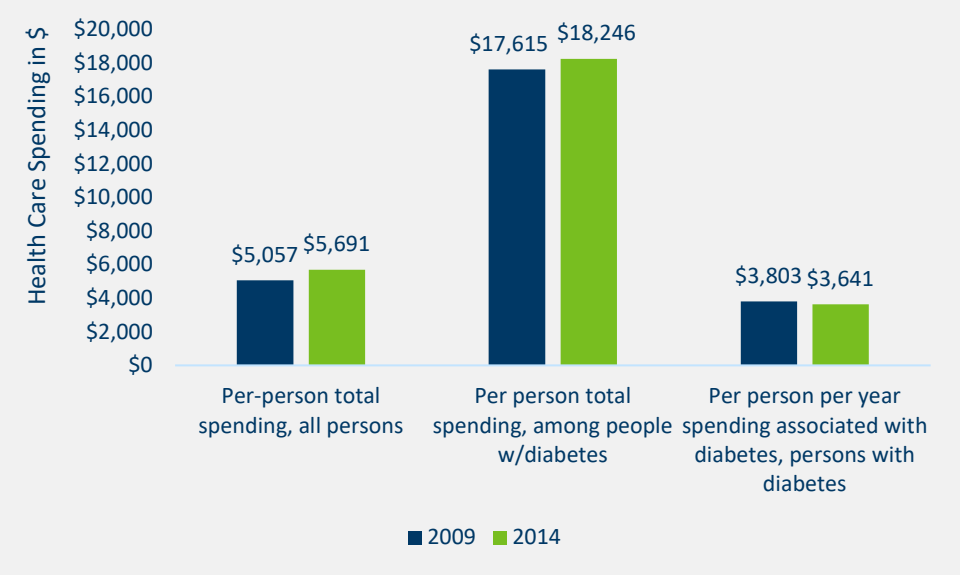
In 2014, more than 336,000 Minnesotans of all ages had diabetes for which they received health care services. The number of people with diabetes increased by about 44,000 between 2009 and 2014, growing for all age groups. The largest increase (23.9 percent) was seen among adults 65 years old or older. This age group accounted for nearly 66 percent of the growth in the population with diabetes over the five-year period.

Health Care Spending on Diabetes

We estimate that in 2014 Minnesotans with treated diabetes spent about 3.2 times as much on health care as did Minnesotans without diabetes or related illnesses (about $18,000 and

$5,700, respectively, as shown in Figure 1). About 20 percent of the 2014 per-person spending for people with diabetes, or $3,641, was directly attributable or thought to be caused by having diabetes.

Figure 1: Per Person Health Care Spending Among All Minnesotans and People with Diabetes



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Figure 2 illustrates that estimated medical spending, including spending for doctors' appointments, laboratory tests, procedures and equipment, made up 72 percent (or $3,054) of costs attributed to treated diabetes in Minnesota in 2014. Pharmacy spending, mainly prescriptions, accounted for 28 percent (or $749) of costs attributed to treated diabetes in Minnesota.

If we aggregate the total costs for diabetics that we can directly link back to the condition or, in other words, attributed costs, four percent of all health care spending in Minnesota was for diabetes or related conditions. As shown in Figure 3, in 2014 this amounted to about $1.2 billion for conditions attributed to diabetes (the sum of 880 million in medical spending and $344 million in retail drug spending).

Total diabetes-attributable health care spending increased by about 10 percent between 2009 and 2014 even though per-person spending attributed to the condition decreased modestly over the same period.

Figure 2: Per Person Per Year Spending Associated w/Diabetes, Type of Spending

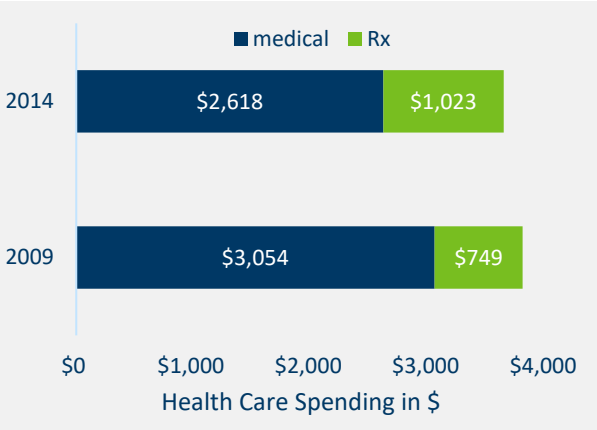
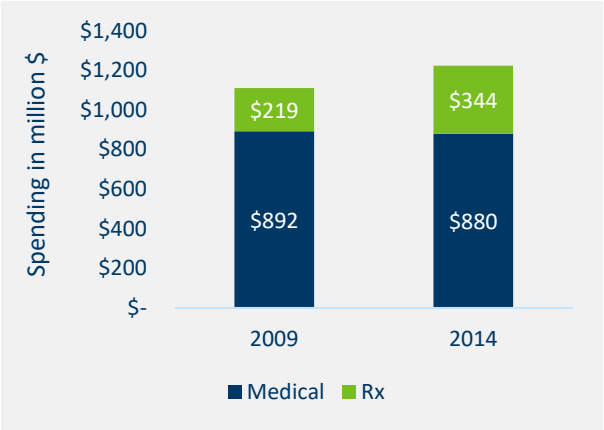


Figure 3: Total Annual Spending Attributable to Diabetes by Type of Spending ($ millions)



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Hypertension

Our analysis of health care spending that is attributable to hypertension is designed to:

- Include spending for hypertension-related conditions, such as heart attack and stroke, and
- Exclude spending for unrelated conditions or acute care needs, such as pneumonia, obesity and diabetes that are not likely caused by hypertension.[9]

The estimates use health care administrative data derived from payers of health care, including insurers, PBMs and TPAs. To account for health care spending for people who are not typically part of this data (e.g., the uninsured and some federal payers), the estimates are adjusted using the Midwestern sample of the Medical Expenditure Panel Survey, adjusted to reflect Minnesota's distribution of health insurance coverage. Estimates of hypertension-attributable spending for this report are calculated across all ages.

Because the source data for the analysis are medical and pharmacy claims, the estimates cannot account for two groups of individuals:

[9] In late 2017, the national guideline for the identification and management of hypertension was revised, lowering the threshold for a hypertension diagnosis from 140/90 mm Hg to 130/80 mm Hg. The estimates and projections presented in this report are consistent with the original higher hypertension cutpoint of 140/90 mm Hg, and do not take the revised hypertension guidelines into account.

- An unknown number of patients with a hypertension diagnosis who have not had any medical claim over the course of the year, even if they are taking hypertension medications. This includes patients who receive free blood pressure checks at their provider as a way to monitor their hypertension; this population has very low or no medical costs attributable to hypertension.
- Patients who have elevated blood pressure but do not have a hypertension diagnosis or pharmacy claim for a hypertension medication.[10] This population is likely incurring costs, especially medical costs, for hypertension and associated conditions.

Treated Hypertension Prevalence

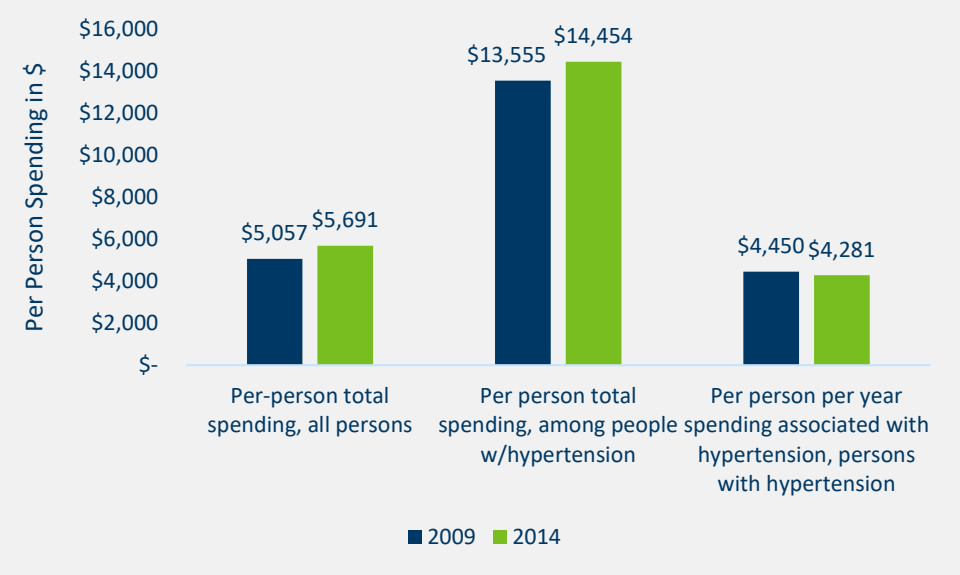
In 2014, about 1.04 million Minnesotans of all ages had hypertension, or high blood pressure, a condition for which they received health care services. The number of people with hypertension grew between 2009 and 2014 for all age groups, increasing by about 126,000 people, with the largest increase seen among adults 65 years old or older (a 23.4 percent increase). This age group accounted for more than 70 percent of the growth in the population with hypertension over the five-year period.

Health Care Spending on Hypertension

We estimate that in 2014 Minnesotans with treated hypertension spent about 2.5 times more on health care than did Minnesotans without hypertension or related illnesses (about $14,500 and $5,700, respectively, as shown in Figure 4). Nearly one-third (29 percent) of the 2014 per-person spending for people with hypertension, or $4,281, was directly attributable or thought to be caused by having hypertension.

[10] Data from the 2011-2012 National Health and Nutrition Examination Survey estimates this population of unaware, undiagnosed, and untreated individuals to increase the estimated number of hypertensive adults by approximately 22%. (Nwankwo T, Yoon SS, Burt V, Gu Q. Hypertension among adults in the United States: National Health and Nutrition Examination Survey, 2011–2012. NCHS data brief, no 133. Hyattsville, MD: National Center for Health Statistics. 2013).

Figure 4: Per Person Spending Among All Minnesotans and People with Hypertension



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Figure 5 illustrates that estimated medical spending including doctor's appointments, hospitalizations, laboratory tests, procedures, and equipment made up nearly 82 percent (or $3,530) of costs attributed to treated hypertension in Minnesota. Pharmacy spending, mainly retail prescriptions, accounted for the remaining 18 percent of costs attributed to treated hypertension in Minnesota (or $751).

If we aggregated the total costs of hypertension that we can directly link back to the condition or, in other words, attributed costs, 16 percent of all health care spending in Minnesota was for hypertension or related conditions. As shown in Figure 6, in 2014 this amounted to about $4.5 billion in spending for conditions attributed to hypertension (the sum of $3.7 billion in medical spending and $783 million in prescription drug costs).

Total hypertension-attributable health care spending increased between 2009 and 2014 (by about 9.5 percent), even though per-person spending attributed to hypertension decreased modestly over that period.

The modest decrease in per-person spending attributed to hypertension was due to decreases in medical spending, especially for seniors. Significant increases in per-person pharmacy spending were observed for all age groups (11 percent in seniors to 41 percent in children).

Figure 5: Per Person Per Year Spending Associated w/Hypertension, Type of Spending

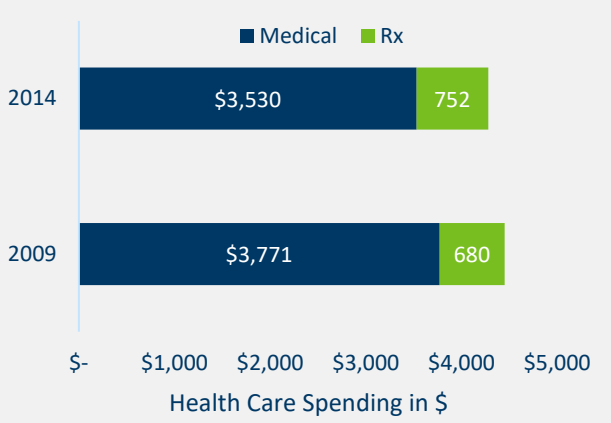
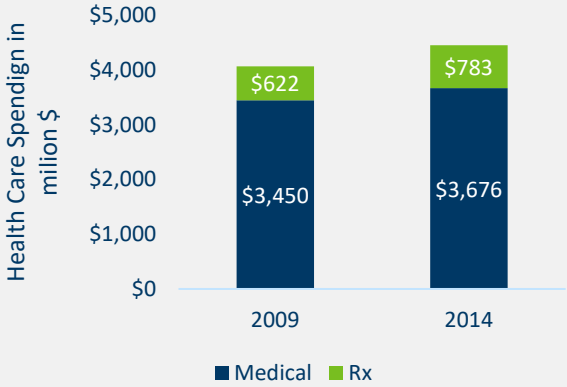


Figure 6: Total Annual Spending Attributable to Hypertension by Type of Spending ($ millions)



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Dementia

Our estimates of health care spending attributable to dementia aims to include spending for services directly caused by dementia and exclude spending for unrelated conditions or acute care needs. Because diagnoses of dementia are very rare among children, the estimates are limited to adults 18 years old or older.

The estimates were developed by identifying the presence of a dementia diagnosis and attributed health care costs in administrative health care claims data.[11] As such, a clinical diagnosis of dementia was necessary to identify dementia-related spending. However, to the extent that clinicians do not actively seek a dementia diagnosis – it typically requires performing tests without clear benefits derived from establishing a diagnosis – the number of individuals with dementia and their spending in this report likely represent an undercount. This is even more so the case, as a significant share of the costs associated with dementia is out-of-pocket spending for formal in-home or nursing home care that is largely not an insurance- or program-covered service, identifiable in health care claims data.

In addition, the focus in this analysis is on dementia for elderly people, including Alzheimer's, and vascular dementia, and does not include dementias brought on by alcohol-related diseases

[11] Additional methodological detail is available in the methods appendix.

(e.g., Wernicke-Korsakoff Syndrome) or manifestations of diseases such as Huntington's or Parkinson's.

Treated Dementia Prevalence

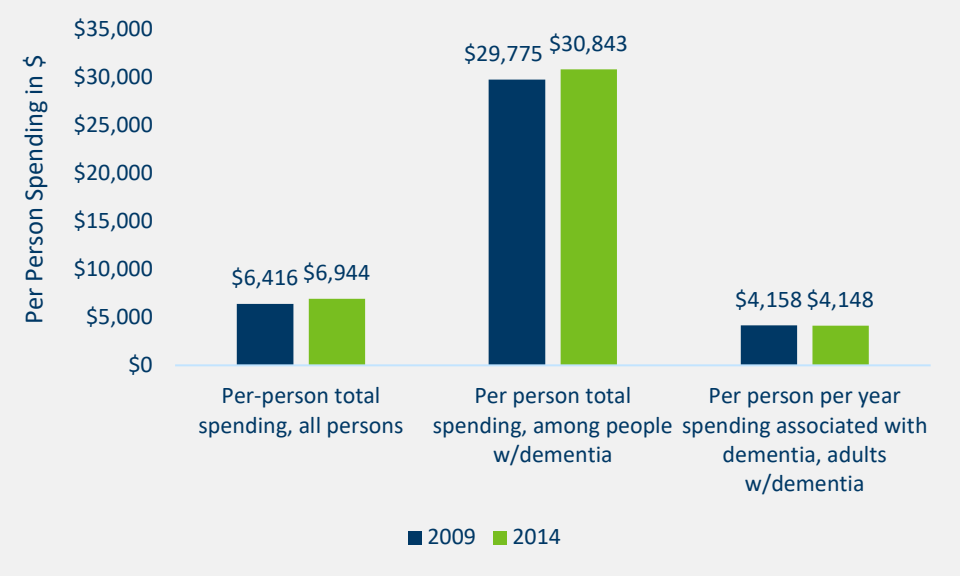
In 2014, about 54,000 Minnesotans were estimated to have been diagnosed and treated for a range of dementias, including Alzheimer's and vascular dementia. Most of these individuals (87.7 percent) were 65 years old or older; dementia under age 45 was rare, accounting for about 1.9 percent.

Treated prevalence for dementia – the percent of people within an age group diagnosed with the disease – remained largely unchanged between 2009 and 2014. However, because the size of the population age 65 or older, those with the greatest likelihood to develop the disease, increased substantially between 2009 and 2014, the number of people in Minnesota living with the disease grew as well (by about 17.8 percent).

Health Care Spending on Dementia

We estimate that in 2014, Minnesota adults with treated dementia and related conditions had more than four times as much health care spending as did adults without the disease ($31,000 and $6,900, respectively, as shown in Figure 7). Approximately 13.2 percent of the 2014 per-person spending for people with dementia, or $4,148 was directly related to the care of dementia and related conditions. Per-person spending for dementia between 2009 and 2014 was largely unchanged, declining by approximately one-fourth of a percent.

Figure 7: Per Person Spending Among All Minnesotans and People with Dementia



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Figure 8 illustrates that estimated medical spending, including spending on doctors' appointments, hospitalizations, laboratory tests, procedures, and equipment for Minnesotans with dementia, accounted for nearly all (94.4 percent) of dementia-attributable per-person spending in 2014, or about $3,915. Pharmacy spending on prescription medication accounted for the remaining 5.5 percent of dementia-attributable spending that year, or $233.

If we aggregate the total cost that we can directly link to treating dementia, in other words, attributed costs, we find that less than one percent (0.89 percent), or $223.2 million in health care spending, was devoted for the treatment of dementia in 2014. This is up 17.1 percent (about $32.7 million) from total dementia-attributable spending in 2009. All of the increase was associated with greater medical spending for a growing population; pharmacy spending actually fell over this five-year period.

Figure 8: Per Person Per Year Spending Associated w/Dementia, Type of Spending

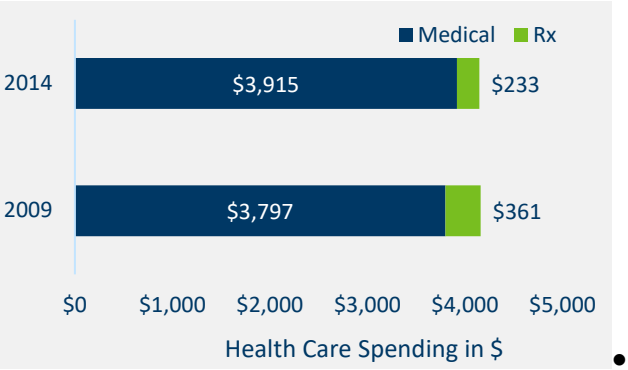
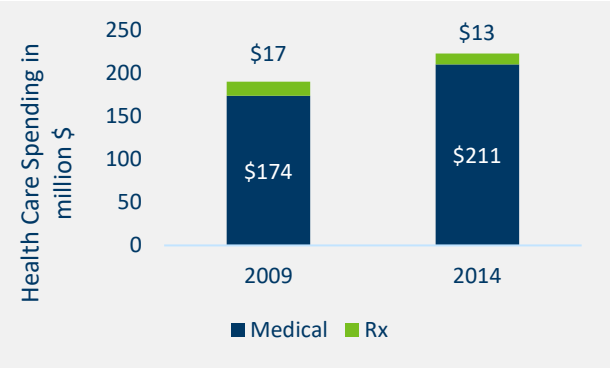


Figure 9: Total Annual Spending Attributable to Dementia by Type of Spending ($ millions)



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Chronic Disease For People 60 Years Old or Older

Our analysis of health care spending for people 60 years old or older is designed to identify costs attributable to chronic disease. The estimates were developed by identifying the presence of a diagnosed chronic condition and associated treatment in health care administrative data using the Johns Hopkins ACG algorithm.[12] The chronic conditions considered in this part of the analysis include those conditions that otherwise are the focus of this report (diabetes, hypertension, dementia, and obesity) but extend beyond them to include, among others, diseases of the central nervous system, cancers, metabolic disorders, and cardiovascular disease. This analysis was not extended to include people who were uninsured or had Tricare coverage, because there were too few people of that age in the MEPS population sample to support stable estimates.[13]

Treated Prevalence of Chronic Conditions for People Age 60 or Older

As noted earlier, most people ages 60 years or older live with one or more diagnosed condition for which they receive medical care or prescription drugs. In 2014, this was about 878,000 Minnesotans, accounting for 81.2 percent of the total population 60 years old and older. As prevalence of chronic disease grows with age, more people 75 years old or older had a chronic condition in 2014 (87.8 percent) than did people age 60 to 64 (77.5 percent).

Both the share of people age 60 or older with a chronic disease and the number of people with chronic conditions jumped between 2009 and 2014 for all age groups. In total, there were almost 183,000 more people age 60 or older in 2014 who had a treated chronic condition compared to five years earlier - a 26.3 percent increase.

Health Care Spending for People Age 60 or Older with Chronic Conditions

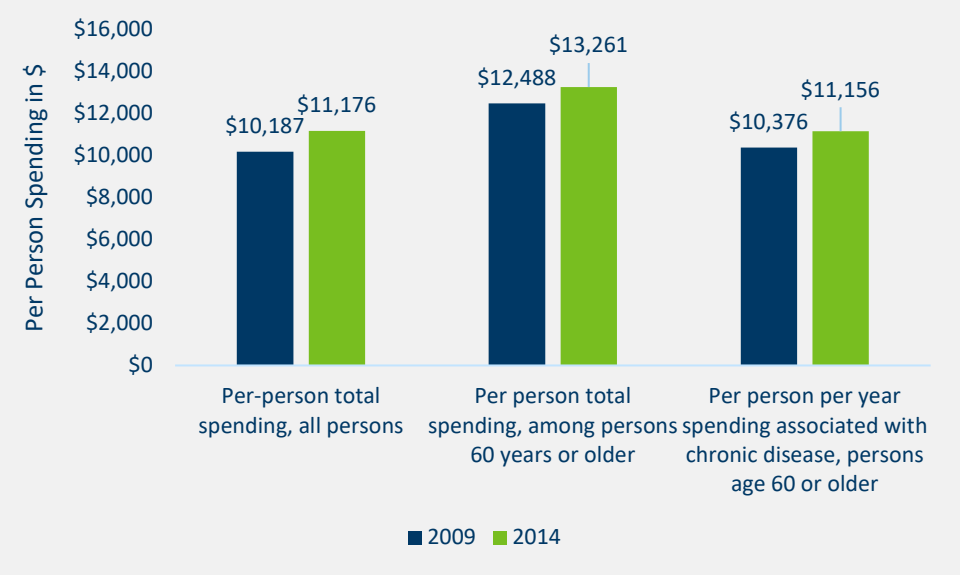
[12] This algorithm was used in an earlier analysis on the treated prevalence and cost of care for people with chronic conditions from 2016: http://www.health.state.mn.us/divs/hpsc/hep/publications/costs/20160127_chronicconditions.pdf. Additional methodological detail is available in the methods appendix.

[13] Most people that age had commercial coverage or were enrolled in Medicare.

Health care spending for Minnesotans age 60 and older with one or more treated chronic conditions was comparable to similarly aged people without chronic conditions, largely as a result of the broad cross-section of elderly needing care for chronic disease. As shown in Figure 10, per-person spending differed by approximately $2,000 in both 2009 and 2014.

For people in this age group with chronic disease, nearly all of their 2014 health care spending (84.2 percent), or about $11,156, was associated with treating their chronic condition.

Figure 10: Per Person Spending Among All Minnesotans and People with a Chronic Condition, Persons Age 60 or Older



Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates exclude persons who are uninsured or enrolled in Tricare, and therefore are not represented in the MN APCD

Figure 11 illustrates that estimated medical spending, including spending on doctor's appointments, laboratory tests, procedures, and equipment, made up 90.2 percent of costs attributed to treated chronic conditions for this group. Pharmacy spending on retail prescription medication made up the remaining 9.8 percent of chronic disease-attributable cost.

If we aggregate the total costs of chronic disease for people age 60 or older that we can directly link to treating chronic conditions, these attributable costs of health care spending made up about $9.79 billion in 2014 (see Figure 12).

Compared to five years earlier, total chronic disease-attributable spending in 2014 rose substantially, at 35.8 percent, with the pharmacy portion of spending outpacing that of medical

care by a factor of two (77.9 percent and 32.1 percent, respectively). As noted earlier, this change is driven both by growth in per person spending, as well as an increase in the number of people 60 years old or older with a chronic disease.

Figure 11: Per Person Per Year Spending Associated w/Chronic Disease, for Persons Age 60 or older, by Type of Spending

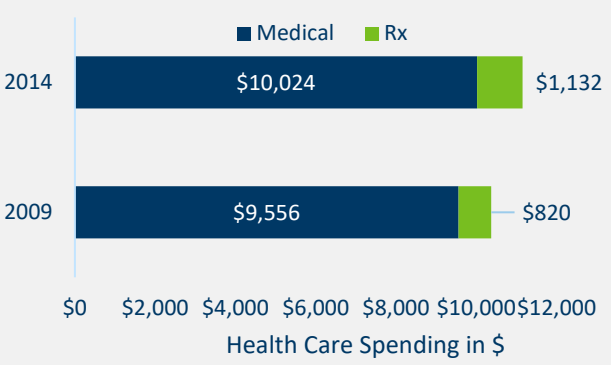
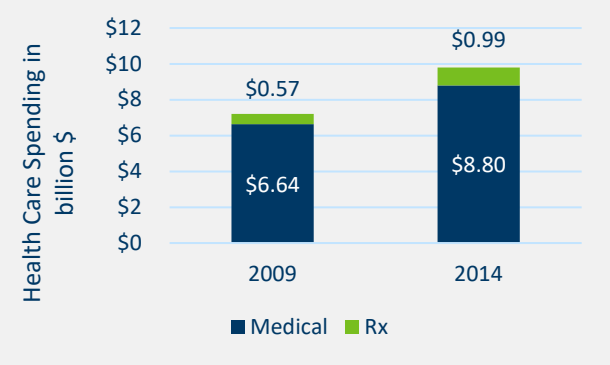


Figure 12: Total Annual Spending Attributable to Chronic Disease for Persons Age 60 or Older, Type of Spending ($ billions)



Source: Mathematica Policy Research analysis of the Minnesota All Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Smoking Exposure

Our analysis of health care spending attributable to smoking exposure is designed to capture spending on health care services and prescription drugs for care that:

- Is directly attributable to smoking and secondhand smoke, defined in this report as current smokers, former smokers, or individuals who lived with a family member who smoked, and
- Includes spending for health care conditions directly related to the forms of smoking exposure analyzed for this report, such as asthma and lung cancer.
- Excludes spending for unrelated conditions or acute care needs.

Estimates of spending for smoking and secondhand smoke exposure were calculated for people age 18 to 64, primarily because stable estimates for older Minnesotans could not be derived from available data that are characterized by a low number of observations.

Because smoking status is not identified in claims data, the analysis identifies current smokers by using data from the Medical Expenditure Panel Survey (MEPS). Past smoking was identified through a linked MEPS sample to the adult National Health Interview Survey. Secondhand

smoke exposure—for which living with a smoker was used as a proxy—was determined using Behavioral Risk Factor Surveillance System (BRFSS) data. Spending estimates are based on national data from the MEPS adjusted to match the MEPS Midwest region that includes Minnesota. To improve the accuracy of estimates, the analysis used three-year pooled data, as is common practice. Compared to other available studies, this analysis much more precisely controlled for health care spending for conditions unrelated to smoking, or co-morbidities.[14]

Nevertheless, the analysis of smoking exposure more so than for chronic conditions relied on a relatively small number of observations, which produced somewhat variable estimates across the years. As such, these estimates are likely associated with greater statistical error than other estimates produced for this report. Additional detail on the methodological approach, data and detailed estimates is available in the Appendix.

Prevalence of Smoking Exposure

In 2014, an estimated 1.2 million Minnesotans ages 18 to 64 were current smokers, former smokers, or lived with a family member who smoked (and thus, were potentially exposed to secondhand smoke). The proportion of people who were current or former smokers, or who lived with a family member who smoked, actually decreased between 2009 and 2014 by about 4.9 percent. The largest decline for the study population was seen among persons age 45 to 64, which fell by 8.5 percent or an estimated 55,000 Minnesotans.

Health Care Spending for Patients with Smoking Exposure

We estimate that in 2014, non-elderly Minnesotans with smoking exposure, that is current and past smokers, as well as people living with a family member who smoked, experienced an average of about $196 in health care spending per person to treat smoking related conditions. This estimate captures a wide variation of experiences, with some patients having little to no health care spending related to smoking and others seeking treatment for lung and heart problems, smoking-related skin and eye conditions, or smoking-related cancers.

Figure 13 illustrates that estimated medical spending, including doctor's appointments, laboratory tests, procedures, and equipment made up 34 percent of costs attributed to smoking and secondhand smoke exposure in Minnesota. Pharmacy spending on retail prescription medications made up the remaining 66 percent of smoking exposure-attributable costs in Minnesota.

If we aggregated the total costs directly linked to smoking exposure, the attributed costs in 2014 accounted for about $243 million (see Figure 14). Compared to five years earlier, total

[14] See Appendix 5 for an overview of available estimates in the literature.

smoking exposure-attributable spending in 2014 more than doubled despite lower rates of smoking exposure in 2014. (This is likely to some extent an expression of the small sample size used for the analysis.) Most of this change (82.7 percent) appears to be driven by prescription drug spending.

Figure 13: Per Person Per Year Spending Associated w/Smoking Exposure, by Type of Spending

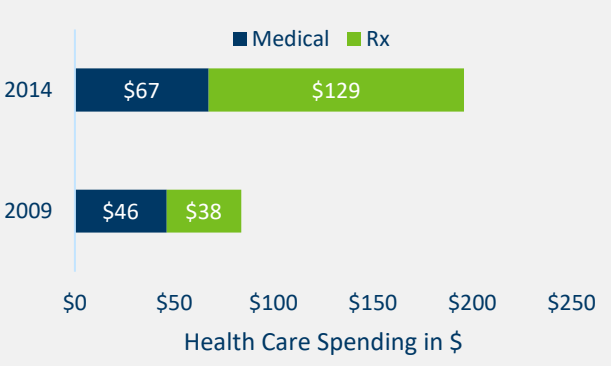
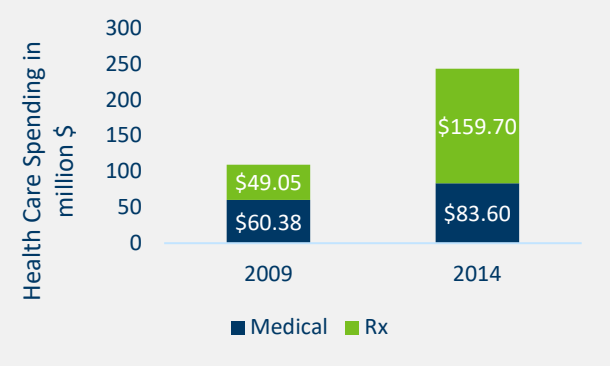


Figure 14: Total Annual Spending Attributable to Smoking Exposure, Type of Spending ($ millions)



Source: Mathematica Policy Research analysis of the 2009 and 2014 Medical Expenditure Panel Survey and the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to smoking exposure; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error. Because the estimates rely on MEPS benchmarked to total spending in the APCD (among both smokers and nonsmokers), we do not report per-person estimates among persons exposed to smoking.

Obesity

Our analysis of health care spending attributable to obesity is designed to include spending directly related to obesity and health care conditions that derive from obesity. For the purpose of this analysis, health care spending for patients identifiable as obese that are for unrelated comorbid conditions (i.e., likely were not cause by obesity), such as acute care needs, were excluded from the estimates. This process of carefully controlling for clinically unrelated conditions likely accounts for much of the difference between estimates presented here and in the literature.[15]

[15] See additional detail about estimates in the literature in Appendix 5.

Prevalence estimates of obesity for this analysis were calculated using Minnesota data for the Behavioral Risk Factor Survey (BRFSS). Spending estimates for obesity largely rely on pooled data from the Medical Expenditure Panel Survey (MEPS) adjusted to match the MEPS Midwest region that includes Minnesota. To ensure stable estimates, the final analysis is limited to persons with obesity between ages 10 and 64 years, with varying ranges of body mass index rates used to identify obesity.[16] By excluding persons age 65 or older, these estimates underestimate the fully attributable cost of obesity

Additional detail on methodological approach, data and detailed estimates is available in the Appendix.

Treated Prevalence of Obesity

In 2014, about 1,000,335 Minnesotans between the ages of 10 and 64 met the definition of obesity. Relative to 2009 the number represents an increase of about 9 percent or about 81,000 Minnesotans. The largest increase was experienced by children ages 10 to 17 (20.5 percent). However, rates of obesity remained most significant for people between ages 45 to 64, with nearly one-third of that group (32.2 percent) meeting the definition.

Health Care Spending Attributable to Obesity

We estimate that Minnesotans meeting the definition for obesity experienced an average of $451 per-person in spending for the treatment of obesity and obesity-related conditions. This is up by about 20 percent compared to 2009, when the per-person obesity-attributable spending was about $376.

Figure 15 illustrates that in 2014 just over half (51.2 percent) of obesity-attributable spending was for medical services, such as doctors' appointments, laboratory tests, procedures and equipment. Pharmacy spending on retail prescription drugs made up the remaining 48.8 percent. Growth in prescription drug spending accounted for all of the increase in obesity-attributable spending between 2009 and 2014; it grew by about 70 percent over this period, while medical spending actually decreased.

If we aggregate the costs directly linkable to the treatment of obesity and obesity-related conditions, attributed costs in 2014 amounted to $451 per person, as shown in Figure 16. Compared to five years earlier, total obesity-related health care spending in 2014 rose 30.6 percent, at a faster pace than the per-person spending increase. Spending on retail prescription

[16] For this study, obesity was defined in the following way: adults age 18 to 64 with reported body mass index (BMI) of 30.0 or more; children age 10 to 18 with BMI greater than the 95th percentile in the United States for their age-gender category.

drugs accounted for most (95.9 percent) of the growth in obesity-attributable health spending, having nearly doubled over this period.

Figure 15: Per Person Per Year Spending Associated w/Obesity, by Type of Spending

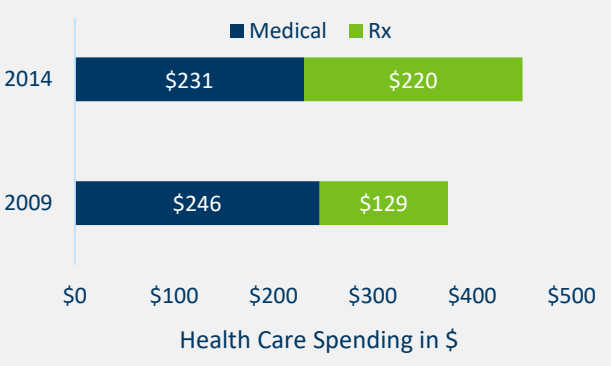
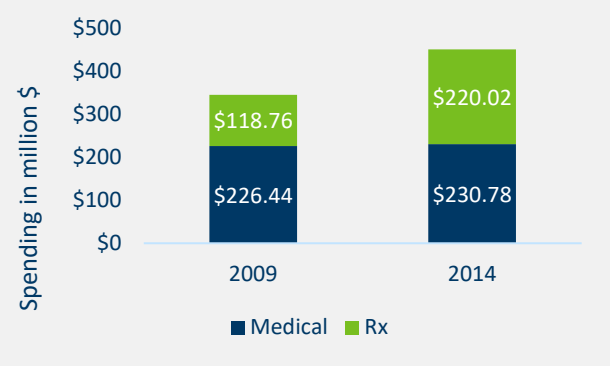


Figure 16: Total Annual Spending Attributable to Obesity, Type of Spending ($ millions)



Source: Mathematica Policy Research analysis of the 2009 and 2014 Medical Expenditure Panel Survey and the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to obesity; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error.

Actual Health Care Spending Compared to Baseline Projections

As part of directing MDH to develop estimates of health care spending attributable to a set of conditions and risk factors, the Legislature also wanted to know:

- What are the expected future patterns of spending for these conditions and smoking exposure; and
- How does spending for the most recently available data compare with where we expected spending to be?

These questions aim to assess the extent to which growth in aging, inflation and prevalence of disease will impact growth in health care spending and whether Minnesota is making progress or losing ground with constraining health care related spending.

For the purpose of assessing progress, the projections build in demographic changes such as aging and population growth, as well as projected inflation in health care prices. That means that the projections reflect the aging of Minnesotans and the resulting expected increase in the number of people living with chronic disease. The projections also reflect that health care prices will rise.

If the treatment patterns for patients with these conditions – through a mix of medical services and prescription drugs – did not change, and if the rate at which people within age and sex groups are treated for a disease in future years stayed consistent with 2009, we would expect future actual spending to be very close to projections developed for this report. Substantial changes from projections could represent progress or losing ground; however, they could also be a reflection of imprecise forecasts of demographic and price changes, shifts in the distribution of insurance coverage, or changes in how data is reported or generated by the health care system.

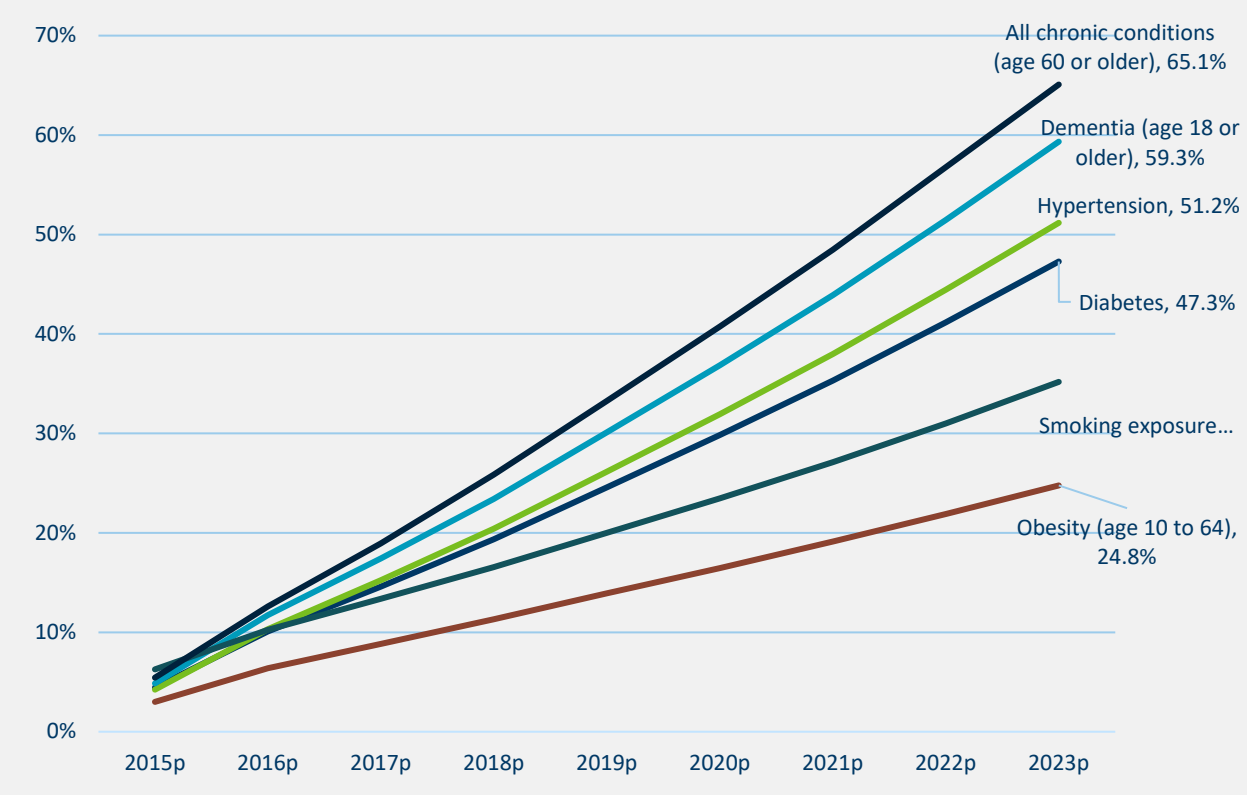
As always, a big unknown in these projections is the role of technology in health care. Depending on the nature of innovation, technology can be a significant factor driving health care spending (e.g., through new expensive prescription drugs that do not otherwise lower health care spending) or lowering spending (e.g., by moving care out of institutions or shortening the length of stay at these facilities). Because technological innovation for the period covered by the 10-year projections is unknown, by definition, the associated effect of technology has not been incorporated.

Ten-Year Health Care Spending Projections

For most of the conditions we considered, the projected cost attributed to chronic conditions is expected to rise steadily, as the prevalence of chronic conditions in Minnesota increases with population aging. The projected cumulative total rate of growth between 2014 and 2023, as shown in Figure 17, ranges from 24.8 percent for non-elderly adults with obesity and 65.1 percent for the cost of chronic condition for people 60 years old or older.

Numerous factors affect these expected increases in spending. As noted throughout the report, a major one concerns the impact of aging on chronic conditions. In the figure, the highest growth rates are observed for conditions where the number of affected Minnesotans is expected to rise just because of demographic changes through 2023.

Figure 17: Cumulative Percent Change in Projected Health Care Spending Attributed to Selected Chronic Conditions and Smoking Exposure



Source: Mathematica Policy Research, November 2017
Note: “p” indicates a projected year. Estimates and projections reflect current dollars.

As shown in Figure 18, the attributed cost of all chronic conditions among Minnesotans age 60 or older is projected to rise from $9.75 billion in 2014 to $16.10 billion in 2023.[17] Among Minnesotans of all ages, health care costs attributed to hypertension and diabetes are also projected to rise. The projected increase for hypertension from 2014 to 2023 is about $2.65 billion (from $5.18 billion to $7.83 billion). The attributed cost of diabetes—after hypertension, the next most costly chronic condition we considered—is projected to rise from $1.40 billion to $2.06 billion in 2023.

The attributed cost of chronic conditions such as dementia (which affects primarily adults age 65 or older) is less than the attributed cost of hypertension or diabetes, conditions that are more prevalent across the population at every age. However, with population aging, the attributed cost of dementia is projected to rise faster than the attributed cost of any other single condition we considered, from $249.0 million in 2014 to $396.7 million in 2023.

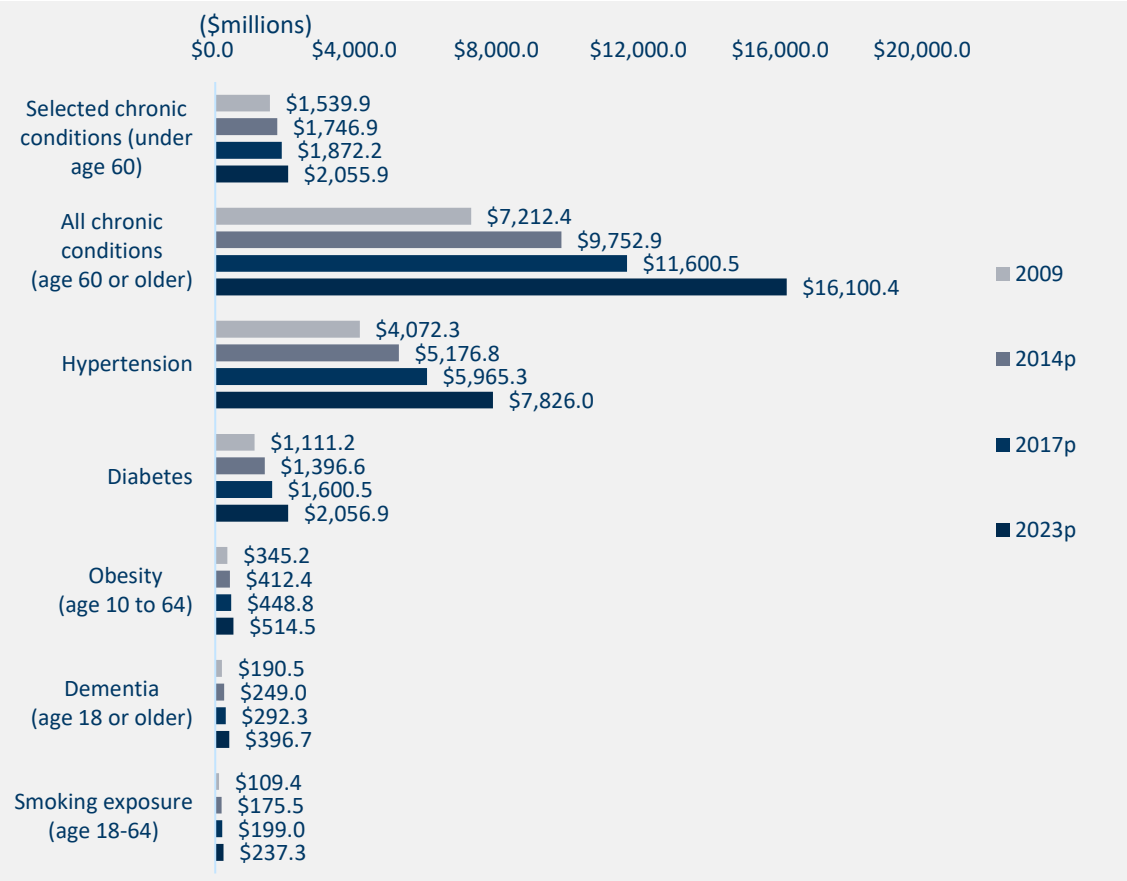
The attributed health care costs of obesity and smoking exposure – the family of estimates that are likely less robust than others presented here – are projected to rise more slowly from 2014 to 2023 than the attributed costs of other conditions individually or all costs among Minnesotans age 60 or older (from $412.4 million to $514.5 million and from $175.5 million to $237.3 million, respectively). The projections for both conditions reflect the impacts of a growing population age 18 to 44 in Minnesota (compared with adults 45 to 64) and the lower prevalence of both the conditions and their comorbidities among younger adults.[18]

Despite faster rates of growth in attributed spending for pharmacy compared with medical services (see Appendix Tables 4.1 through 4.6), most of the projected change in attributed spending for chronic conditions in Minnesota from 2014 to 2023 is due to change in spending for medical services.

[17] Estimates of actual and projected spending attributable to selected chronic conditions and risk factors in total and separately, attributed to medical and pharmaceutical categories by year and for each condition are available in Appendix Tables 4.1 to 4.6.

[18] The number of adults age 18 to 44 in Minnesota is projected to rise from 57.0 percent of the adult population age 18 to 64 in 2014, to 59.9 percent in 2023. See: Minnesota State Demographic Center, Minnesota Population Projections by Age and Gender, 2015-2065. http://mn.gov/admin/demography/data-by-topic/population-data/our-projections/.

Figure 18: Annual Health Care Spending Attributed to Selected Chronic Conditions and Smoking Exposure, Projected from 2009 for Selected Years



Source: Mathematica Policy Research

Note: "p" indicates a projected year. Attributed costs for 2009 and 2014 are estimated from historical data. Estimates and projections are expressed in current (versus real) dollars.

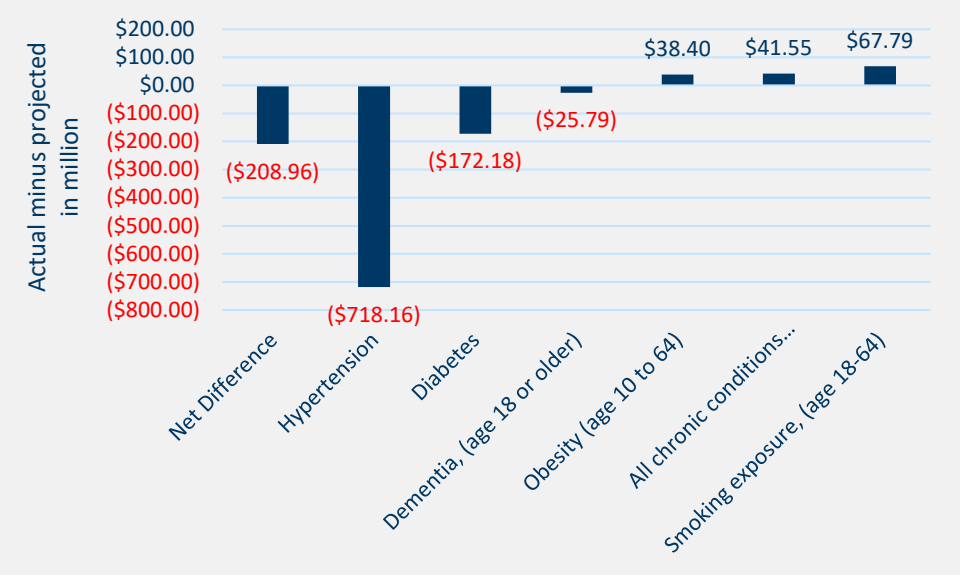
Actual 2014 Spending Compared to Baseline Projections

As noted in the beginning of this section, one purpose of developing baseline spending projections for selected chronic conditions and risk factors was to compare actually observed spending against the baseline to ask: "was there progress in the underlying trend?" The measure of "progress" is here a fairly narrow one, focused just on overall spending for select conditions, rather than assessing alternative measures such as efficiency and appropriateness of care.

That said, Figure 19 illustrates what we have learned from this research on the narrow question of progress this report focuses on by showing the difference between actual and projected spending for 2014, with actual spending falling short of projections displayed as a negative number and the reverse as a positive value. As the figure illustrates, estimated actual costs in 2014 were:

- Lower than estimated in the baseline projections for hypertension, diabetes, and dementia; and
- Higher than estimated in the baseline projections for attributed costs of treating obesity, all chronic conditions among Minnesotans age 60 or older, and smoking exposure among non-elderly adults.[19]

Figure 19: Estimated Difference Between Actual and Projected Health Care Spending Attributed to Selected Chronic Conditions and Smoking Exposure



Source: Mathematica Policy Research.

Note: Projections are expressed in current (versus real) dollars.

Because the spending estimates and projections in Figure 19 and Appendix Table 2 capture health care spending for related conditions (e.g., some expenditures for treating diabetes would also be considered expenditures attributable to obesity), they cannot simply be added

[19] Detailed estimates are in Appendix 4.7

up to estimate the "net" difference; doing so would result in considerable double-counting of spending.

In addition to developing individual condition models, our analytics vendor for this work, Mathematica Policy Research, constructed two additional models with the goal of developing condition-overarching estimates, by separately estimating spending for:

- Persons under 60 years of age with select chronic conditions, and
- Persons 60 years old and older with any treated chronic condition identifiable in claims data.

As a result of this secondary analysis, we estimate that, with the exception of considering the impact of smoking exposure, actual spending in 2014 was approximately $209 million less than expected by the projection baseline (also shown in Figure 17). This difference results from lower-than-expected spending for people with select conditions under 60 years of age (-$250.50 million) and higher-than-expected spending for people 60 years old or older with chronic conditions ($41.6 million). We could not incorporate the impact of smoking exposure into this analysis for a number of technical reasons that relate to how the estimates of smoking exposure were derived (multiple years were pooled and estimates were derived from sub-samples of the Medical Expenditure Panel Survey). That said, a sizable portion of tobacco-related health spending is likely covered by considering spending on other chronic conditions.

What does the difference between what we observe in 2014 and what we expected to see tell us about the shape of the spending curve? While the study was not designed to be able to pinpoint with any sense of conclusiveness the reasons why actual and projected spending might differ, there are a variety of factors that may have contributed:

- Factors related to delivery system changes (e.g., reduction in hospitalizations) likely played a role in constraining health care spending.
- Spillover effects from Medicare payment and policy changes likely contributed to this trend, along with changes in coverage that appear to have resulted in more healthy people gaining Medicaid coverage in Minnesota.
- Pointing in the opposite direction, including for the estimates for people age 60 or older, is the observation that increases in prevalence of chronic disease occurred beyond the impact one would have expected from demographic changes (which the projection accounted for).
- However, technical factors that relate to how care is coded by the health care system and how data are submitted may have also affected the magnitude and the direction of both actual spending and baseline projections. These factors are discussed in greater detail in Appendix 3, where we address data used in for analysis and resulting limitations.

Share of Minnesota State-Administered Programs

The legislation authorizing this work also directed MDH to estimate the state-administered programs' (Medicaid, MinnesotaCare and SEGIP) share of the net difference between actual and projected spending. While the most desirable and robust approach would have been to develop this estimate directly as part of the disease-specific modeling, we were not able to do this for two reasons:

1. The data we had available for this work are de-identified or are secondary data (data not directly aggregated by the state). This prevented us from identifying SEGIP enrollees, the presence of chronic disease and smoking exposure in that population, and related costs.
2. Even if more detailed data were available, the resulting estimates would have been more unstable, because they would have been based on cells with a smaller number of observations.

Absent specific information on condition-attributable actual and projected spending, we estimated the state-administered program share by using a number of alternative approaches to triangulate the likely share.

Under one method, which produced the lower end of our range of estimates, we considered evidence on the age distribution for state-administered programs relative to the population with select chronic conditions and smoking exposure in our study, separately for the population under 60 years of age and age 60 or older. Under a second approach, which established the upper end of our estimate, we used age and coverage-specific prevalence of chronic conditions from earlier work by MDH,[20] to assess the portion of individuals in the study that are likely enrollees or beneficiaries of state-administered programs.

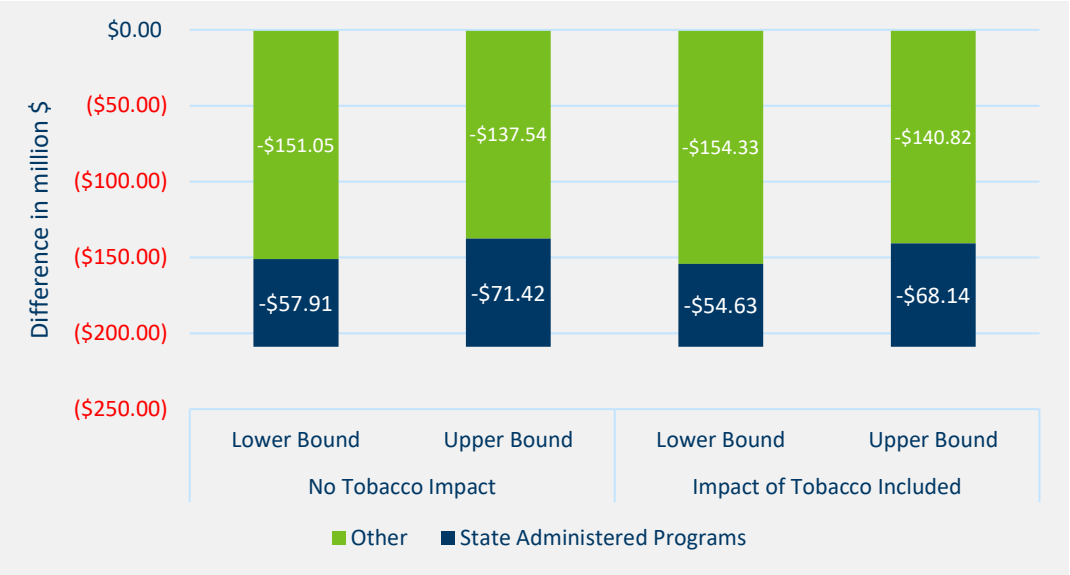
As shown in Figure 20, the resulting range in the estimate of the state-administered program-attributable difference between actual and projected spending for 2014 falls between 27.7 percent and 34.2 percent of the $209.0 million by which actual spending was lower than projected (between $57.9 and $71.4 million). Not surprisingly, most of state-administered program share derives from condition-attributable spending for people under 60 years of age.

We also wanted to consider the potential impact of smoking exposure on the state-administered program share, particularly because it would reduce that share. Relying on

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

evidence that shows the extent to which smoking exposure is linked to the development of chronic disease, we assumed that most (75 percent) of the tobacco impact would be accounted for in the net estimates by the joint consideration of chronic disease and attributed a portion of the remaining amount to our estimates. This reduced the range of the state-administered program share of spending below projections to between $54.6 million and $68.1 million.

Figure 20: State-administered Program Share of Net Difference Between Actual Spending and Projection Baseline, 2014



Source: Analysis by the Health Economics Program of MDH, using estimates developed by Mathematica Policy Research, November 2017.

Discussion

This report represents a bold attempt to better understand the extent to which financial resources in Minnesota are tied to providing health care for treatment of select chronic diseases and smoking exposure. This information helps illustrate the cost of inaction to prevent or delay disease and give us a tool to monitor whether we are making progress in "bending" the curve of health care spending or disease prevalence.

However, this analysis is only a very high-level look at this issue, with a focus on just one aspect of disease and risk factors: clinical treatment costs. As such, this study could not consider other aspects of disease or risk factor-related spending, like lost income or caregiver support. It also:

- Spans a number of conditions with different treatment approaches, treatment cost structures and degrees of preventability;
- Covers people across the age spectrum with radically different patterns of health care use, disease severity and cost burden; and
- Zeroes in on condition-attributable spending instead of capturing the mix of diseases likely present for many patients.

As such, the findings from this analysis are not designed to identify what is or is not working for treatment or prevention of specific diseases.[21] Instead, the analysis provides more broadly generalizable takeaways about recent trends in health care delivery, and long-term sustainability, to motivate and inform change. They include:

The rate of the population affected by disease and smoking exposure matters: Many chronic conditions become more common with age. As the population ages, we should expect more Minnesotans to live with chronic disease unless we can reduce the age-specific prevalence rate. However, this analysis showed that for all of the conditions other than smoking exposure the prevalence of disease rose between 2009 and 2014 for nearly all age groups, and especially for the population ages 60 or older. This means more people received treatment for a chronic condition than would have been expected from demographic change alone.

[21] This type of analysis, some of which is underway at the Health Department and elsewhere in the area of diabetes, would require a detailed investigation of the causes of diabetes (type 1 and type 2, separately) in different age groups, the effect of intervention and their interaction with changes in prices (of prescription drugs and medical services), service use and mix of services over time.

Short-term total health care spending growth was significant: Despite the promising decline between 2009 and 2014 in per-person spending for diabetes, hypertension and dementia, total disease-attributable health care spending across the board jumped by double-digits for this period. Contributing to this was the increase in the number of people treated for conditions and diseases related to smoking exposure, but also the impact of health care price inflation.[22] Chronic disease-attributable spending, particularly for the elderly, accounted for a sizable amount of total health care spending for people with the select conditions and smoking exposure.

Chronic disease spending over the long term is not sustainable: Even if prevalence rates stay roughly the same, health care spending for select chronic conditions and smoking exposure over a ten-year window will climb between 24.8 percent for obesity and 65.1 percent for chronic disease spending for persons 60 years or older. If the current trend of increase in prevalence across most age groups continues, actual spending will outpace these projections, diverting more public and private resources from other economic activities to the treatment of chronic disease.

The pace of prescription drug spending growth is worrisome: Although we project that most of the long-term spending growth will be driven by growth in medical spending, the rate of increase in spending on retail prescription drugs in the recent past has been extraordinary. As noted elsewhere, this has affected life-saving treatments, products that have been on the market for decades, generics, and brand-name drugs, as well as new specialty drug products.[23] If the pace continues, it will have a tremendous impact on chronic disease spending for Minnesotans age 60 or older with chronic disease.

In powerful ways, these findings underscore what we have known for some time: solutions to our chronic disease cost crisis cannot be found solely within the health care system itself. While making improvements in the efficiency of health care delivery is essential, health care spending will continue to climb, in part because a greater share of Minnesota's population will develop one or more chronic conditions. Minnesota cannot treat its way out of this situation. We must continue to place a greater focus on upstream prevention efforts and on establishing environments that support the opportunity for health and well-being for all.

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[22] Minnesota Department of Health, Health Economics Program, "Health Care Spendign and Projections, 2014." Report to the Legislature, forthcoming.

[23] Minnesota Department of Health, Health Economics Program, "Pharmaceutical Spending and Use in Minnesota: 2009-2013." Issue Brief, Nov. 2016

This study cannot – and was not intended to – shed light on the reasons underlying changes in prevalence and per-person spending. However, we know that a range of factors likely played an important role in these findings or at least coincided with them:

- More people obtained coverage in 2014 – about 250,000 Minnesotans gained coverage relative to 2013 – which likely resulted in more people receiving a diagnosis and treatment for certain chronic conditions.[24]
- At the same time, there are a series of initiatives underway in Minnesota and nationally that aim to affect treatment patterns and reduce costs, including changes in payment incentives (e.g., shared savings arrangements in Medicare, Medicaid ACOs); changes in patterns of health care delivery (e.g., health care homes); and population health and public health investments.
- Minnesota's robust provider quality measurement landscape – for clinics and hospitals – contributed to public accountability for the outcomes of key health care conditions, including diabetes, and motivated systems change to drive performance improvements.
- After a slow recovery following the economic recession that ended in 2010, seasonally adjusted unemployment trended below four percent starting in 2014. Increased employment-based coverage and rising disposable income for some would have affected health care use over that period.[25]
- Lastly, changes in coverage that required more cost sharing by patients and in network design that limited access to providers likely depressed health care use by some.

While health care providers have made strides in improving the quality of care for individuals who experience one or more chronic diseases, and slowing the rate of cost growth, their efforts alone cannot bend the cost curve as overall health care costs continue to rise and our population grows. Many chronic diseases could be prevented, delayed or alleviated by decreasing smoking and obesity levels, and improving the diet and activity levels of the population. 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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[24] Although the increase in the number of people having insurance coverage and receiving treatment pushes up health care spending, it can also serve to dampen long-term expenditures. Early diagnosis of conditions can help in managing the presence of a disease through lifestyle changes or effective pharmacological treatment, thereby avoiding or delaying high spending on acute exacerbation of disease or institutional care.

[25] Minnesota Department of Employment and Economic Development, https://mn.gov/deed/data/current-econ-highlights/state-national-employment.jsp; accessed 12/1/2017.

In recognition of this, 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.

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 challenges remain daunting. More than a quarter of Minnesota adults are obese and 14.4 percent smoke. Nearly 15 percent of Minnesota's children are growing up in poverty (2014),[26] unemployment and underemployment remain high for populations of color and American Indians, and too many people in both rural and urban areas lack access to adequate nutrition, stable homes and meaningful work. Disparities and inequities in smoking and secondhand smoke exposure continue to persist across several sociodemographic characteristics, including but not limited to, race, ethnicity, sexual orientation, gender identity, income, education, age, geography and mental health. Those who are affected by mental health issues and who have lower levels of income and education are more likely to smoke. Given these realities, policymakers, health care providers and public health professionals need to employ multi-sectoral efforts to impact spending for chronic disease.

The literature and public health practice point to a number of tools to manage the future of chronic disease through delaying onset of disease, slowing its progression and helping patients to live well with chronic disease. They include:

- Focusing on primary and secondary prevention, including community-based initiatives;
- Strengthening the provision of care delivery through primary care providers, with appropriate coordination between providers and across all settings of support services;
- Empowering patients across the spectrum of health and health care; and

[26] 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

- Enhancing incentives to deliver efficient and high-quality care to patients.

Accomplishing this will take initiative and creativity across the state, with individuals, employers, local public, communities, advocacy organizations and local and state government, with the help of federal partners coordinating best practices. A brief description of some of the activities currently underway in Minnesota to impact chronic disease is below.

Creating Healthy Communities

Efforts such as the Statewide Health Improvement Partnership (SHIP), Blue Cross Blue Shield Center for Prevention, ClearWay Minnesota grant programs, and other initiatives that focus on implementing policy, system, and environmental changes to support healthy living in communities across the state, have already shown results in the areas of improving healthy eating, reducing smoking, and increasing physical activity, all of which are linked to chronic disease prevalence. The fruits of the many focused policy, systems and environmental change efforts in selected communities are beginning to emerge. For example, 14.4 percent of adult Minnesotans smoke cigarettes, down from 22.1 percent in 1999.[27] 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.

Primary Care and Care Coordination

Minnesota's certified Health Care Homes, which focus on providing coordinated, team-based primary care to complex patients, have shown an ability to achieve higher performance on key quality measures related to chronic disease, while lowering costs for Medicaid and Medicare recipients. As part of its overall health reform approach, Minnesota has also worked to promote the use of multi-disciplinary care teams that manage care coordination in community and clinic settings, and include the use of community paramedics, community health workers, dental therapists and other emerging professions.

In addition, the 15 Accountable Communities for Health (ACH) established under Minnesota's federal State Innovation Model (SIM) grant are showing early promise by developing unique approaches to community-wide care coordination for specific high-risk populations, focusing on

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

actively and meaningfully engaging populations that experience health disparities in developing local solutions to high rates of chronic conditions and other issues.

Payment reform

Performance-based payment models introduced by federal payers and Minnesota private and public purchasers aim to change the focus from delivering units of health care services to delivering better health for patients and the broader community. These models involve setting targets for cost and quality of care to specific groups of patients, and may include population health components.

A key takeaway from this analysis is that it is possible to reduce costs on a per-patient basis for certain conditions, but that it is difficult to understand the factors that contribute to that change, and even more difficult at this point to know whether these trends are sustainable. However, overall health care costs continue to rise and our population continues to grow, as does the percent of the population experiencing chronic conditions. If Minnesota does not focus on prevention of illnesses such as diabetes, dementia, and hypertension through policy, systems and environmental change at the community level, the state will continue to see ever-increasing and ultimately unsustainable health care costs.

Appendix 1. Certification to the Commissioner of Minnesota Management and Budget

DEPARTMENT OF HEALTH

Protecting, Maintaining and Improving the Health of All Minnesotans

November 30, 2017

Mr. Myron Frans
Commissioner, Minnesota Management and Budget
400 Centennial Building
658 Cedar Street
St. Paul, MN 55155

Dear Commissioner Frans:

The 2015 Minnesota Legislature directed the Minnesota Department of Health (MDH) to construct projections of health care spending attributable to select conditions and smoking exposure, annually estimate actual health care spending for the conditions of interest, and compare estimated actual spending against the projection baseline. If estimated actual spending is less than projections, MDH must calculate the portion of this difference attributable to state-administered programs (Minnesota Statutes, Chapter 62U.10, subd. 5 to 8).

For 2014 health care spending attributable to the five statutorily identified conditions, we found net actual health care spending was below baseline projections by about $209 million. As we note in the report, because we lack definitive data and research methods to *directly* estimate the state-administered program share of spending, we developed two distinct analytic approaches for indirectly estimating that share. Using these two approaches, we estimate that between $54.6 and $68.1 million of this difference is attributable to state-administered programs, including Medicaid, MinnesotaCare and the State Employee Group Insurance Program.

The results of our analysis are presented together with information on research methods, data limitations and an actuarial certification of our approach in the enclosed report to the Legislature. Based on these results, I certify on behalf of MDH that the state-administered portion of the differences between actual and projected spending, termed "savings" in the statute, exceeds the $50 million threshold required by statute to trigger a transfer of $50 million from the General Fund to the Health Care Access Fund in the next fiscal year.

Should you or your staff have any questions about the analysis or this certification, please contact Stefan Gildemeister, director of the Health Economics Program, at Stefan.Gildemeister@state.mn.us or 651-201-3554.

Sincerely,

Edward P. Ehlinger, M.D., M.S.P.H.
Commissioner
P.O. Box 64975
St. Paul, MN 55164-0975

Enclosure

cc: Eric Hallstrom, Deputy Commissioner, MMB
Margaret Kelly, Assistant Commissioner / State Budget Director, MMB

Appendix 2: Actuarial Certification

Willis Towers Watson

November 27, 2017

Mr. Stefan Gildemeister
Director, Health Economics Program
Minnesota Department of Health
85 East Seventh Place
Suite 220
Saint Paul, MN 55101

Subject: Actuarial Certification

Dear Stefan:

Willis Towers Watson has provided an actuarial review of the final estimates of the cost and prevalence of selected chronic conditions and health risk factors in Minnesota developed by Mathematica Policy Research (Mathematica) for the Minnesota Department of Health (MDH). These estimates include diabetes, hypertension, dementia, smoking exposure, and obesity for individuals of all ages, as well as all chronic conditions for older individuals. Our review considered the tables that Mathematica provided, presenting historic estimates for 2009 and 2014 and projections through 2023. Our review also included examination of supporting documentation, discussion of data sources and methodologies, and requests for additional documentation and clarification.

Based on this review, we find the data sources and methodologies used are valid and reasonable. We further certify that the cost and prevalence estimates are reasonable based on our review of the data used, the methodologies employed, and health care spending trends observed nationally.

Best Regards,

Sandra J. Loyal

Sandra J. Loyal, FSA, MAAA
Willis Towers Watson

cc: Deborah Chollet, David Jones – Mathematica Policy Research
Ryan Lore – Willis Towers Watson

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Appendix 3: Data and Limitations

As noted elsewhere in this report, the analysis MDH was directed to perform is unique in terms of research conducted by other states, expansive in that it required developing estimates and projections across a range of conditions and risk factors, and technically demanding. To help the readers weigh the evidence for policy-making purposes or use in public health planning, this section provides context about the data that were used, information about high-level assumptions that were made along the way, and detail about potential limitations that are associated with this study. Because relevant technical information is provided throughout the report and the methodology is provided separately in Appendix 6, this section is intended to provide high-level, summary information.

This section does not focus on alternative ways of measuring the impact of chronic disease in Minnesota or on identifying strategies to affect the prevalence or the treatment cost of specific conditions; it is intended to provide detail on the study at hand for the specific measurement focus MDH was directed to pursue.

Generally speaking, developing an estimate of the costs of medical services and prescription drugs associated with specific conditions or risk factors requires answering three questions:

1. How many people in Minnesota have a particular condition;
2. How much in health care spending is delivered to patients with that conditions; and
3. What portion of spending devoted to a patient's care is unrelated to the condition in question.[28]

In addition, to estimating future health care spending, analysts have to determine what is known about expected demographic change (chronic disease prevalence increases with age) and change in the level of health care prices, or medical inflation. Lastly, to assess the role of state public payers of health care spending, researchers need to have information on the prevalence of disease among beneficiaries of those programs or the age distribution in those programs relative to others with the disease.

Because there is no single data system to address these questions for the four chronic conditions that are the focus of this study and smoking exposures, the research team had to

[28] The last question is about making sure estimates attributable to specific chronic conditions control for, or exclude, health care spending that is unrelated to the treatment of a specific condition. Conversely, the aim was to identify all costs for the treatment of a specific condition and all comoribidites that developed as a direct result of the condition, e.g., hypoglycemia for diabetics.

rely on a range of data systems. The following data were matched to specific aspects of the modeling and estimation tasks:

- The **Minnesota All Payer Claims Data (MN APCD)**, which is system that aggregates health care transaction data across public and private payers in Minnesota, was used to identify persons with each chronic condition (diabetes, hypertension, dementia and all chronic conditions for persons 60 year or older), calculate person-level medical and prescription drug costs for these conditions, and control for unrelated costs.[29]
- The **Household Component of the Medical Expenditure Panel Survey (MEPS-HC)** was used to analyze conditions that are not directly observable in the MN APCD (obesity, smoking exposure) and, where applicable, to develop estimates for populations for all conditions of interest that are not part of the MN APCD (the uninsured, TriCare enrollees, and spending for people who rely on care from the Veterans Administration facilities and the Indian Health Services).[30] Depending on the condition, either data from the national, the Midwest or Minnesota sample was used, adjusted to reflect Minnesota's distribution of health insurance coverage. Data is also benchmarked to the MN APCD.
- A pooled sub-sample of the national MEPS is linked to the **Adult Sample** of the **National Health Interview Survey (NHIS)** is obtain information on past smoking status, particularly the time since members in the sample have quit smoking.[31]
- Minnesota's **Behavioral Risk Factor Surveillance Survey (BRFSS)** and the **National Health and Nutrition Examination Survey (NHANES)** were used to develop prevalence estimates of obesity in Minnesota.[32]
- Demographic information from the **American Community Survey (ACS)** and the **Minnesota State Demographic Center** was used to weight estimates to Minnesota population statistics and health insurance coverage distribution and as benchmarks for

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[29] Additional information on the Minnesota All Payer Claims Data, a project of the Minnesota Department of Health (MDH), is available online: http://www.health.state.mn.us/healthreform/allpayer/index.html

[30] Additional information on the Household Component of the Medical Expenditure Panel Survey, a project of the Agency for Healthcare Research and Quality (AHRQ), is available online: https://meps.ahrq.gov/survey_comp/household.jsp

[31] Additional information on the National Health Interview Survey, a project of the Centers for Disease Control and Prevention (CDC), is available online: https://www.cdc.gov/nchs/nhis/index.htm

[32] Additional information on the Behaviroral Risk Factor Surveillance Survey (BRFSS) and the National Health and Nutrition Examination Survey, both projects of the CDC, is available online: https://www.cdc.gov/brfss/index.html and https://www.cdc.gov/nchs/nhanes/index.htm

age/sex cohorts. The ACS was also used to capture household income effects on service use by mapping MN APCD zip codes to U.S. Census-defined Zip Code Tabulation Areas (ZCTA).[33]

- Lastly, expected price trends were computed using data from the **Consumer Price Index** for **Urban Consumers (CPI-U)** and the **National Health Expenditure Accounts (NHEA).**[34]

Although an interdisciplinary team of MDH researchers, analysts at Mathematica Policy Research and external content experts contributed for over more than a year to the development of a robust methodology for estimating condition-attributable spending, the resulting estimates, as is true for all empirical investigations, remain associated with a number of methodological challenges and potential limitations. They derive from data available for the study and assumptions that were made in the process of developing estimates. Many of the key challenges and limitations presented below are discussed in greater detail in Appendix 6, where we present a detailed methodology for the estimation effort, including considerations for choosing among alternative methodological options.

Controlling for unrelated health care spending: Key for the analysis was the decision to identify which health conditions are related or the direct outcome of one of the four chronic condition and smoking exposure. Much of the existing related literature, as noted in Appendix 5, either does not control for comorbidities or uses somewhat crude approaches to do so. For this study, Mathematica Policy Research, MDH's analytics vendor, considered evidence from some of the most robust empirical studies and sought additional clinical expertise to identify unrelated comorbidities. Nevertheless, there is currently no consensus among researchers and clinicians we are aware of about how to identify health care services for the treatment of specific conditions and related diseases.

Use of administrative claims data to identify health care spending: The availability of health care claims data from transactions between health insurers and providers for Minnesota

[33] Additional information on the Amercian Community Survey, a project of the U.S. Census Bureau, is available online: https://www.census.gov/programs-surveys/acs/. Additional information on data from the Minnesota Demographic Center is as well available online: https://mn.gov/admin/demography/.

[34] Additional information on the Consumer Price Index (CPI-U), a project of the U.S. Bureau of Labor Statistics (BLS) and the National Health Expenditure Accounts (NHEA), a project of the U.S. Centers for Medicare & Medicaid Services, is available online: https://www.bls.gov/cpi/ and https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/index.html

residents collected, in the MN APCD,[35] was what made this study possible in the first place. Nevertheless, the data are associated with a number of potential limitations.

- Though our analysis captures, where possible, spending for individuals who are not routinely found in the MN APCD (e.g., TriCare, the uninsured, and people who primarily rely on care through the Veterans Administration facilities and the Indian Health Service), health care claims data typically only include costs for health care services that represent covered insurance benefits. Costs for denied claims, services received outside of insurer provider networks (like, for example, assisted living costs for people with dementia), and contractual withholds are not captured in the data. Also not included are expenditures for over-the-counter medication, complementary or alternative therapies, spiritual healing or traditional (ethnic) medicine. Conversely, claims capture expenditure data that are not payments for services rendered, but relate to support for medical education or delivery of free or discounted care. As such, estimates could reflect an over- or undercount of actual spending.
- By definition, health care claims only capture costs of care for patients who seek health care services.[36]
- Estimates of prevalence for specific conditions are, again by definition, limited to patients who present for health care and whose condition was diagnosed and recorded in claims data. Where there are barriers to making a diagnosis – conducting expensive tests, for example – or where the diagnosis will not affect the course of treatment, the number of patients identified as having a certain condition will be undercounted.
- Due to changes in coding practices over time, health care costs for a given set of conditions or services can appear to have changed solely as a result of the extent and scope to which providers submitted data to payers. This could be resulting from attempts over time to optimize payments, the learning curve associated with coding practices, or changes in guidelines issued by payers to reduce unintended consequences associated with certain billing practices.

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[35] The Minnesota All Payer Claims data, funded by Minnesota's provider tax, is the most comprehensive data system for health care delivery in Minnesota. It collects information from all major public and private payers of health care services delivered to Minnesota residents, covering the spectrum of the delivery system and tracking de-identified information over time and across the state's geography. Data from the MN APCD have been available since calendar year 2009. Use of the data is limited by the legislature in MN Statutes 62U.04, subd. 11 to specific activities conducted by MDH. Minnesota is one of 16 or so states with an active APCD (https://www.apcdcouncil.org/state/map).

[36] Cost estimates for diabetes include only persons with a medical claim and at least one primary or secondary diagnosis of diabetes. However, many people with diabetes might be undiagnosed, and many more might have prediabetes, which does not correspond to a diagnostic code in medical claims data.

Use of MEPS data as proxy for Minnesota health care spending: Key methodological challenges associated with the MEPS relate to the fact that it does not capture health care spending for individuals who are institutionalized (either in long-term care facilities or by the Justice system). Although beginning approaches exist to adjust estimates for this gap, they have not been developed for state samples; no related adjustment were made for this study, likely resulting in underestimates for obesity and tobacco. In addition, the MEPS records diagnosis information only to the three-digit level, thereby foregoing precision associated with the more detailed coding under the system of International Classification of Diseases, version 9 (ICD-9). Further, unlike the MN APCD, the MEPS is a sample with limited number of observations in certain age/sex and disease categories, particularly at the regional and state level (see additional detail in the discussion on tobacco and obesity estimates).

Bias in the Behavioral Risk Factor Surveillance System: Like all surveys, the BRFSS is subject to a range of biases, including selection bias that might affect the survey's generalizability to the total Minnesota population, and response and recall bias, affecting the precision of obesity and tobacco prevalence estimates.

Use of the Johns Hopkins Adjusted Clinical Group (ACG) and Expanded Diagnosis Cluster System for chronic disease estimation: Identifying the presence of disease on the basis of diagnosis codes and prescription drugs in claims data involves making a host of decisions concerning how to interpret the presence and combination of codes. For the identification of chronic disease among persons age 60 or older, our analytics vendor used ACG-flagged EDCs augmented with additional conditions outside of the ACG system that are generally viewed as chronic. To the extent that the black-box assignment differs from alternative choices, estimates could be subject to bias in either direction.

Estimates of smoking exposure and obesity: Unlike the other conditions that were the focus of this study, smoking exposure and obesity was not directly observable in the MN APCD. That is, claims data do not consistently record diagnostic information permitting clear identification of either risk factors. Because of this spending attributed to obesity and smoking exposure was estimated using relative cost factors derived from the MEPS public use data adjusted to the Midwest population sample. This approach assumes that the relative probability of service use and the relative cost of acute care services in Minnesota for smoking exposure and obesity is equal to the average (by age and sex) among all Midwestern states, and that long-term care costs in the MN APCD because of obesity or smoking exposure are higher in the same

proportion as acute care costs.[37] Should this alignment not exist, resulting estimates could have an upward or downward bias.

Both estimates are further characterized by likely high statistical error that derives from the small number of observations available to the estimation process. While all estimates in this report are associated with estimation error, it is higher for estimates that rely on fewer observations, like smoking exposure and obesity.

Finally, cost estimates of smoking exposure are further limited by the following factors:

- Like elsewhere, this research was not able to account for the impact of health care spending from forms of smoking exposure other than tobacco use , likely yielding artificially high numbers of "non-smokers;"
- The data used to estimate current smoking, former smoking, and secondhand smoke exposure did not assess actual exposure to secondhand smoke exposure. Instead, "living with a smoker" was used as a proxy. While this helps to account for some individuals exposed to secondhand smoke, there are others who do not live with a smoker but are regularly exposed to secondhand smoke. This results in an underestimate of the impact of smoking exposure;
- Modeling revealed substantial challenges with predicting low-cost cases or outliers at the low end of the cost distribution. As a result, in those cases cost estimates were not stable enough to be reported for this study. The smoking-attributable estimates exclude respective health care spending for children below age 18 and adults older than 65, creating a downward bias of total smoking exposure attributable estimates.[38]

Unobserved factors that affect projected health care spending: The estimates in this study control for a large number of diagnoses, as well as a resident's age and gender. However, various characteristics that might affect expenditures—such as race and ethnicity—are not observed. As in any analysis of this type, failure to control for an unobserved characteristic that is systematically related the outcome variable can result in projections that are too high or too low, if that characteristic changes over time. The projections also do not account for other changes that could occur over the course of a decade—including changes in disease prevalence (other than associated with changes in the age and sex distribution of the population); health insurance coverage (other than aging into Medicare); changes in medical technology that affect

[37] As noted above, because estimating smoking exposure was limited to a single survey question in MEPS about the (adult) respondent's current smoking status, the analysis also used linked MEPS and NHIS data to improve precision of estimates.

[38] This is also true for obesity-related spending estimates for children under age 10 and adults 65 years of age or older.

cost; the introduction of new drugs that can affect cost; price increases for existing drugs, generic or otherwise, that are outside of ordinary patterns of price inflation; and current high-cost drugs going off-patent. Although such “steady state” assumptions are usual when making projections, they can lead to significant error especially in later years of the projection period.

Appendix 4.1: Detailed Data Table – Diabetes

Table I.2. Prevalence of diagnosed diabetes among children and adults in Minnesota 2009 and 2014

	2009		2014		
	Number of persons with diabetes (000s)	Percent of persons with diabetes within age group	Number of persons with diabetes (000s)	Percent of persons with diabetes within age group	Percent change in the number of persons with diabetes (2009-2014)
All Minnesotans	292.19	5.67%	336.30	6.23%	15.10%
Children (0-17)	3.56	0.30%	4.16	0.34%	16.90%
Adults (18-64)	167.28	5.01%	181.82	5.35%	8.69%
Adults Age 18-44	41.93	2.18%	42.49	2.21%	1.34%
Adults Age 45-64	125.36	8.83%	139.33	9.46%	11.15%
Seniors (65+)	121.35	18.74%	150.32	19.38%	23.88%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19 and the Medical Expenditure Panel Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Table I.3. Estimated spending attributed to diagnosed diabetes in Minnesota 2009 and 2014

	Total spending			Spending attributed to diabetes			
	Total spending, all persons ($ billions)	Per person total spending, all persons	Per person total spending among persons with diabetes	Total spending attributable to diabetes ($ billions)	Per person per year spending associated with diabetes, persons with diabetes	Percentage of total spending attributed to diabetes among persons with diabetes	Percentage of total spending attributed to diabetes
2009							
Total	$26.068	$5,057	$17,615	$1.111	$3,803	21.46%	4.21%
Medical	$22.008	$4,269	$14,525	$0.892	$3,054	20.86%	4.02%
Pharmacy	$4.060	$788	$3,090	$0.219	$749	24.28%	5.22%
2014							
Total	$30.722	$5,691	$18,246	$1.224	$3,641	19.73%	3.95%
Medical	$25.762	$4,772	$14,579	$0.880	$2,618	17.74%	3.40%
Pharmacy	$4.960	$919	$3,667	$0.344	$1,023	27.70%	6.71%
Percent change							
Total	17.85%	12.54%	3.58%	10.19%	-4.27%	-1.72%	-0.26%
Medical	17.06%	11.78%	0.37%	-1.36%	-14.29%	-3.12%	-0.62%
Pharmacy	22.16%	16.66%	18.68%	57.25%	36.63%	3.42%	1.48%

Source: Mathematica Policy Research analysis of the Minnesota All-Payer Claims Database v. 19 and the Minnesota population sample of the American Community Survey.

Table I.4. Estimated per person spending attributed to diagnosed diabetes in Minnesota by age group 2009 and 2014

	All persons	Children (0-17)	Adults (18-64)	Seniors (65 plus)
2009				
Total	$3,803	$3,504	$3,644	$4,031
Medical	$3,054	$2,147	$2,744	$3,508
Pharmacy	$749	$1,357	$900	$523
2014				
Total	$3,641	-	$3,720	$3,583
Medical	$2,618	$2,494	$2,348	$2,947
Pharmacy	$1,023	- a	$1,372	$636
Percent change				
Total	-4.27%	-	2.09%	-11.11%
Medical	-14.29%	16.14%	-14.43%	-16.00%
Pharmacy	36.63%	- a	52.43%	21.73%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19 and the Medical Expenditure Panel Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.
a Pharmacy cost per person attributed to diabetes was indiscernible among children age 0-17.

Appendix 4.2: Detailed Data Table – Hypertension

Table II.2. Prevalence of diagnosed hypertension among children and adults in Minnesota 2009 and 2014

	2009		2014		
	Number of persons with hypertension (000s)	Percent of persons with hypertension within age group	Number of persons with hypertension (000s)	Percent of persons with hypertension within age group	Percent change in the number of persons with hypertension (2009-2014)
All Minnesotans	915.03	17.75%	1,041	19.29%	13.82%
Children (0-17)	10.44	0.89%	18.25	1.49%	74.82%
Adults (18-64)	521.66	15.62%	550.63	16.21%	5.55%
Adults Age 18-44	111.06	5.78%	114.35	5.95%	2.96%
Adults Age 45-64	410.60	28.91%	436.28	29.61%	6.25%
Seniors (65+)	382.92	59.15%	472.59	60.94%	23.42%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19 and the Medical Expenditure Panel Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.

Table II.3. Estimated spending attributed to diagnosed hypertension in Minnesota 2009 and 2014

	Total spending			Spending attributed to hypertension			
	Total spending, all persons ($ billions)	Per person total spending, all persons	Per person total spending among persons with hypertension	Total spending attributable to hypertension ($ billions)	Per person per year spending associated with hypertension, persons with hypertension	Percent of total spending attributed to hypertension among persons with hypertension	Percent of total spending attributed to hypertension
2009							
Total	$26.068	$5,057	$13,555	$4.072	$4,450	32.60%	15.47%
Medical	$22.008	$4,269	$11,450	$3.450	$3,771	32.67%	15.59%
Pharmacy	$4.060	$788	$2,105	$0.622	$680	32.18%	14.84%
2014							
Total	$30.722	$5,691	$14,454	$4.459	$4,281	29.38%	14.32%
Medical	$25.762	$4,772	$12,141	$3.676	$3,530	28.88%	14.16%
Pharmacy	$4.960	$919	$2,313	$0.783	$752	32.01%	15.16%
Percent change							
Total	17.85%	12.54%	6.64%	9.49%	-3.81%	-3.21%	-1.15%
Medical	17.06%	11.78%	6.03%	6.55%	-6.39%	-3.79%	-1.43%
Pharmacy	22.16%	16.66%	9.90%	25.79%	10.52%	-0.17%	0.32%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19 and the Medical Expenditure Panel Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to hypertension; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error.
a Calculated as the percentage point change from 2009 to 2014.

Table II.4. Estimated per person spending attributed to diagnosed hypertension in Minnesota by age group 2009 and 2014

	All persons	Children with hypertension (0-17)	Adults with hypertension (18-64)	Seniors with hypertension (65+)
2009				
Total	$4,450	$3,916	$3,547	$5,417
Medical	$3,771	$3,355	$2,808	$4,843
Pharmacy	$680	$560	$739	$574
2014				
Total	$4,281	$3,940	$3,587	$5,102
Medical	$3,530	$3,151	$2,760	$4,441
Pharmacy	$752	$788	$827	$662
Percent change				
Total	-3.81%	0.62%	1.14%	-5.81%
Medical	-6.39%	-6.08%	-1.72%	-8.31%
Pharmacy	10.52%	40.74%	12.00%	15.33%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19 and the Medical Expenditure Panel Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Appendix 4.3: Detailed Data Table – Dementia (Ages 18 Years or Older)

Table III.2. Estimated prevalence of diagnosed dementia among adults and seniors in Minnesota 2009 and 2014

	2009		2014		
	Number of persons with dementia (000s)	Percentage of persons with dementia within age group	Number of persons with dementia (000s)	Percentage of persons with dementia within age group	Percent change in the number of persons with dementia (2009-2014)
All Minnesotans	45.81	1.30%	53.80	1.39%	17.44%
Adults (18-64)	5.76	0.20%	6.62	0.21%	14.90%
Adults Age 18-44	1.14	0.07%	1.04	0.06%	-8.40%
Adults Age 45-64	4.62	0.36%	5.58	0.41%	20.63%
Seniors (65+)	40.05	6.19%	47.18	6.08%	17.81%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates include only adults and seniors excluding persons who are uninsured or enrolled in Tricare, and therefore not

Table III.3. Estimated spending attributed to diagnosed dementia among adults and seniors in Minnesota 2009 and 2014

	Total spending			Spending attributed to dementia			
	Total spending, all persons ($ billions)	Per person total spending, all persons	Per person total spending among persons with dementia	Total spending attributable to dementia ($ billions)	Per person per year spending associated with dementia, persons with dementia	Percent of total spending attributed to dementia among persons with dementia	Percent of total spending attributed to dementia
2009							
Total	$22.680	$6,416	$29,775	$0.190	$4,158	14.23%	0.89%
Medical	$19.023	$5,381	$26,614	$0.174	$3,797	14.55%	0.97%
Pharmacy	$3.658	$1,035	$3,161	$0.017	$361	11.52%	0.46%
2014							
Total	$26.795	$6,944	$30,843	$0.223	$4,148	13.23%	0.89%
Medical	$22.281	$5,774	$27,831	$0.211	$3,915	13.83%	1.01%
Pharmacy	$4.515	$1,170	$3,012	$0.013	$233	7.61%	0.29%
Percent change							
Total	18.14%	8.24%	3.59%	17.15%	-0.25%	-1.00%	0.00%
Medical	17.13%	7.31%	4.57%	21.09%	3.11%	-0.72%	0.04%
Pharmacy	23.42%	13.08%	-4.69%	-24.32%	-35.56%	-3.91%	-0.18%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates include only adults and seniors, and exclude persons who are uninsured or enrolled in Tricare, and therefore are not represented in the MN APCD. Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to dementia; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error.
a Calculated as the percentage point change from 2009 to 2014.

Table III.4. Estimated per person spending attributed to diagnosed dementia among adults and seniors in Minnesota by age group 2009 and 2014

	All persons with dementia	Adults (18-64) with dementia	Seniors age 65 or older with dementia
2009			
Total	$4,158	$9,793	$3,348
Medical	$3,797	$9,095	$3,036
Pharmacy	$361	$698	$312
2014			
Total	$4,148	$9,746	$3,363
Medical	$3,915	$9,178	$3,177
Pharmacy	$233	$568	$185
Percent change			
Total	-0.25%	-0.48%	0.44%
Medical	3.11%	0.91%	4.67%
Pharmacy	-35.56%	-18.60%	-40.63%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American

Appendix 4.4: Detailed Data Table – Chronic Disease for Persons Age 60+

Table IV.1. Prevalence of diagnosed chronic conditions among Minnesota adults age 60 or older 2009 and 2014

	2009		2014		
	Number of persons with chronic condition (000s)	Percentage of persons with chronic conditions within age group	Number of persons with chronic condition (000s)	Percentage of persons with chronic conditions within age group	Percent change in the number of persons with chronic conditions (2009-2014)
All Minnesotans (60+)	695.13	77.83%	877.96	81.17%	26.30%
Age 60-64	181.21	74.65%	237.14	77.46%	30.86%
Age 65 - 74	244.46	73.97%	337.06	78.47%	37.88%
Age 75+	269.45	84.23%	303.76	87.78%	12.73%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19.
Estimates are weighted to population and coverage estimates reported in the Minnesota sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Table IV.2. Estimated spending attributed to diagnosed chronic conditions among adults age 60 or older 2009 and 2014

	Total spending			Spending attributed to chronic conditions			
	Total spending, all persons (billions)	Per person spending, all persons	Per person spending among persons with chronic condition	Estimated total spending (billions)	Estmated per person spending, persons with chronic conditions	Estimated percentage of total spending, persons with chronic conditions	Estimated percentage of total spending, all persons
2009							
Total	$9.099	$10,187	$12,488	$7.212	$10,376	83.01%	78.73%
Medical	$7.687	$8,607	$10,712	$6.643	$9,556	89.12%	86.37%
Pharmacy	$1.411	$1,580	$1,775	$0.570	$820	46.12%	38.76%
2014							
Total	$12.089	$11,176	$13,261	$9.794	$11,156	84.24%	80.69%
Medical	$10.216	$9,444	$11,317	$8.800	$10,024	88.70%	86.16%
Pharmacy	$1.873	$1,731	$1,944	$0.994	$1,132	58.26%	51.65%
Percent change							
Total	32.86%	9.70%	6.20%	35.80%	7.52%	1.23%	1.96%
Medical	32.89%	9.73%	5.65%	32.48%	4.89%	-0.42%	-0.21%
Pharmacy	32.71%	9.58%	9.49%	74.50%	38.16%	12.14%	12.88%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates exclude persons who are uninsured or enrolled in Tricare, and therefore are not represented in the MN APCD. Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to chronic conditions; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error.

Table IV.3. Estimated per person spending attributed to chronic conditions among Minnesotans age 60 or older by age group 2009 and 2014

	Persons with one or more chronic conditions			
	All persons	Age 60-64	Age 65 - 74	Age 75+
2009				
Total	$10,376	$9,867	$8,992	$11,973
Medical	$9,556	$8,655	$8,188	$11,403
Pharmacy	$820	$1,212	$805	$569
2014				
Total	$11,156	$10,587	$9,652	$13,269
Medical	$10,024	$8,915	$8,478	$12,604
Pharmacy	$1,132	$1,672	$1,174	$665
Percent change				
Total	7.52%	7.30%	7.33%	10.83%
Medical	4.89%	3.00%	3.54%	10.53%
Pharmacy	38.16%	38.02%	45.89%	16.71%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates exclude persons who are uninsured or enrolled in Tricare, and therefore are not represented in the MN APCD. Percent change estimates may reflect rounding error.

Appendix 4.5: Detailed Data Table – Smoking Exposure, Non-elderly Adult

Table V.2. Estimated prevalence of smoking exposure among adults in Minnesota 2009 and 2014

	2009		2014		
	Number of persons exposed to smoking (000s)	Percentage of persons exposed to smoking within age group	Number of persons exposed to smoking (000s)	Percentage of persons exposed to smoking within age group	Percent change in the number of persons exposed to smoking (2009-2014)
Adults (18-64)	1,307.3	39.6%	1,242.8	36.8%	-4.9%
Adults Age 18-44	657.4	34.7%	648.2	33.9%	-1.4%
Adults Age 45-64	649.9	46.1%	594.6	40.6%	-8.5%

Source: Mathematica Policy Research estimates from the Minnesota Behavioral Risk Factor Surveillance System. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Table V.3. Estimated spending attributed to smoking exposure among adults in Minnesota 2009 and 2014

	Total spending, all persons (billions)	Per person total spending, all persons	Total spending attributed to smoking exposure ($ Billions)	Per person spending attributed to smoking exposure, persons exposed to smoking	Percentage of total spending attributed to smoking exposure, all persons
2009					
Total	$14.462	$4,378	$0.109	$84	0.76%
Medical	$11.687	$3,538	$0.060	$46	0.52%
Pharmacy	$2.774	$840	$0.049	$38	1.77%
2014					
Total	$15.805	$4,677	$0.243	$196	1.54%
Medical	$12.547	$3,713	$0.084	$67	0.67%
Pharmacy	$3.258	$964	$0.160	$129	4.90%
Percent change					
Total	9.29%	6.84%	122.34%	133.88%	-0.78% [a]
Medical	7.36%	4.95%	38.46%	45.64%	-0.15% [a]
Pharmacy	17.43%	14.80%	225.59%	242.48%	-3.13% [a]

Source: Mathematica Policy Research analysis of the 2009 and 2014 Medical Expenditure Panel Survey and the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to smoking exposure; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error. Because the estimates rely on MEPS benchmarked to total spending in the APCD (among both smokers and nonsmokers), we do not report per-person estimates among persons exposed to smoking
[a] Calculated as the percentage point change from 2009 to 2014.

Table V.4. Estimated per person spending attributed to smoking exposure among adults in Minnesotans in 2009 and 2014

	Adults	Adults (18-44)	Adults (45-64)
2009			
Total	$84	-	$139
Medical	$46	- a	$93
Pharmacy	$38	$29	$46
2014			
Total	$196	-	$300
Medical	$67	- a	$141
Pharmacy	$129	$100	$160
Percent change			
Total	133.9%	-	116.4%
Medical	45.6%	- a	51.3%
Pharmacy	242.5%	241.4%	248.1%

Source: Mathematica Policy Research analysis of claims and encounter data from the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Estimates exclude persons who are uninsured or enrolled in Tricare, and therefore are not represented in the MN APCD. Percent change estimates may reflect rounding error.
[a] Medical cost per person attributed to smoking was indiscernible among adults age 18-44.

Appendix 4.6: Detailed Data Table – Obesity (Ages 10 to 64)

Table VI.2. Estimated prevalence of obesity among Minnesotans 2009 and 2014

	2009		2014		
	Number of persons with obesity (000s)	Percentage of persons with obesity within age group	Number of persons with obesity (000s)	Percentage of persons with obesity within age group	Percent change in the number of persons with obesity
All Minnesotans	919.21	23.58%	1,000.33	25.20%	8.83%
Children (10-17)	61.30	10.99%	73.83	12.89%	20.45%
Adults (18-64)	857.91	25.68%	926.50	27.28%	8.00%
Adults Age 18-44	451.94	23.54%	451.94	23.50%	0.00%
Adults Age 45-64	405.97	28.58%	474.56	32.21%	16.90%

Source: Mathematica Policy Research estimates from the Minnesota Behavioral Risk Factor Surveillance System and the National Health and Nutrition Survey. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Table VI.3. Estimated spending attributed to diagnosed obesity in Minnesota 2009 and 2014

	Total spending		Spending attributed to smoking exposure		
	Total spending, all persons (billions)	Per person total spending, all persons	Total spending attributed to obesity ($ millions)	Per person per year spending attributed to obesity, persons with obesity	Percent of total spending attributed to obesity
2009					
Total	$18.026	$4,625	$0.345	$376	1.92%
Medical	$15.132	$3,882	$0.226	$246	1.50%
Pharmacy	$2.894	$743	$0.119	$129	4.10%
2014					
Total	$20.247	$5,100	$0.451	$451	2.23%
Medical	$16.638	$4,191	$0.231	$231	1.39%
Pharmacy	$3.609	$909	$0.220	$220	6.10%
Percent change					
Total	12.3%	10.3%	30.6%	20.0%	0.3%
Medical	10.0%	8.0%	1.9%	-6.3%	-0.1%
Pharmacy	24.7%	22.4%	85.3%	70.2%	2.0%

Source: Mathematica Policy Research analysis of the 2009 and 2014 Medical Expenditure Panel Survey and the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note Percentage of total spending estimates are calculated on expected values of total spending and spending attributed to obesity; total expected spending may vary slightly from actual total spending. Percent change estimates may reflect rounding error.

Table VI.4. Estimated per person spending attributed to obesity in Minnesota by age group 2009 and 2014

	All persons age 10-64 with obesity	Children with obesity (age 10-17)	Adults with obesity (age 18-64)
2009			
Total	$376	$493	$367
Medical	$246	$183	$251
Pharmacy	$129	$309	$116
2014			
Total	$451	$421	$453
Medical	$231	$34	$246
Pharmacy	$220	$387	$207
Percent change			
Total	20.00%	-14.61%	23.38%
Medical	-6.35%	-81.45%	-1.78%
Pharmacy	70.24%	24.96%	77.66%

Source: Mathematica Policy Research analysis of the 2009 and 2014 Medical Expenditure Panel Survey and the Minnesota All-Payer Claims Database v. 19. Estimates are weighted to population and coverage estimates reported in the Minnesota population sample of the American Community Survey.
Note: Percent change estimates may reflect rounding error.

Appendix 4.7: Detailed Data Table – Projected Medical Service and Pharmacy Spending, 2009 and 2014-2023 (millions)

	2009	2014p	2015p	2016p	2017p	2018p	2019p	2020p	2021p	2022p	2023p
						(in millions)					
Total attributed spending											
Total	$8,752.2	$11,499.8	$12,075.7	$12,828.6	$13,472.7	$14,171.4	$14,920.2	$15,678.4	$16,457.8	$17,304.6	$18,156.2
Selected chronic condition under age 60	$1,539.9	$1,746.9	$1,792.5	$1,847.0	$1,872.2	$1,896.4	$1,924.6	$1,949.6	$1,976.5	$2,014.2	$2,055.9
All chronic conditions (age 60 or older)	$7,212.4	$9,752.9	$10,283.2	$10,981.5	$11,600.5	$12,275.0	$12,995.6	$13,728.9	$14,481.3	$15,290.4	$16,100.4
Diabetes	$1,111.2	$1,396.6	$1,458.8	$1,537.4	$1,600.5	$1,666.8	$1,739.8	$1,813.2	$1,889.9	$1,917.8	$2,056.9
Hypertension	$4,072.3	$5,176.8	$5,395.8	$5,710.2	$5,965.3	$62,334.0	$6,530.5	$6,830.6	$7,143.3	$7,477.8	$7,826.0
Dementia (age 18 or older)	$190.5	$249.0	$261.1	$278.1	$292.3	$307.3	$323.8	$340.7	$358.2	$377.1	$396.7
Obesity (age 10-64)	$345.2	$412.4	$424.8	$438.8	$448.8	$459.0	$469.7	$480.3	$491.3	$502.7	$514.5
Smoking exposure (age 18-64)	$109.4	$175.5	$186.5	$193.5	$199.0	$204.6	$210.6	$216.7	$223.1	$229.9	$237.3
Attributed medical spending											
Total	$7,843.1	$10,282.0	$10,795.1	$11,489.1	$12,073.3	$12,708.4	$13,391.0	$14,077.4	$14,781.1	$15,552.9	$16,325.5
Selected chronic condition under age 60	$1,200.5	$1,339.8	$1,373.6	$1,418.6	$1,437.1	$1,454.6	$1,476.0	$1,493.6	$1,512.3	$1,539.2	$1,568.7
All chronic conditions (age 60 or older)	$6,642.6	$8,942.2	$9,421.5	$10,070.5	$10,636.2	$11,253.8	$11,915.0	$12,583.9	$13,268.8	$14,013.7	$14,756.8
Diabetes	$892.4	$1,115.9	$1,165.9	$1,233.2	$1,285.3	$1,339.9	$1,400.5	$1,461.1	$1,523.8	$1,590.6	$1,659.6
Hypertension	$3,450.1	$4,373.5	$4,556.1	$4,835.2	$5,056.4	$5,289.0	$5,547.7	$5,807.1	$6,076.3	$6,363.9	$6,661.8
Dementia (age 18 or older)	$174.0	$226.2	$237.1	$252.8	$265.6	$279.1	$294.2	$309.3	$325.1	$341.9	$359.4
Obesity (age 10-64)	$226.4	$263.8	$270.8	$280.5	$286.5	$292.5	$299.1	$305.3	$311.5	$317.9	$324.4
Smoking exposure (age 18-64)	$60.4	$101.8	$109.4	$113.7	$116.6	$119.4	$122.5	$125.5	$128.5	$131.8	$135.3
Attributed pharmacy spending											
Total	$909.1	$1,217.8	$1,280.6	$1,339.5	$1,399.4	$1,463.0	$1,529.3	$1,601.0	$1,676.7	$1,751.7	$1,830.8
Selected chronic condition under age 60	$339.4	$407.1	$418.9	$428.4	$435.1	$441.8	$448.7	$456.0	$464.2	$474.9	$487.1
All chronic conditions (age 60 or older)	$569.8	$810.7	$861.7	$911.1	$964.3	$1,021.2	$1,080.6	$1,145.0	$1,212.5	$1,276.7	$1,343.6
Diabetes	$218.8	$280.7	$292.8	$304.3	$315.2	$326.9	$339.0	$352.1	$366.1	$381.2	$397.3
Hypertension	$622.2	$803.2	$839.7	$874.9	$908.9	$944.9	$982.8	$1,023.5	$1,067.0	$1,113.9	$1,164.3
Dementia (age 18 or older)	$16.5	$22.7	$23.9	$25.3	$26.7	$28.1	$29.7	$31.4	$33.2	$35.1	$37.2
Obesity (age 10-64)	$118.8	$148.6	$154.0	$158.3	$162.3	$166.4	$170.6	$175.1	$179.8	$184.8	$190.2
Smoking exposure (age 18-64)	$49.1	$73.7	$77.1	$79.8	$82.4	$85.2	$88.1	$91.2	$94.6	$98.2	$102.0

Source: Mathematica Policy Research.
Note: "p" indicates a projected year. Estimates and projections reflect current (versus real) dollars.

Appendix 4.8: Detailed Data Table - Actual Spending Compared to Baseline Projections, 2014

	Actual	Projected	Difference: actual minus projected	Actual as a percentage of projected
	-------- (in million $) --------			
Net Total	$11,290.82	$11,499.78	($208.96)	98.2%
Selected chronic conditions (under age 60)	$1,496.35	$1,746.86	($250.51)	85.7%
All chronic conditions (age 60 or older)	$9,794.47	$9,752.92	$41.55	100.4%
Hypertension	$4,458.63	$5,176.78	($718.16)	86.1%
Diabetes	$1,224.40	$1,396.58	($172.18)	87.7%
Obesity (age 10 to 64)	$450.80	$412.41	$38.40	109.3%
Dementia (age 18 or older)	$223.16	$248.95	($25.79)	89.6%
Smoking exposure (age 18-64)	$243.30	$175.51	$67.79	138.6%

Source: Mathematica Policy Research.
Note: Projections are expressed in current (versus real) dollars.

Appendix 4.8: Detailed Data Table – State-administered Program Share of Difference Between Actual and Projected Spending

Row #	Analysis Step	Rate	Under 60 years	Age 60 or older	All Ages
			(in mill $)		
5	**CONDITION-SPECIFIC DIFFERENCE (actual less projected); /1**				
6	Hypertension				($718.16)
7	Diabetes				($172.18)
8	Obesity (age 10 to 64)				$38.40
9	Dementia (age 18 or older)				($25.79)
10	Smoking exposure (age 18-64)				$67.79
11	All chronic conditions (age 60+)			$41.60	$41.55
13	**NET DIFFERENCE (w/o impact of smoking exposure; /2**		**($250.50)**	**$41.60**	**($208.96)**
15	**PORTION STATE-ADMINISTERED PROGRAMS (SAP)**				
16	Lower Bound (age distribution); /3				
17	Pct of net difference (row 13)	@24.7pct	($61.93)		
18	Pct of net difference (row 13)	@9.7pct		$4.03	**($57.91)**
19	Upper Bound (presence of chronic condition); /4				
20	Pct of net difference (row 13)	@31.1pct	($74.66)		
21	Pct of net difference (row 13)	@7.8pct		$3.24	**($71.42)**
24	**TOBACCO-ATTRIBUTABLE SHARE OF NET DIFFERENCE**				
25	Chronic disease spending accounted for; /5	@75pct			$50.84
26	Likely unaccounted spending	@25pct			$16.95
27	Portion state-administered; /6,7	@19.3pct			$3.27
29	**TOTAL NET DIFF W/TOBACCO ESTIMATE**				
30	Lower Bound (row 27 + row 18)				**($54.63)**
31	Higher Bound (row 27 + row 21)				**($68.14)**

/1 Model results by Mathematica Policy Research with separate models for each condition and smoking exposure;
/2 Model results by Mathematica Policy Research combining conditions with separate models for the under 60 and 60 plus populatin. Because smoking exposure was calculated across multiple years of data and with a subset of information from a separate data set, net estimate modeling could not assess the impact of tobacco. Because of the overlap between chronic conditions and smoking, one expects that a majority of tobacco-related spending (and the difference between actual to projected spending) is considered in the net total.
/3 age-group specific ratio of state-administered programs to total population; additional detail on calculation available upon request
/4 age group and insurance type-specific prevalence of treated chronic conditions; additional detail on calculation available upon request
/5 Seventy-five percent of smokers have one or more chronic conditions. Their spending (and the net difference between actual and projected spending) is likely accounted for in the net estimate of row 13. Spending for the remaining 25 percent is not; additional detail on calculation available upon request
/6 Using BRFSS estimates of the share of current smokers on Medicaid and with private coverage, adjusted to approximate SEGIP contribution to private (5.4 percent of privately insured)
/7 Estimates for the report are based on smoking exposure, which includes current and former smokers. For this calculation we were only able to consider current smokers. As long as the ratio of fomer smokers to current smokers is consistent across health insurance coverage, this should not present a bias.

Appendix 5: 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.[39] 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. However, there are also limited opportunities for benchmarking this work to existing estimates, either locally or nationally.

[39] 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.

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

					Per person cost associated with the condition		
Condition	Ref. #	Time period	Reference population	Per person total cost	Estimate is not controlled for comorbidities	Estimate is controlled for comorbidities	Payer
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
	4	2017	Minnesota adults, current and former smokers	--	$593	--	All payers
Obesity	5	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
	6	2006 (2008 $)	Noninstitutionalized adults age 18+	--	$1,429	--	All payers
	7	2006	Full-time workers age 60+ by extent of obesity	--	$475 - $1,269 (men) $1,269 - $2,395 (women)	--	All payers
	8	2004-2013 (2013 $)	Adult members of Geisinger Health Plan: Northern PA	$4,166	-$1,305	--	Private insurance
	9	2007-2010	Children age 3-17 in integrated health system: MN and CO		$937	$897	Private insurance
	10	2007-2012	Noninstitutionalized adults age 18+	--	$941 (moderate obesity) to $1,980 (severe obesity)	--	All payers
Diabetes	11	2001-2006	Adults age 65+	$9,061	$6,414 - $6,649	--	All payers

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

	24	2003-2009 (2009 $)	Adults age 18+ enrolled in Kaiser Permanente (Portland, OR)	--	--	$550	Private insurance
Dementia	25	1998	Noninstitutionalized patients with Alzheimers or other diagnosed dementia	$12,081 (Alzheimers) $8,027 (Other dementia)	--	--	All payers
	26	1997-2005 (2005 $)	Medicare beneficiaries age 65-101	--	--	$10,814 (Medicare) $6,234 (Medicaid)	Medicare
	27	2001-2002	Patients age 65+ enrolled in large commercial managed care plan	--	--	$2,062	All payers
	28	2004	Medicare beneficiaries age 65+ with employer-sponsored supplemental	--	--	$1,475	Medicare and private insurance
	29	1998-2011 (2004 $)	Nonrepresentative sample of dementia patients, baseline average age 76	$8,753	--	--	Self-reported, all payers
	30	2000-2004 (2010 $)	National sample age 70+	--	--	$10,039	All payers
	31	2000-2008 (2010 $)	Persons age 70+	$33,329	$28,501	--	Medicare and out of pocket

Source: Mathematica Policy Research.

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Appendix 6: Study Methodology, Mathematica Policy Research (Oct. 2017)

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.

I. INTRODUCTION

The methods used to produce initial estimates of health care spending for four chronic diseases (diabetes, hypertension, obesity and obesity-related conditions, and dementia) and one risk behavior (tobacco exposure) are documented below. In this section, we describe our general approach and provide key definitions. In additional sections, we offer details on the data and methods used to develop estimates for each chronic condition, smoking exposure, all chronic conditions among Minnesotans age 60 or older, and total estimates for the selected chronic conditions among Minnesotans under age 60. Finally, we describe the methods used to project the spending estimates to 2020 and outline several important methodological challenges and limitations.

A. General approach

To estimate spending related to diabetes, hypertension, and dementia for medical services and pharmacy (Rx) in 2009 and 2014, we identify persons with each condition, estimate their probability of service use, and estimate medical and Rx spending per person per month among service users. All analyses are conducted at the unique person level. The per-person-per-month cost estimates control for unrelated conditions that contribute to spending. All person-level observations are weighted by the number of months the person is observed in the source data.

In general, the estimating equations are specified as:

(1) $P(U_i) = f(X_i, C_{ik})$

(2) $S_j = f(X_j, C_{jk}, C_{jm})$

where P(Ui) is the probability (equal to zero or one) that person i uses any services that generate spending of at least $1 per month, Sj is average spending per person per month among the subset j of persons with spending of at least $1 per month, and Xi and Xj are vectors of personal characteristics describing persons i and the subset of persons j. Cik and Cjk are indicator variables for the condition of interest k, and Cjm is a vector of indicator variables for conditions that are unrelated to Cjk.

This method of estimation is analogous the methods underlying the Centers for Disease Control and Prevention(CDC)/RTI cost estimation model with three key distinctions:40, 41

- We use the 2009 and 2014 Minnesota All Payer Claims Database (MN APCD) to identify Minnesotans with each condition (defined by diagnosis codes on one or more medical claims), and use claims both to identify service users and to calculate medical and Rx spending controlling for unrelated conditions. Models estimated using the MN APCD omit the first estimating equation; the probability of service use among persons with the condition of interest (C_{ik}) is set to one.

- We use the Medical Expenditure Panel Survey (MEPS) only to analyze conditions that are not observable in the MN APCD (tobacco exposure and obesity) and populations that do not report to the MN APCD (Tricare enrollees and the uninsured, including those who rely on care from Veterans Health Administration facilities or the Indian Health Service).[42]

- We estimate spending per person per month separately for different age groups and levels of spending in order to improve the accuracy of the estimates in the "tails" of the spending distribution. This method serves to minimize overestimation of spending among very low spenders and underestimation of spending among very high spenders.

Because the MN APCD captures payments for formal long-term care, we do not estimate those costs separately. The estimates for tobacco exposure and obesity—which rely on MEPS and are

[40] 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 the technical documentation available at http://www.cdc.gov/chronicdisease/calculator/resources.html, accessed November 30, 2015.

[41] See Mathematica Policy Research. "CDC/RTI Chronic Disease Cost Calculator and Comparison with Proposed Mathematica Methods." Memorandum submitted to the Health Economics Division, Minnesota Department of Health (December 3, 2015).

[42] In contrast, the CDC/RTI estimates of service use and expenditures rely on the relatively small non-public sample of the Minnesota population in the MEPS.

benchmarked to the APCD—assume, in effect, that long-term care costs are proportional to acute care costs associated with those conditions.

For Minnesotans who are privately insured or enrolled in Medicare or Medicaid, we estimate the probability of service use and per-person cost among service users associated with (1) diabetes, (2) hypertension, (3) dementia, and (4) all chronic conditions among persons aged 60 or older from the MN APCD. Estimates for population groups not represented in the MN APCD (Minnesotans enrolled in Tricare or who are uninsured), and all estimates for obesity and smoking, are derived from MEPS and benchmarked to the MN APCD.

Outliers are defined among persons with medical or Rx spending greater than $1 per person month and removed from both datasets. In the MN APCD, outliers are defined as persons with medical or Rx spending per month that is more than twice the 99.99th percentile among all spenders, calculated separately for children, adults, and seniors. To develop MEPS-based estimates for smoking and obesity, outliers in MEPS are defined as persons with medical or Rx spending per month above the 99.90th percentile among all spenders, calculated separately for children, adults, and seniors. We selected the lower threshold to define outliers in MEPS because persons with spending above the 99.90th percentile included too few persons with the condition of interest to yield stable estimates.

B. Definitions

The following sections describe the definition of conditions, assignment of coverage categories (which enables benchmarking to account for persons not represented in the MN APCD), and how household income is estimated for modeling the probability and use of services underlying each set of cost estimates.

1. Disease coding

To identify the key diagnoses/risk factors and other diagnoses, we use (as available in each data source):

- Screening variables (in MEPS and the National Health Interview Survey [NHIS])
- *International Classification of Diseases*, version 9 (ICD-9) codes (in MEPS and the MN APCD)
- Adjusted Clinical Group (ACG)/Expanded Diagnosis Clusters (EDCs) codes appended to the MN APCD.

MEPS reports three-digit ICD-9 diagnosis codes, while the MN APCD reports full ICD-9 diagnosis codes. The more detailed coding available in the MN APCD likely produces more accurate estimates of spending attributed to these conditions for populations represented in the APCD than for those whose cost estimates rely on MEPS.

Table A.1. ICD-9 and ACG[43] codes used to define conditions in MEPS and MN APCD

Condition	MEPS	MN APCD
1. Diabetes (DIAB)	250	362.0, 357.2, 366.41, 250, or ACG definition of DIAB
2. Obesity (OBES)	Reported BMI	ACG definition of OBES
3. Hypertension (HPER)	401-405 twice or more	401-405 twice or more, or ACG definition of HPER
4. Dementia (DEMT)	290, 331	290, 331.0-331.3, 331.5-331.9
5. Tobacco use (TBCO)	Reported current smoker (age 18+)	305.1, 649.01-649.04, V15.82
6. Arthritis (ARTH)	714-716	714-716 or ACG definition of ARTH
7. Asthma (ASTH)	493	493 or ACG definition of ASTH
8. Any cancer (CANC)	140-209, 230-239	140-209, 230-239
9. Cancers associated with obesity (CANC_OBES)[44]	150, 153, 156, 157, 174 (if AGE>50), 182, 189, 193, 209, 230	150, 153, 157, 209, 230, 174 (if AGE>50), 182, 189, 193, 156
10. Cancers not associated with obesity (OTH_CANC_O)	140-209 230-239 and CANC_OBES = 0	140-209, 230-239 and CANC_OBES = 0
11. Cancer associated with diabetes (CANC_DIAB)	153,155,157,174,175,179,182,188	153,155,157,174,175,179,182,188
12. Cancer not associated with diabetes (OTH_CANC_D)	140-209, 230-239 and CANC_DIAB = 0	140-209, 230-239 and CANC_DIAB = 0
13. Cancers associated with smoking (CANC_TBCO)[45]	140-149, 150, 151, 157, 160 – 162, 180, 183, 188, 189, 205, 230, 231, 235	140-149, 150, 151, 157, 160 – 162, 180, 183, 188, 189, 205, 230, 231, 235
14. Cancers not associated with smoking (OTH_CANC_T)	140-209, 230-239 and CANC_TBCO = 0	140-210, 230-239 and CANC_TBCO = 0
15. Congestive heart failure (CHF)	428	428
16. Coronary artery disease (CAD)	414	414
17. Stroke (STRO)	433-435	433-435
18. Other cerebrovascular disease (OCVD)	402; 415-417; 420-423; 429	402; 415-417; 420-423; 429

[43] ACGs are assigned using the Johns Hopkins Adjusted Clinical Groups® system.

[44] Obesity-related cancers are those reported at https://www.cancer.gov/about-cancer/causes-prevention/risk/obesity/obesity-fact-sheet#q5.

[45] Tobacco-related cancers are those reported by the CDC, augmented to also include uterine cancer, nasal and paranasal sinus cancers, and cerebrovascular disease (stroke). See http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5745a3.htm.

Condition	MEPS	MN APCD
19. Depression (DEPR)	300, 311	ACG definition of DEPR
20. Injuries (INJR)	800-846,848-998	800-846,848-998
21. Injuries not related to diabetes (INJR_DIAB)	800-846,848-997	800-846,848-998 except 998.83
22. Surgical Wounds (SURW)	998	998.83
23. Dyslipidemia (DYSL)	272	ACG definition of DYSL or 272
24. HIV/AIDS and varicose veins of other sites (HIVA)	042, V08, 456	ACG definition of HIVA or 042, V08, 456
25. Pneumonia (PNEU)	480-486	480-486
26. Chronic obstructive pulmonary disease (COPD)	491-492, 494-496	ACG definition of COPD
27. Other mental health/substance abuse (MHSA)	291-299, 301-308, 310, 312-314, V40	291-295, 296, 299, 301-305.0, 305.2-308,310, 312-314, V40
28. Back problems (BACK)	720-724,847	720-724, 739.1-739.3, 847
29. Skin disorders (SKIN)	216, 680-686, 690-698, 700-702, 705-709, 782	216, 680-686, 690-698, 700-702, 705-709, 782
30. Skin disorders not related to obesity (SKIN_OBES)	216, 680-685, 690-698, 700-702, 705-706, 708-709, 782	216, 680-685, 690-698, 700-702, 705-706, 708-709, 782
31. Skin disorders not related to dementia (SKIN_DEMT)	216, 680-685, 690-698, 701-702, 705-706, 708-709, 782	216, 680-685, 690-698, 701-702, 705-706, 708-709, 782
32. Renal failure and chronic kidney disease (RENL)	584-586	584-586
33. Pregnancy (PREG) [46]	630-677,679, V22-24,V27, V28 (restriction: female, age 15-55)	630-677,679, V20.3,V21.3,V21.8,V21.9,V22-24,V27, V28 (restriction: female, age 15-55)
34. Perinatal and fetal conditions (PRNT)	678, V21, V29, 760-779	678, V21.3,V21.8,V21.9, V29, 760-779
35. Perinatal and fetal conditions not related to smoking	678, 760, 767, 768, 771, 773-776, 778	678, 760, 767, 768, 771, 773-776, 778
36. Rheumatic heart disease (RHEU)	391-393, 395, 398	391-393, 395, 398
37. Underweight (UNDERWGT)	Reported BMI	-
38. Diseases of mitral and aortic valves & other endocardial structures (VALV)	093, 394, 396, 424, 725, 745, 746	093, 394, 396, 424, 725, 745, 746

[46] Pregnancy diagnoses are restricted to women age 15 to 55. In the MN APCD, 58 percent of the pregnancy diagnosis codes for females age 10 to 15 derived from a diagnosis of alcohol affecting the fetus or newborn via placenta or breast milk (767.01).

Condition	MEPS	MN APCD
39. Diseases of mitral and aortic valves & other endocardial structures not related to hypertension (VALV_HPER)	093, 394, 396, 725, 745, 746	093, 394, 396,725, 745, 746
40. Acute and chronic pulmonary heart disease (PULM)	415-416	415-416
41. Acute and chronic pulmonary heart disease not related to obesity (PULM_OBES)	415	415
42. Acute and other pericardial & endocardial disease (PERI)	397	397
43. Cardiomyopathy (CARM)	425	425
44. Conduction disorders (COND)	426	426
45. Cardiac dysrhythmias (CDYS)	427	427
46. Other or ill-defined heart disease (OTHH)	410-413, 429	410-413, 429
47. Overall heart conditions (OHD)	RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH	RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH
48. Other conditions (OTHC)[47]	0-41,45-66,70-88,90-92, 94-133, 134-139, 211-215, 217-229, 240-246, 249, 251-259, 260-270, 273-277, 279-289, 315, 316,317-319, 320-323, 324-326, 327, 330, 332, 333-337, 338-359, 360-379, 380-389, 417, 420-423, 430-432,440-442, 443, 444-449, 451-454, 455, 457, 458, 459, 460-466, 470-473, 474-478, 487,488, 490, 500-516, 517, 518-519, 520-579, 580- 583, 590-599, 600-608, 610-612, 614-616, 617-629, 703-704, 710-713, 717-719, 726-739, 740-744, 747-759, 780-781, 783-799, 999	0-41,45-66,70-88,90-92, 94-133, 134-139, 211-215, 217-229, 240-246, 249, 251-259, 260-270, 273-277, 279-289, 315, 316,317-319, 320-323, 324-326, 327, 330, 331.4, 332, 333-337, 338-359, 360-379, 380-389, 417, 420-423, 430-432, 440-442,443, 444-449, 451-454, 455, 457, 458, 459, 460-466, 470-473, 474-478, 487,488, 490, 500-516, 517, 518-519, 520-579, 580- 583, 590-599, 600-608, 610-612, 614-616, 617-629, 703-704, 710-713, 717-719, 726-739, 740-744, 747-759, 780-781, 783-799, 999
49. Other conditions not related to smoking (OTHC_TBCO)	OTHC except 218, 256, 365, 366, 368, 370, 440-442, 443, 460-466, 473, 478, 521-523, 527, 529, 530-533, 627, 786,	OTHC except 218, 256, 365, 366, 368, 370, 440-442, 443, 460-466, 473, 478, 521-523, 527, 529, 530-533, 627, 786,
50. Other conditions made worse by smoking (OTHC_TBCO_INTR)	277, 487, 488, 517, 500-516,	277, 487, 488, 517, 500-516,
51. Other conditions not related to obesity (OTHC_OBES)	OTHC except 274, 327, 440-442, 451, 454, 530, 539, 574, 717, 780, 786-788	OTHC except 327, 274, -442, 451, 454, 530, 539, 574, 717, 780, 786-788
52. Other conditions not related to diabetes (OTHC_DIAB)	OTHC except 365, 369, 440-442	OTHC except 365, 369, 440-442
53. Other conditions not related to hypertension (OTHC_HPER)	OTHC except 274, 327, 346, 443, 440-442, 784-785	OTHC except 274, 327, 346, 443, 440-442, 784-785

[47] Other conditions include all codes that are not categorized elsewhere.

Condition	MEPS	MN APCD
54. Other conditions not related to dementia (OTHC_DEMT)	OTHC except 005, 008, 009, 013, 038, 041, 046, 094, 242, 244, 252, 266, 276, 317-319, 327, 332, 333, 417, 440, 487-488, 521-523, 590, 595, 780-781, 797, 799, 999	OTHC except 005, 008, 009, 013, 038, 041, 046, 094, 242, 244, 252, 266, 276, 317-319, 327, 332, 333, 417, 440, 487-488, 521-523, 590, 595, 780-781, 797, 799, 999

2. Coverage

Common definitions of coverage are used for both 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, 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. When two or more sources account for an equal number of 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 the assignment of each person to a unique, primary coverage status, although the person might have claims paid from multiple sources of coverage during the year. 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 account for categories of persons not included in the MN APCD—specifically, Tricare enrollees and uninsured persons. The final estimates reflect the distribution of coverage (by age and sex) reported in 2009 and 2014 in the Minnesota Health Access Survey.[48]

3. Household income

To capture the effects of household income on service use in the analyses that rely on the MN APCD, we assign each person in the MN APCD to a community. This assignment is done by mapping each person's zip code to their U.S. Census-defined Zip Code Tabulation Area (ZCTA). Household income is calculated from the Minnesota population sample of the 2009 and 2014 American Community Survey, arraying population-weighted mean household income by ZCTA, rounding to the nearest $100 and scaling by $10,000. For models using MEPS data, we use actual reported household income.

[48] The Minnesota Health Access Survey is a biennial dual-frame, random-digit-dial household survey that collects information on health insurance and health care access among Minnesotans. See http://www.health.state.mn.us/divs/hpsc/hep/hasurvey/about.html, accessed June 10, 2016.

II. DIABETES

Medical and Rx spending associated with diabetes is estimated from the MN APCD and from MEPS:

- Spending among persons with Medicare, private (commercial) insurance, or Medicaid or other public coverage is estimated using the MN APCD.
    - Spending among uninsured persons and persons in Tricare (neither represented in the MN APCD) is estimated using MEPS.

A. Estimating average monthly spending for persons in Medicare, private insurance, or Medicaid or other public coverage

In the MN APCD, a person is defined as having diabetes if he or she had a diagnosis of diabetes or application of The Johns Hopkins ACG system indicated diabetes.[49] We summarize the difference between diabetes identified by the diagnosis coded in at least one medical claim unrelated to a lab test and the lenient ACG criteria (which require at least one medical diagnosis but separately consider Rx information as well) in Table A.2. In total, we find that 97.2 percent of persons identified as having or not having diabetes by inspection of medical claims are also flagged by the ACG system.[50] Combining the claim-based and ACG criteria, we identified 7.7 percent of persons in the MN APCD as having diabetes.

Table A.2. Persons with diabetes in the MN APCD identified by claim-based and ACG methods

Diabetes identified by at least one diagnosis on a medical claim	Diabetes identified by ACG (lenient criteria)	Total number of persons	Total persons as a percentage of all persons with medical coverage
Yes	Yes	268,866	7.0%
Yes	Rx only	565	0.0%
Yes	No	10,278	0.3%

[49] Diabetes diagnosis codes include 362.0, 357.2, 366.41, and 250. Diagnosis codes for gestational diabetes are excluded.

[50] Most persons identified as having diabetes based on medical claims but not identified by the ACG system have the following conditions: pneumonia, organism unspecified (ICD-9 486); bronchopneumonia, organism unspecified (ICD-9 485); or viral pneumonia, unspecified (ICD-9 480.9). Conversely, most persons identified by the ACG system but not by examination of medical claims have a diagnosis of pneumonitis due to inhalation of food or vomitus (ICD-9 507.0).

No	Yes	11,610	0.3%
No	Rx only	5,034	0.1%
No	No	3,517,483	92.2%

Because so few people with diabetes in the MN APCD (0.1 percent) are identified only by their pharmacy spending, we do not separately model the probability of spending among persons with diabetes in the MN APCD. Instead, we assume that all persons with diabetes in the MN APCD have medical spending. The probability of Rx spending among diabetics and the probabilities of medical and Rx spending among non-diabetics are set equal to the actual probabilities in the MN APCD by age, gender, and coverage category.

The level of medical or Rx spending among those with monthly spending above $1 is estimated from a series of medical cost and Rx cost models. We estimate average spending per month for each of 12 population groups (in total, 24 models), including children (age 0-17), young adults (age 18-44), older adults (age 45-64), and seniors (age 65 or older) in each of three spending categories (to minimize error in predicting spending in the tails of each distribution):

- Low cost, defined as persons with average monthly spending below the 80th percentile within their age category
- High cost, defined as persons with average monthly spending at or above the 80th percentile but below the 98th percentile within their age category
    - Extra high cost, defined as persons with average monthly spending at or above the 98th percentile within their age category

Estimates of average monthly spending among persons with total spending above $1 are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses independent of diabetes. The spending models, estimated by coverage category among medical service and Rx users are specified as follows:

- Medical spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, TBCO, DIAB, OBES, HPER, DEMT, ARTH, ASTH, OTH_CANC_D, INJR_DIAB, SURW, HIVA, PNEU, COPD, MHSA, BACK, PREG, PRNT, RHEU, VALV, PULM, PERI, OTHC_DIAB, AGE*SEX, DIAB*AGE, DIAB*SEX, HPER*DIAB, DEMT*DIAB, TBCO*DIAB, ARTH*DIAB, SURW*DIAB, HIVA*DIAB, PNEU*DIAB, COPD*DIAB, MHSA*DIAB, PREG*DIAB, VALV*DIAB, PULM*DIAB, PERI*DIAB)
    - Rx spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, TBCO, DIAB, OBES, HPER, DEMT, ARTH, ASTH, OTH_CANC_D, INJR_DIAB, SURW, HIVA, PNEU, COPD, MHSA, BACK, PREG, PRNT, RHEU, VALV, PULM, PERI, OTHC_DIAB, AGE*SEX, DIAB*AGE, DIAB*SEX, HPER*DIAB, DEMT*DIAB, TBCO*DIAB, ARTH*DIAB, SURW*DIAB, HIVA*DIAB,

PNEU*DIAB, COPD*DIAB, MHSA*DIAB, PREG*DIAB, VALV*DIAB, PULM*DIAB, PERI*DIAB)

In the specifications above, AGE, INCOME, AND INCOME_SQ are continuous variables equal to the person's age, family income, and family income squared (to capture potential non-linear effects of income on spending). MCR and MCD are categorical variables equal to 1 if the person is enrolled, respectively, in Medicare or Medicaid (or other public coverage) in most months of the year; TBCO is an indicator variable for the person's current smoking status based on the MEPS screening question asked of all persons age 18 or older in the MEPS sample.

All other control variables are categorical variables indicating medical conditions that are clinically unrelated to diabetes (DIAB)—that is, a reduction in diabetes would not be expected to affect the incidence of these conditions). The clinically unrelated conditions are: obesity (OBES), hypertension (HPER), dementia (DEMT), arthritis (ARTH), asthma (ASTH), cancers unrelated to diabetes (OTH_CANC_D), injuries unrelated to diabetes (INJR_DIAB), surgical wounds (SURW), HIV-AIDS (HIVA), pneumonia (PNEU), chronic obstructive pulmonary disease (COPD), mental health and substance abuse (MHSA), back problems (BACK), pregnancy (PREG), perinatal conditions and fetal conditions (PRNT), rheumatic heart disease (RHEU), diseases of mitral and aortic valves and other endocardial structures (VALV), pulmonary disease (PULM), acute and other pericardial and endocardial disease (PERI), and some additional rare conditions (OTHC_DIAB). The ICD-9 diagnosis codes that compose these conditions are listed in Table A.1.

Because the models do not control for diagnoses clinically linked to diabetes, the coefficient estimated for diabetes (DIAB) captures spending associated with clinically related conditions. Some condition variables (hypertension, dementia, tobacco, arthritis, surgical wounds, HIV, pneumonia, chronic obstructive pulmonary disease, mental health and substance abuse, pregnancy, diseases of mitral and aortic valves and other endocardial structures, pneumonia, pulmonary disease, acute and other pericardial and endocardial disease, and some additional rare conditions) are interacted with diabetes, as diabetes does not affect the occurrence of these conditions but can affect the health outcomes and cost of treating these conditions.

The models are edited (via stepwise regression) to remove variables with statistically insignificant associations with average monthly spending ($p > 0.15$). Only variables with statistically significant associations with average monthly spending remain in the final specification and contribute to the final spending estimates.

Using the estimated parameters, we calculate (separately) average monthly medical and Rx spending for diabetes by age and gender as the difference between the sum of expected spending per person per month and the average monthly spending that would occur in each coverage category if no person were diagnosed with diabetes (estimated with DIAB = 0):

(1) Medical cost of diabetes = Med spending (DIAB = actual) - Med spending (DIAB = 0)

(2) Rx cost of diabetes = Rx spending (DIAB = actual) - Rx spending (DIAB = 0)

B. Estimating average monthly spending for persons who are uninsured or in Tricare

Because the MN APCD does not include information for persons who are uninsured or on Tricare, we use MEPS data to estimate their spending. For these persons, we estimate logit models to predict the probability of medical and pharmacy spending among persons who are diabetic versus nondiabetic. These models are estimated over a subset of the MEPS national population sample, including the persons with commercial insurance (baseline), persons who are uninsured (UNIS), and persons in Tricare (TRI). The models are specified as:

- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, DIAB, UNIS)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, DIAB, UNIS)
- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, DIAB, TRI)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, DIAB, TRI)

Because of the relatively small MEPS sample of persons with diabetes, we estimate medical and Rx cost models only for adults and in two population groups (in total, four models):

- Low-cost adults, defined as adults with average monthly spending below the 80th percentile among adults
- High-cost adults, defined as adults with average monthly spending at or above the 80th percentile among adults

Other than adding a MIDWEST region indicator, the medical and Rx cost models are specified identically to the MN APCD-based models. We estimate each model for persons in the MEPS sample who are (1) commercially insured or uninsured and (2) commercially insured or in Tricare. Statistically insignificant variables ($p > 0.15$) are removed via step-wise regression, and only statistically significant variables remain in the final specifications.

We then calculate the same equations (1) and (2) as for the MN APCD population, but using estimates derived from MEPS. These results are benchmarked to spending among the privately insured population in the MN APCD (Equations 3 to 6 below) to arrive at the average monthly medical and Rx cost of diabetes for Minnesotans who are uninsured or in Tricare:

(3) $$\text{Medical cost of diabetes (uninsured)} = \frac{\text{Med cost of DIAB (unin\_MEPS)}}{\text{Med cost of DIAB (comm\_MEPS)}} * \text{Med cost of DIAB (comm\_APCD)}$$

(4) $\text{Rx cost of diabetes (uninsured)} =$

$$\frac{\text{Med cost of DIAB (unin\_MEPS)}}{\text{Med cost of DIAB (comm\_MEPS)}} * \text{Rx cost of DIAB (comm\_APCD)}$$

(5) $\text{Medical cost of diabetes (Tricare)} =$

$$\frac{\text{Med cost of DIAB (Tricare\_MEPS)}}{\text{Med cost of DIAB (comm\_MEPS)}} * \text{Med cost of DIAB (comm\_APCD)}$$

(6) $\text{Rx cost of diabetes (Tricare)} =$

$$\frac{\text{Rx cost of DIAB (Tricare\_MEPS)}}{\text{Rx cost of DIAB (comm\_MEPS)}} * \text{Rx cost of DIAB (comm\_APCD)}$$

C. Estimating total cost

Total medical and Rx spending associated with diabetes is calculated as average monthly spending associated with diabetes among Minnesotans with diabetes in each coverage category (by age and sex) annualized over 12 months and multiplied by the estimated number of persons with diabetes. These calculations are done somewhat differently for persons observed in the MN APCD (in Medicare, Medicaid or other public coverage, or commercial insurance), versus those not observed in the MN APCD (in Tricare or uninsured):

- For persons with Medicare, Medicaid or other public coverage, or commercial insurance, the percentage of Minnesotans with diabetes (by age, sex, and source of coverage) is derived from the MN APCD. In effect, we assume that Minnesotans in very small private insurance plans that do not report to the MN APCD have the same rate of diabetes as the average among those in plans that do report.
    - For persons in Tricare or who are uninsured, the number of Minnesotans with diabetes is estimated (by age, sex, and coverage) as the percentage of persons in Minnesota Behavioral Risk Factor Surveillance System (MN BRFSS) who report having ever been told they have diabetes, multiplied by the national MEPS percentage of all diabetics who are in Tricare or are uninsured (respectively).

These percentages are multiplied by the number of persons in Minnesota population sample of the American Community Survey (ACS) who reported each coverage status to arrive at a total spending estimate benchmarked to the ACS. The total number of persons across coverage

categories is then adjusted to Minnesota's total population estimates by age and sex to produce final total cost estimates.

III. HYPERTENSION

Medical and Rx spending associated with hypertension is estimated from the MN APCD and the MEPS – Household Component:

- Spending among persons with Medicare, private (commercial) insurance, or Medicaid or other public coverage is estimated using the MN APCD.
    - Spending among uninsured persons and persons in Tricare (neither represented in the MN APCD) is estimated using MEPS.

A. Estimating average monthly medical and Rx cost among service users: persons in Medicare, private insurance, or Medicaid or other public coverage

Persons represented in the MN APCD are identified as having hypertension if they have a diagnosis of hypertension on at least two claims unrelated to a lab test, or application of The Johns Hopkins Adjusted Clinical Groups® (ACG®) system (lenient criteria) indicates hypertension. The difference between hypertension identified by the diagnosis coded in two or more medical claims unrelated to a lab test and the lenient ACG criteria, which require at least one medical diagnosis but separately also consider Rx information, is summarized in Table A.3. Using both the claims-based and ACG criteria, we identified 24.2 percent of persons in the MN APCD as hypertensive.[51]

Table A.3. Persons with hypertension in the MN APCD identified by claim-based and ACG methods

Hypertension identified by a diagnosis on two or more medical claims	Hypertension identified by ACG (lenient criteria)	Number of persons	Total persons as a percentage of all persons with medical coverage
Yes	Yes	560,868	14.7%
Yes	Rx only	4,852	0.1%
Yes	No	2,612	0.1%
No	Yes	160,230	4.2%

[51] In late 2017, the national guideline for the identification and management of hypertension was revised, lowering the threshold for a hypertension diagnosis from 140/90 mm Hg to 130/80 mm Hg. The estimates and projections presented in this report are consistent with the original higher hypertension cutpoint of 140/90 mm Hg, and do not take the revised hypertension guidelines into account.

No	Rx only	195,331	5.1%
No	No	2,889,943	75.8%

Because few people with hypertension in the MN APCD (5.1 percent) are identified only by their pharmacy spending, we do not separately model the probability of spending among persons with hypertension in the MN APCD. Instead, the probability of spending among hypertensive and non-hypertensive persons, respectively, is set equal to the actual rate of any medical or Rx use in the MN APCD by age, gender, and coverage category.

The level of medical or Rx spending among those with average monthly spending above $1 is estimated from a series of medical cost and Rx cost models. We estimate medical and Rx spending for each of 12 population groups (in total, 24 models), including children (age 0 to 17), young adults (age 18 to 44), older adults (age 45 to 64) and seniors (age 65 or older) in each of three spending categories (to minimize error in predicting spending in the tails of each distribution):

- Low cost, defined as persons with average monthly spending below the 80th percentile within their age category
- High cost, defined as persons with average monthly spending at or above the 80th percentile but below the 98th percentile within their age category
    - Extra high cost, defined as persons with average monthly spending at or above the 98th percentile within their age category

Estimates of average monthly spending among persons with total spending above $1 are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses that are independent of hypertension. Estimated by coverage category among, respectively, medical service and Rx users, the spending models are specified as follows:

- Medical spending per month = f (AGE, SEX, INCOME, INCOME_SQ,[52] MCR, MCD, HPER, OBES, DEMT, TBCO, ARTH, ASTH, CANC, INJR, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN, PREG, PRNT, RHEU, VALV_HPER, PULM, PERI, OTHH, OTHC_HPER, AGE*SEX, HPER *AGE, HPER *SEX, HPER*OBES, DEMT* HPER, ARTH* HPER, ASTH* HPER, CANC* HPER, DYSL* HPER, COPD* HPER, MHSA* HPER, PREG* HPER, PULM* HPER)
    - Rx spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, HPER, OBES, DEMT, TBCO, ARTH, ASTH, CANC, INJR, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN,

[52] We included income and the square of income to capture the non-linear effect of income on spending.

PREG, PRNT, RHEU, VALV_HPER, PULM, PERI, OTHH, OTHC_HPER, AGE*SEX, HPER *AGE, HPER *SEX, HPER*OBES, DEMT* HPER, ARTH* HPER, ASTH* HPER, CANC* HPER, DYSL* HPER, COPD* HPER, MHSA* HPER, PREG* HPER, PULM* HPER)

In these specifications, AGE, INCOME, INCOME_SQ are continuous variables. MCR and MCD are indicator variables for coverage status (private insurance is the omitted category).

All other variables are indicator variables for diagnosed conditions: hypertension (HPER), obesity (OBES), dementia (DEMT), tobacco use (TBCO), arthritis (ARTH), asthma (ASTH), cancer (CANC), injuries (INJ), dyslipidemia (DYSL), HIV-AIDS (HIVA), pneumonia (PNEU), chronic obstructive pulmonary disease (COPD), mental health and substance abuse (MHSA), back conditions (BACK), conditions of the skin (SKIN), pregnancy (PREG), perinatal conditions (PRNT) rheumatic heart disease (RHEU), diseases of mitral and aortic valves & other endocardial structures unrelated to hypertension(VALV_HPER), pulmonary disease (PULM), acute and other pericardial and endocardial disease (PERI), other or ill-defined heart disease(OTHH), and other conditions unrelated to hypertension (OTHC_HPER). The ICD-9 diagnosis codes that compose these conditions are listed in Table A.1.

Because the models do not control for diagnoses clinically linked to hypertension, the coefficient estimated for hypertension (HPER) captures the impact on spending of clinically related conditions. Some condition variables (obesity, dementia, asthma, arthritis, cancer, dyslipidemia, chronic obstructive pulmonary disease, mental health and substance abuse, pregnancy, diseases of mitral and aortic valves and other endocardial structures, pneumonia, and pulmonary disease) are interacted with hypertension, because hypertension does not affect the occurrence of these conditions but can affect the health outcomes and cost of treating them.

The models are edited (via stepwise regression) to remove variables with statistically insignificant associations with average monthly spending ($p > 0.15$). Only variables with statistically significant associations with average monthly spending remain in the final specification and contribute to the final spending estimates.

Using the estimated parameters, we calculate (separately) medical and Rx spending for hypertension by age and gender as the difference between the sum of expected spending per person per month and the average monthly spending that would occur if no person were diagnosed with hypertension (estimated with HPER = 0):

(1) Medical cost of hypertension = Med spending (HPER = actual) - Med spending (HPER = 0)

(2) Rx cost of hypertension = Rx spending (HPER = actual) - Rx spending (HPER = 0)

B. Estimating the probability of medical service and Rx use and average monthly spending among service users: persons who are uninsured or in Tricare

Because the MN APCD does not include information for persons who are uninsured or in Tricare, we use MEPS data to estimate their spending. For these persons, we estimate logit models to predict the probability of medical and pharmacy spending among persons who are hypertensive versus those who are not. These models are estimated over a subset of the MEPS national population sample, including the persons with commercial insurance (baseline), persons who are uninsured (UNIS, and persons in Tricare (TRI). The models are specified as:

- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, HPER, UNIS)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, HPER, UNIS)
- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, HPER, TRI)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, HPER, TRI)

Because of the relatively small MEPS sample of persons with hypertension, we estimate medical and Rx cost models only for adults and seniors combined, in two population groups (in total, four models):

- Low-cost adults and seniors, defined as adults with average monthly spending below the 80th percentile among adults and seniors
- High-cost adults and seniors, defined as adults with average monthly spending at or above the 80th percentile among adults and seniors

The medical and Rx cost modes specifications are based on those used above for APCD, adding an indicator variable (MIDWEST) to designate the MEPS Midwest population sample. We estimate each model twice, respectively for persons who are (1) commercially insured or uninsured and (2) commercially insured or in Tricare. Statistically insignificant variables ($p > 0.15$) are removed via step-wise regression, and only statistically significant variables remain in the final specification.

We then calculate the same equations (1) and (2) as for the MN APCD population, but using estimates derived from MEPS. These results are benchmarked spending among the privately insured population in the MN APCD (Equations 3 to 6 below) to arrive at the average monthly medical and Rx cost of hypertension for Minnesotans who are uninsured or in Tricare:

$$(3)\ \text{Medical cost of HPER (uninsured)} = \frac{\text{Med cost of HPER (unin\_MEPS)}}{\text{Med cost of HPER (comm\_MEPS)}} * \text{Med cost of HPER (comm\_APCD)}$$

(4) Rx cost of HPER (uninsured) =

$$\frac{\text{Rx cost of HPER (unin\_MEPS)}}{\text{Rx cost of HPER (comm\_MEPS)}} * \text{Rx cost of HPER (comm\_APCD)}$$

(5) Medical cost of HPER (Tricare) =

$$\frac{\text{Med cost of HPER (Tricare\_MEPS)}}{\text{Med cost of HPER (comm\_MEPS)}} * \text{Med cost of HPER (comm\_APCD)}$$

(6) Rx cost of HPER (Tricare) =

$$\frac{\text{Rx cost of HPER (Tricare\_MEPS)}}{\text{Rx cost of HPER (comm\_MEPS)}} * \text{Rx cost of HPER (comm\_APCD)}$$

C. Estimating total cost

Total medical and Rx spending associated with hypertension is calculated as average monthly spending associated with hypertension among Minnesotans with hypertension in each coverage category (by age and sex) annualized over 12 months and multiplied by the number of persons with hypertension. These calculations are done somewhat differently for persons observed in the MN APCD (in Medicare, Medicaid or other public coverage, or commercial insurance), versus those not observed in the MN APCD (in Tricare or uninsured):

- For persons with Medicare, Medicaid or other public coverage, or commercial insurance, the percentage of Minnesotans with hypertension (by age, sex, and source of coverage) is derived from the MN APCD. In effect, we assume that Minnesotans in very small private insurance plans that do not report to the MN APCD have the same rate of hypertension as the average among those in plans that do report.
- For persons in Tricare or who are uninsured, the number of Minnesotans with hypertension is estimated (by age, sex, and coverage) as the percentage of persons in BRFSS who report having ever been told they have high blood pressure, multiplied by the national MEPS percentage of all hypertensive persons in Tricare or who are uninsured (respectively).

These percentages are multiplied by the number of persons in the ACS who reported each coverage status to arrive at a total spending estimate benchmarked to the ACS. The total number of persons across coverage categories is then adjusted to Minnesota's total population estimates by age and sex to produce final total cost estimates.

IV. DEMENTIA

Medical and Rx spending associated with dementia among persons with Medicare, private (commercial) insurance, or Medicaid or other public coverage is estimated using the MN APCD. We found no diagnoses of dementia among uninsured persons and persons on Tricare in the MEPS population (presumably because of small sample size), so we do not estimate spending attributed to dementia among those population groups.

Persons with at least one diagnosis of dementia unrelated to a lab test in the MN APCD are defined as having dementia.[53] We chose not to use Johns Hopkins EDC indicator for dementia (NUR24) after investigating sources of differences between dementia identified by the diagnosis coded in at least one medical claim versus the ACG system. Specifically, most persons with dementia identified from medical claims but not identified by the ACG system have dementia that derives from other diagnosed conditions.[54] Because we expect that legislative interest is focused largely on senile dementias, we chose to use only medical claims diagnoses to identify dementia.

Using only claims-based criteria to identify dementia, 1.4 percent of all persons in the MN APCD had at least one diagnosis of dementia in 2009 (Table A.4, rows 1 and 2). Because further investigation indicated that instances of dementia among children under age 18 were very rare[55] and highly clustered among infants, we also omitted children from the analysis.

Table A.4. Persons with dementia in the 2009 MN APCD identified by claim-based and ACG methods

Dementia identified by at least one diagnosis on a medical claim	Dementia identified by ACG	Total number of persons by dementia status	Total persons by dementia status as a percentage of all persons with medical coverage
Yes	Yes	39,253	1.0%
Yes	No	16,046	0.4%
No	Yes	4,686	0.1%
No	No	3,753,851	98.4%

[53] ICD-9 codes indicating dementia are 290, 331.0–331.3, and 331.5–331.9.

[54] Most persons with dementia identified by the ACG system but not by examination of medical claims have the following diagnoses: other persistent mental disorders due to conditions not classified elsewhere (ICD-9 294.8), dementia in conditions classified elsewhere without behavioral disturbance (ICD-9 294.10), dementia in conditions classified elsewhere with behavioral disturbance (ICD-9 294.11), or alcohol-induced persisting dementia (ICD-9 291.2).

[55] Such conditions included Reye's syndrome (ICD-9 331.81) and communicating hydrocephalus (ICD-9 331.3).

A. Estimating average monthly medical service and Rx cost among service users

The level of medical or Rx spending among those with average monthly spending above $1 is estimated from a series of medical cost and Rx cost models. We estimate medical cost and Rx cost models (in total, 18 models) for young adults (age 18 to 44), older adults (age 45 to 64), and seniors (age 65 or older) in each of three spending categories:

- Low cost, defined as persons with average monthly spending below the 80th percentile within their age category
- High cost, defined as persons with average monthly spending at or above the 80th percentile but below the 98th percentile within their age category
- Extra high cost, defined as persons with average monthly spending at or above the 98th percentile within their age category

Estimates of average monthly spending among persons with total spending above $1 are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses independent of dementia. Estimated by coverage category among, respectively, medical service and Rx users, the spending models are specified as follows:

- Medical spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, DEMT, DIAB, OBES, HPER, TBCO, ARTH, ASTH, CANC, CHF, CAD, STRO, OCVD, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN_DEMT, RENL, PREG, PRNT, RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH, OTHC_DEMT, AGE*SEX, DEMT*AGE, DEMT*SEX, HPER*DEMT, DIAB*DEMT, TBCO*DEMT, ARTH*DEMT, ASTH*DEMT, CANC*DEMT, CHF*DEMT, CAD*DEMT, STRO*DEMT, OCVD*DEMT, DYSL*DEMT, HIVA*DEMT, PNEU*DEMT, COPD*DEMT, MHSA*DEMT, SKIN_DEMT*DEMT, RENL*DEMT, RHEU*DEMT, VALV*DEMT, PULM*DEMT, PERI*DEMT, CARM*DEMT, COND*DEMT, CDYS*DEMT, OTHH*DEMT)
- Rx spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, DEMT, DIAB, OBES, HPER, TBCO, ARTH, ASTH, CANC, CHF, CAD, STRO, OCVD, DYSL, HIVA, PNEU, COPD, MHSA, BACK, SKIN_DEMT, RENL, PREG, PRNT, RHEU, VALV, PULM, PERI, CARM, COND, CDYS, OTHH, OTHC_DEMT, AGE*SEX, DEMT*AGE, DEMT*SEX, HPER*DEMT, DIAB*DEMT, TBCO*DEMT, ARTH*DEMT, ASTH*DEMT, CANC*DEMT, CHF*DEMT, CAD*DEMT, STRO*DEMT, OCVD*DEMT, DYSL*DEMT, HIVA*DEMT, PNEU*DEMT, COPD*DEMT, MHSA*DEMT, SKIN_DEMT*DEMT, RENL*DEMT, RHEU*DEMT, VALV*DEMT, PULM*DEMT, PERI*DEMT, CARM*DEMT, COND*DEMT, CDYS*DEMT, OTHH*DEMT)

In these specifications, AGE, INCOME, INCOME_SQ are continuous variables. MCR and MCD are indicator variables for coverage status (private insurance is the omitted category).

All other variables are indicator variables for diagnosed conditions: diabetes (DIAB), obesity (OBES), hypertension (HPER), tobacco use (TBCO), arthritis (ARTH), asthma (ASTH), cancer (CANC), congestive heart failure (CHF), coronary artery disease (CAD), stroke (STRO), other cerebrovascular disease (OCVD), dyslipidemia (DYSL), HIV-AIDS (HIVA), pneumonia (PNEU), chronic obstructive pulmonary disease (COPD), mental health and substance abuse (MHSA), back conditions (BACK), skin conditions unrelated to dementia behaviors (SKIN_DEMT),[56] renal failure and chronic kidney disease (RENL), pregnancy (PREG), perinatal and fetal conditions (PRNT), rheumatic heart disease (RHEU), diseases of mitral and aortic valves & other endocardial structures (VALV), pulmonary disease (PULM), acute and other pericardial and endocardial disease (PERI), cardiomyopathy (CARM), conduction disorders (COND), cardiac dysrhythmias CDYS, other or ill-defined heart disease (OTHH), and other rare conditions unrelated to dementia (OTHC_DEMT). The ICD-9 diagnosis codes that compose these conditions are listed in Table A.1.

Because the models do not control for diagnoses clinically linked to dementia (DEMT), the coefficient estimated for dementia captures the impact on spending of clinically related conditions. The model interacts with dementia many control conditions for which dementia can affect the cost of treatment, although it does not affect their occurrence.

The models are edited (via stepwise regression) to remove variables with statistically insignificant associations with average monthly spending ($p \geq 0.15$). Only variables with statistically significant associations with average monthly spending remain in the final specification and contribute to the final spending estimates.

Using the estimated parameters, we calculate (separately) medical and Rx spending for dementia by age and gender as the difference between the sum of expected spending per person per month and average monthly spending that would occur if no person were diagnosed with dementia (estimated with DEMT = 0):

(1) Medical cost of dementia = Med spending (DEMT = actual) - Med spending (DEMT = 0)

(2) Rx cost of dementia = Rx spending (DEMT = actual) - Rx spending (DEMT = 0)

B. Estimating total cost

[56] Skin conditions related to dementia include corns and callosities (ICD-9 700), chronic ulcer of skin (ICD-9 707), and other local infections of skin and subcutaneous tissue (ICD-9 686).

Total medical and Rx spending associated with dementia is calculated as average monthly spending associated with dementia among Minnesotans with dementia in each coverage category (by age and sex) annualized over 12 months. These calculations assume, in effect, that Minnesotans in very small private insurance plans that do not report to the MN APCD have the same rate of dementia as the average among those in plans that do report.

These percentages are multiplied by the number of persons in MHAS who reported each coverage status to arrive at a total spending estimate benchmarked to MHAS. The total number of persons across coverage categories is then adjusted to Minnesota's total population estimates by age and sex to produce final total cost estimates.

V. PERSONS AGE 60 OR OLDER

We estimate spending attributed to one or more chronic conditions among residents age 60 or older only among Minnesotans who use services reported in the MN APCD. These persons have private insurance, Medicare, or Medicaid or other public coverage. Persons age 60 or older who are uninsured or have Tricare are omitted from the estimates only because they are too few in the MEPS population sample (the great majority are enrolled in commercial insurance or Medicare) to support stable cost estimates benchmarked to the APCD.

To develop estimates of total spending for chronic conditions, we select all persons age 60 or older in their first enrollment month in 2009 and 2014, respectively—thus, we consider spending only in months when they were at least age 60. A person is identified as having one or more chronic conditions if he or she has at least one EDC flagged by the ACG Chronic Condition Count Marker[57] as "an alteration in the structures or functions of the body that is likely to last longer than 12 months and is likely to have a negative impact on health or functional status." We conducted a further clinical expert review of all EDCs and identified several additional EDCs that are generally viewed as chronic.[58] The analysis proceeded using the ACG-flagged EDC augmented with these additional conditions.[59] Outliers (identified as persons with average

[57] See page 50 of The Johns Hopkins ACG® System, Excerpt from Version 11.0 Technical Reference Guide (November 2014) at https://www.healthpartners.com/ucm/groups/public/@hp/@public/documents/documents/cntrb_035024.pdf.

[58] These additional EDC codes are: MUS13 (Cervical pain syndromes); NUR04 (Vertiginous syndromes); NUR07 (Seizure disorder); PSY20 (Major depression); SKN02 (Dermatitis and eczema); and SKN12 (Psoriasis).

[59] Note that obesity is not included in the ACG definition of chronic conditions, we separately estimated cost of obesity among those who do not have any chronic conditions.

monthly medical or Rx spending that is more than twice the level of average monthly spending at the 99.99 percentile) are removed from the data.

Because the analysis relies only on observation of service users in the MN APCD, we calculate the probability of spending among persons with one or more chronic conditions directly from the data. All persons flagged with a chronic condition have either medical or Rx spending, but might not have both. As a result, although the probabilities of medical and Rx spending, respectively, among persons with a chronic condition are high, each is less than 1. Conversely, the probability of medical and Rx spending, respectively, for persons without a chronic condition (all other persons in the APCD) include persons with no medical or Rx spending.

A. Estimating average monthly medical and Rx cost

To estimate costs associated with chronic conditions, we specify a series of medical and Rx cost models for three age groups (60–64, 65–74, and 75 or older) and two levels of average monthly spending (in total 12 models) as follows:

- Average monthly spending below the 80th percentile within the person's age category
- Average monthly spending at or above the 80th percentile within the person's age category

The models control for diagnoses clinically unrelated to chronic conditions ($X_{\sim CC}$). Some control conditions (X_{int}) are interacted with chronic conditions that can affect the cost treating the control condition but are not known to affect its occurrence.[60] The estimated coefficient on chronic conditions captures the impact of EDCs linked to one or more chronic conditions and, therefore, are omitted from the model.[61]

Estimates of average monthly medical and Rx spending among persons with average spending above $1 are based on generalized least-squares (log-linked, gamma distribution) regression. The regression models are specified as follows:

- Medical spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, CC, $X_{\sim CC}$, X_{int}, X_{int}*CC)

[60] Interacted conditions are: FRE04, GAS06, GSU02, GSU04, GSU05, NUR15, and REC04.

[61] The following conditions are omitted from the models: ADM02, CAR13, DEN01-04, EAR01, EAR06, EAR09, EYE07, EYE09, FRE02, FRE05, FRE06, FRE08-09, FRE13, GAS08, GAS11, GS106-108, GSU08, GSU10, GSU13-14, GUR06, GUR08, GUR11, HEM02, INF01-02, INF05-06, INF08-09, MUS01, MUS10, MUS12, MUS15-16, NEW03-04, NUR02, NUR10, NUT02, NUT04, PSY06, PSY10, RES01, RES05, RES07, RES14, RHU04, SKN07-09, SKN11, SKN13, SKN16, SKN20, and TOX02.

- Rx spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MCR, MCD, CC, $X_{\sim CC}$, X_{int}, X_{int}*CC)

In these models, AGE, INCOME, and INCOME_SQ are continuous variables. SEX is an indicator variable, as are MCR (Medicare) and MCD (Medicaid or other public coverage). CC is a binary indicator for one or more chronic conditions; $X_{\sim CC}$ and X_{int} are vectors of unrelated conditions and interacted conditions defined as above.

The models are edited (via stepwise regression) to remove variables with statistically insignificant associations with average monthly spending ($p \geq 0.15$). Only variables with statistically significant associations with average monthly spending remain in the final specification and contribute to the final spending estimates.

Using the estimated parameters, we calculate average monthly medical and Rx spending for one or more chronic conditions (CC) by age group and gender as the difference between the sum of total expected spending (with CC = actual) and the spending that would occur if no person had chronic conditions (setting CC = 0 for all persons):

(1) Medical cost of chronic conditions = Med spending (CC = actual) - Med spending (CC = 0)

(2) Rx cost of chronic conditions = Rx spending (CC = actual) - Rx spending (CC = 0)Differences between these calculations (at the person level) are summed to produce estimates of total cost among persons age 60 or older in the APCD. Lastly, we estimated cost of obesity among persons age 60 or older who do not have any chronic conditions. The total cost attributed to chronic conditions is the sum of cost attributed to any chronic conditions (excluding obesity) and cost attributed to obesity among those who do not have any chronic conditions. These estimates are then weighted to the population estimates by source of coverage derived from the ACS to calculate the total cost of chronic conditions among persons age 60 or older in Minnesota.

B. Estimating total cost

Total medical and Rx spending associated with chronic conditions among persons age 60 or older is calculated as average monthly spending associated with chronic conditions among those with chronic conditions in each coverage category (by age and sex) annualized over 12 months. These calculations assume, in effect, that Minnesotans age 60 or older in very small private insurance plans that do not report to the MN APCD have the same rate of chronic conditions as the average among those in plans that do report.

These percentages are multiplied by the number of persons age 60 or older in MHAS who reported each coverage status to arrive at a total spending estimate benchmarked to MHAS.

The total number of persons across coverage categories is then adjusted to Minnesota's total population estimates by age and sex to produce final total cost estimates.

VI. SMOKING EXPOSURE

Because smoking status is not identified in the MN APCD, we use the MEPS national population sample (to obtain information on current smoking status) linked to the Sample Person NHIS, Adult Sample NHIS (to obtain additional information on past smoking status—specifically, time since having quit smoking). To estimate the probability of service and average monthly cost among persons with smoking exposure, we use two three-year periods of MEPS data: 2008–2010 for the 2009 estimates, and 2012–2014 for the 2014 estimates. We adjust the MEPS person weight for individuals observed in more than one year of the two-year panel.

The MEPS sample is drawn from the prior-year NHIS. Because the MEPS sample includes each sample household for two years, each person has one or two annual responses to the MEPS question about current smoking. Among those that can be matched to NHIS, NHIS asks about current smoking and, if they do not currently smoke, whether they ever smoked and how long since they stopped smoking. MEPS and NHIS question only adults (age 18 to 64) and seniors (age 65 or older) about current or past smoking status.

For each calendar year, the information on smoking obtained by combining MEPS and NHIS for each estimation year is described in Table A.5.

Table A.5. Merged information from 2009 and 2014 MEPS with NHIS

MEPS panel year	2009	2014
First year	• Current smoking status from the 2009 MEPS	• Current smoking status from the 2014 MEPS
	• Current smoking status from the 2008 NHIS; also, if not a smoker at time of 2008 NHIS question, whether the person ever smoked and how long ago the person quit	• Current smoking status from the 2013 NHIS; also, if not a smoker at time of 2013 NHIS question, whether the person ever smoked and how long ago the person quit
Second year	• Current smoking status from the 2009 MEPS	• Current smoking status from the 2014 MEPS
	• Current smoking status from the 2008 MEPS	• Current smoking status from the 2013 MEPS
	• Current smoking status from 2007 NHIS, if not a smoker at time of 2007 NHIS question; also, if not a	• Current smoking status from 2012 NHIS if not a smoker at time of 2012 NHIS question; also, if not a

	smoker at time of 2007 NHIS question, whether the person ever smoked and how long ago the person quit	smoker at time of the 2012 NHIS question, whether the person ever smoked and how long ago the person quit

We use three years of the MEPS sample to improve the accuracy of the estimates. For 2009, we combine the 2008–2010 MEPS; for 2014, we combine the 2012–2014 MEPS.[62] Information from MEPS and NHIS are combined to derive information for each data year (analogous to 2009 and 2014 as shown in Table A.5). For example, we match the 2009 MEPS population sample to their 2007 and 2008 NHIS data and to 2008 MEPS, and we match the 2014 MEPS population sample to their 2012 and 2013 NHIS data and to 2013 MEPS.

The analyses of the probability of medical and Rx use—and average monthly medical and Rx costs among service users—rely on these matched data. For adults and seniors, we define six categorical variables for direct smoking (current or past) and second-hand smoking:

- Current smokers (SMOKE_CURRENT) are persons who identified themselves as current smokers in MEPS.
- Nonsmokers (SMOKE_NEVER) are persons who identified themselves as NOT a current smoker in MEPS and never smoker in NHIS.
- Past smokers who quit within the past year (SMOKE_QUIT_PASTYEAR) are persons who identified themselves as NOT a current smoker in MEPS and either a current smoker in the prior year in NHIS or a current smoker in prior year MEPS.
- Past smokers who quit between one and five years ago (SMOKE_QUIT_PAST1_4) are persons who identified themselves as NOT a current smoker in MEPS and quit between one and four years in NHIS.
- Past smokers who quit more than five years ago (SMOKE_QUIT_PAST5) are persons who identified themselves as NOT a current smoker in MEPS and quit more than five years ago in NHIS.
- Persons exposed to secondhand smoking (SMOKE_SH), defined by living in the same dwelling as other family members that currently smoke

The first five categorical variables are mutually exclusive (never smoked is the omitted variable); SMOKE_SH can be 0 or 1 for any person.

[62] 2015 MEPS was not available in time for use in this study.

We model the probability of use and average monthly spending among service users. Medical service and Rx users are defined as persons with average medical and Rx spending, respectively, equal to at least $1 per month.

A. Estimating the probability of medical service and Rx use

The medical service and Rx probability models for 2009 and 2014 are estimated using logistic regression. These models are specified as follows:

- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, MCR, MCD, UINS, TRI, TBCO, YEAR)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, MCD, MCR, UINS, TRI, TBCO, YEAR)

In these models, AGE and INCOME are continuous variables; SEX indicates gender; MIDWEST indicates the MEPS Midwest population sample; and MCR, MCD, UINS, and TRI indicate insurance status during most months of the year (respectively Medicare, Medicaid or other public programs, uninsured, or Tricare). TBCO is a vector of the smoking variables defined above. YEAR is a vector of indicator variables (2008, 2010 and 2012, 2013 respectively) that capture any secular change in each time period relative to the baseline years (2009 and 2014).

We calculate relativity factors from the probability models to benchmark the estimates to the probability of service use in Minnesota. These relativity factors are defined as the ratio of (1) the probability of medical or Rx spending for a person who *is exposed* to tobacco (ever smoked, currently exposed to SHS) to (2) the probability of medical spending or Rx for a person who *is not* exposed in those ways:

- $R_{PMED\_TBCO} = \frac{P(\text{Medical service use} \mid TBCO=1)}{P(\text{Medical service use} \mid TBCO=0)}$
- $R_{PRX\_TBCO} = \frac{P(\text{Rx use} \mid TBCO=1)}{P(\text{Rx use} \mid TBCO=0)}$

The probability of medical service among Minnesotans not exposed to tobacco is calculated by solving the following equation for the probability of any service use among persons not exposed to tobacco in the APCD:

(1) $P\_MED_{APCD} = P\_TBCO * R_{PMED\_TBCO} * P(\text{Medical service use} \mid TBCO=0) + (1 - P\_TBCO) * P(\text{Medical service use} \mid TBCO=0)$

⇨ $P(\text{Medical service use} \mid TBCO=0) = P\_MED_{APCD} / (P\_TBCO * R_{PMED\_TBCO} + 1 - P\_TBCO)$

In these equations, P_MED_{APCD} is the probability of any service use (regardless of tobacco exposure status) in the APCD. P_TBCO is the probability of tobacco exposure among persons in the MN BRFSS. R_{PMED_TBCO} is the relativity factor defined above, estimated from MEPS.

A probability-of use estimate for Rx adjusted to the APCD and MN BRFSS rates of smoking is calculated analogously, to produce (2):

⇨ $P(\text{Rx use} \mid \text{TBCO=0}) = P\_RX_{APCD} / (P\_ \text{TBCO} * R_{PRX\_ TBCO} + 1 - P\_ \text{TBCO})$

Medical and Rx spending associated with tobacco exposure among medical service and Rx users are estimated relative to non-exposed adults. The spending estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models adults (age 18 to 64) . We estimate a medical cost model and an Rx cost model for each of 4 population groups (in total, 4 models):

- Low-cost adults, defined as adults with average monthly spending below the 80th percentile among adults
- High-cost adults, defined as adults with average monthly spending at or above the 80th percentile among adults

B. Estimating average monthly medical service and Rx cost among service users

Estimates of average monthly spending are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models controlling for diagnoses independent of tobacco exposure. Because the models do not control for diagnoses clinically linked to tobacco exposure, the estimated coefficients on tobacco exposure capture their impact on the dependent variable. The models interact many control conditions with current or past smoking, as smoking can affect the cost treating these conditions, but it is not known to affect their occurrence. A number of rare conditions unrelated to current or past smoking are clustered in a single indicator variable (OTHC_TBCO) to simplify the models. In addition, outliers are defined as persons with medical or Rx average spending per month at or above the 99th percentile of all spenders, calculated separately for adults and seniors.

The spending models for adults/seniors are specified as follows (using the same specifications for medical and Rx spending):

- Spending per month =

f (AGE, SEX, INCOME, MIDWEST, YEAR, TRI, MCD, MCR, UINS, SMOKE_CURRENT, SMOKE_QUIT_PASTYEAR, SMOKE_QUIT_PAST1_4, SMOKE_QUIT_PAST5, SMOKE_SH, DIAB,

OBES, ARTH, OTH_CANC_T, DEPR, INJR, DYSL, HIVA, MHSA, BACK, SKIN, PREG, OHD, OTHC_TBCO, OTHC_TBCO_INTR, AGE * SMOKE_CURRENT, AGE * SMOKE_QUIT_PASTYEAR, AGE * SMOKE_QUIT_PAST1_4, AGE * SMOKE_QUIT_PAST5, SEX * SMOKE_CURRENT, SEX * SMOKE_QUIT_PASTYEAR, SEX * SMOKE_QUIT_PAST1_4, SEX * SMOKE_QUIT_PAST5, DIAB * SMOKE_CURRENT, DIAB * SMOKE_QUIT_PASTYEAR, OBES * SMOKE_QUIT_PASTYEAR, OBES * SMOKE_QUIT_PAST1_4, OBES * SMOKE_QUIT_PAST5, DYSL * SMOKE_CURRENT, DYSL * SMOKE_QUIT_PASTYEAR, HIVA * SMOKE_CURRENT, HIVA * SMOKE_QUIT_PASTYEAR, PREG * SMOKE_CURRENT, PREG * SMOKE_QUIT_PASTYEAR, OHD * SMOKE_CURRENT , OHD * SMOKE_QUIT_PASTYEAR , OHD * SMOKE_QUIT_PAST1_4, OHD * SMOKE_QUIT_PAST5, OTHC_TBCO_INTR * SMOKE_CURRENT , OTHC_TBCO_INTR * SMOKE_QUIT_PASTYEAR, OTHC_TBCO_INTR * SMOKE_QUIT_PAST1_4, OTHC_TBCO_INTR * SMOKE_QUIT_PAST5, INJR * SMOKE_CURRENT, AGE * SMOKE_SH, SEX * SMOKE_SH, DIAB * SMOKE_SH, PERS_OBES * SMOKE_SH, INJR * SMOKE_SH, DYSL * SMOKE_SH, HIVA * SMOKE_SH, PREG * SMOKE_SH, OHD * SMOKE_SH, OTHC_TBCO_INTR * SMOKE_SH)

In these specifications, AGE, INCOME, INCOME_SQ, MIDWEST, YEAR, and UNDERWGT are defined as in the probability models. MCR, MCD, TRI, and UINS indicate the person's primary source of coverage (Medicare, Medicaid or other public coverage, Tricare, or uninsured); private (commercial) insurance is the omitted coverage category.

All other variables are indicator variables for diagnosed conditions: diabetes (DIAB), obesity (OBES), dementia (DEMT), arthritis (ARTH), asthma (ASTH), cancer (CANC), depression (DEPR), injuries (INJ), dyslipidemia (DYSL), HIV-AIDS (HIVA), mental health and substance abuse (MHSA), back conditions (BACK), conditions of the skin (SKIN), pregnancy (PREG), other heard conditions (OHD), and other conditions unrelated to smoking exposure (OTHC_TBCO). The ICD-9 diagnosis codes that compose these conditions are listed in Table A.1.

We employ stepwise regression, which successively adds or removes variables based statistical significance ($p \geq .15$). All variables—including the smoking exposure variables—are allowed to drop from the model if they and none of their interactions terms are statistical significant. Only statistically significant variables remain in the final specification and contribute to the spending estimates.

Medical and Rx spending relativity factors are calculated from the final equations (in categories defined by coverage, age, and sex). The spending relativity factors are the ratio of expected medical service or Rx spending per person per month if all Minnesotans were exposed to tobacco and the medical spending or Rx per person per month that would occur if none were ever exposed in the same ways. The former scenario is estimated by imputing nonsmokers to current or past smokers according their age and sex distribution, while current and past

smokers remain unchanged (TBCO =1). All persons are simulated to be exposed to SHS. The latter scenario is estimated with assigning zero to all current, past, and secondhand smoking categories (TBCO = 0).

- $R_{MED\_TBCO} = \frac{(\text{Predicted medical service per person per month}|\ TBCO=1)}{(\text{Predicted medical service per person per month}|\ TBCO=0)}$
- $R_{RX\_TBCO} = \frac{(\text{Predicted Rx per person per month}|\ TBCO=1)}{(\text{Predicted Rx per person per month}|\ TBCO=0)}$

We use these relativity factors to estimate medical and Rx spending of never-smokers by solving the following equations for $MED_{TBCO=0}$ and $Rx_{TBCO=0}$, which measure the spending that would occur if no Minnesota resident had ever smoked:

(1) $MED_{APCD} = (P\_TBCO * R_{MED\_TBCO} * (\text{Predicted medical service per person per month}|\ TBCO =0)) + (1- P\_ TBCO) * MED_{TBCO=0}$

⇨ $MED_{TBCO=0} = MED_{APCD} / (P\_ TBCO * R_{MED\_ TBCO} + 1- P\_ TBCO)$

(2) $Rx_{APCD} = (P\_ TBCO * R_{RX\_ TBCO} * (\text{Predicted Rx per person per month}|\ TBCO =0)) + (1- P\_ TBCO) * Rx_{TBCO=0}$

⇨ $Rx_{TBCO=0} = Rx_{APCD} / (P\_ TBCO * R_{RX\_ TBCO} + 1- P\_ TBCO)$

In the equations above, MED_{APCD} and Rx_{APCD} are actual medical and Rx spending per person per month among service users in the APCD, aggregated across all persons; P_ TBCO is the probability that an individual is exposed to smoking, estimated from the MN BRFSS; and $R_{MED\_ TBCO}$ and $R_{RX\_ TBCO}$ are the estimated spending relativity factors, as defined above.

Medical and Rx spending (respectively) per person per month attributed to smoking are calculated as the difference between estimated spending if no Minnesotan was exposed to smoking and actual spending in 2009 or 2014:

(3) $(P\_MED_{APCD} * MED_{APCD}) - (P(\text{Medical service use} | TBCO=0) * MED_{TBCO=0})$

(4) $(P\_Rx_{APCD} * Rx_{APCD}) - (P(\text{Rx use} | TBCO=0) * MED_{TBCO=0})$

C. Estimating total cost

Total cost is calculated as spending per person per month attributed to smoking (by coverage, age, and sex) annualized over 12 months. The number of smoking Minnesotans (by age and sex) in each coverage category is estimated as the total percentage of Minnesotans reported as exposed to tobacco in the MN BRFSS, multiplied by (1) the MEPS percentage of all smoking persons in that coverage category and (2) the number of persons reported in the ACS in that

coverage category. The total number of persons across coverage categories is benchmarked to the total Minnesota population by age and sex to produce the final total cost estimates.

VII. OBESITY

To estimate the probability of service and average monthly cost among persons with obesity, we use two three-year periods of MEPS data: 2008–2010 for the 2009 estimates, and 2012–2014 for the 2014 estimates. MEPS is a much smaller dataset compared with APCD, therefore we used six years of MEPS data to achieve better precision in estimating cost associated with obesity. We adjust the MEPS person weight for individuals observed in more than one year of the two-year panel. Outliers are defined among persons with average monthly medical or Rx spending greater than $1 and removed from the data. Outliers are defined as persons with medical or Rx average spending per month at or above the 99.90th percentile of all spenders, calculated separately for children and adults. We were unable to discern any reasonable cost per person attributed to obesity among seniors, so ultimately dropped them from the analysis.

Obesity is defined as a dichotomized indicator.[63] Adults age 18 to 64 with reported body mass index (BMI) of 30.0 or more, and children age 10 to 18 with BMI greater than the 95th percentile in the United States for their age-gender category are defined as obese.[64, 65]

A. Estimating the probability of medical service and Rx use

The probabilities of medical service and Rx use, respectively, are estimated using logistic regression models, specified as:

- P (Medical service use) = f (AGE, SEX, INCOME, MIDWEST, calendar year indicators, MCR, MCD, UINS, TRI, OBES, UNDERWGT, YEAR)
- P (Rx use) = f (AGE, SEX, INCOME, MIDWEST, calendar year indicators, MCR, MCD, UINS, TRI, OBES, UNDERWGT, YEAR)

[63] We tested BMI as a continuous variable but found that a dichotomous variable predicted with slightly better precision as well as performance on common model selection criteria including the Akaike information criterion and Bayesian information criterion. In addition, a continuous BMI would require assignment of every obese or non-obese person, respectively, a specific alternative weight to estimate the cost of obesity, an approach that likely would introduce false precision.

[64] See the CDC guideline for adult obesity at https://www.cdc.gov/obesity/adult/defining.html.

[65] See the CDC guideline for childhood obesity at https://www.cdc.gov/obesity/childhood/defining.html. We omit children under age 9 in order to use the Minnesota rate of obesity estimated from National Survey of Children's Health for children age 10 to 17 to benchmark the estimates.

In these models, AGE and INCOME are continuous variables, and all other variables are dichotomous. UNDERWGT is an indicator for underweight persons, defined as reported BMI of less than 18.5 for adults and BMI less than the 5th percentile in the United States for children by age-gender category. YEAR is a vector of calendar-year indicators (2008 and 2010 in the 2009 models, and 2012 and 2013 in the 2014 models) to capture any secular change relative to the years of interest (2009 and 2014) in each time period. MIDWEST is an indicator variable that controls for the effects of presence in the MEPS Midwest population sample.

We estimate the change in the probability of service use that would occur if no Minnesotan were obese by calculating relativity factors (in categories defined by coverage, age, and sex) from the logistic regression models above. The relativity factors are defined as the ratio of (1) the probability of medical or Rx spending among obese persons to (2) the probability of medical spending or Rx among non-obese persons:

- $R_{PMED\_OBES} = \frac{P(\text{Medical service use} \mid OBES=1)}{P(\text{Medical service use} \mid OBES=0)}$
- $R_{PRX\_OBES} = \frac{P(\text{Rx use} \mid OBES=1)}{P(\text{Rx use} \mid OBES=0)}$

The probability of medical service use among Minnesotans who are non-obese is calculated by solving the following equation for the probability of any service use among non-obese persons in the MN APCD (v19):

(1) $P\_MED_{APCD} = P\_OBES * R_{PMED\sim OBES} * P(\text{Medical service use} \mid OBES = 0) + (1 - P\_OBES) * P(\text{Medical service use} \mid OBES = 0)$

⇨ $P(\text{Medical service use} \mid OBES = 0) = P\_MED_{APCD} / (P\_OBES * R_{PMED\_OBES} + 1 - P\_OBES)$

In the equations above, P_MED_{APCD} is the probability of any service use in the APCD among all persons (whether obese or not); P_OBES is the probability of obesity estimated from BRFSS for adults age 18 or older and from CDC's National Health and Nutrition Examination Survey (NHANES)[66] for children; and R_{PMED_OBES} is the probability of medical service relativity factor estimated from MEPS.

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

(2) P_(Rx use | OBES=0) = P_RXAPCD / (P_OBES * RPRX_OBES + 1 – P_OBES)

[66] See Childhood Overweight and Obesity Trends at http://www.ncsl.org/research/health/childhood-obesity-trends-state-rates.aspx#2007.

B. Estimating average monthly medical service and Rx cost among service users

We use the same MEPS data to estimate medical and Rx spending associated with obesity among medical service and Rx users respectively, defining medical service and Rx users as persons with average monthly spending equal to at least $1. The spending estimates are based on generalized least-squares (log-linked, gamma distribution) unique-person-level regression models.

For each year of interest, we model 5 medical and Rx cost models (in total, 10 models). For children (age 10 to 17), we model medical and Rx costs in two spending categories:

- Low cost, defined as persons with average monthly medical and Rx spending below the 80th percentile within their age category
- High cost, defined as persons with average monthly medical and Rx spending at or above the 80th percentile within their age category

Exploiting their larger sample size, we model adults (ages 18 to 64) in three spending categories:

- Low cost, defined as persons with average monthly medical and Rx spending below the 80th percentile within their age category
- High cost, defined as persons with average monthly medical and Rx spending at or above the 80th percentile but below the 98th percentile within their age category
- Very high cost, defined as persons with average monthly medical and Rx spending at or above the 98th percentile in their age category

In each model, the dependent variable is spending per person per month. The control variables include conditions that are independent of obesity (that is, a change in the rate of obesity would not be expected to change the rate of occurrence of the condition) and exclude diagnoses clinically linked to obesity.[67]

[67] The diagnoses linked to obesity (and therefore omitted from the specifications) are:
- diabetes (DIAB)
- arthritis (ARTH)
- Asthma (ASTH)
- cancers associated with obesity (CANC_OBES)
- congestive heart failure (CHF)
- coronary heart disease (CHD)
- Hypertension (HPER)

Controlling for demographic factors, family income, Midwest region, and coverage category, the medical and Rx spending models are specified as follows for adults (age 18-64):[68]

- Medical spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MIDWEST, YEAR, MCR, MCD, TRI, UINS, UNDERWGT, OBES, DEMT, TBCO, OTH_CANC_O, INJR, HIVA, PNEU, MHSA, SKIN_OBES, PREG, PRNT, PULM_OBES, PERI, RARE, OTHC_OBES, AGE*OBES, AGE*FEMALE, FEMALE*OBES, INJR*OBES, PNEU*OBES, PREG*OBES, PULM_OBES*OBES, PERI*OBES, RARE*OBES)
- Rx spending per month = f (AGE, SEX, INCOME, INCOME_SQ, MIDWEST, YEAR, MCR, MCD, TRI, UINS, UNDERWGT, OBES, DEMT, TBCO, OTH_CANC_O, INJR, HIVA, PNEU, MHSA, SKIN_OBES, PREG, PULM_OBES, PERI, RARE, OTHC_OBES , AGE*OBES, AGE*FEMALE, FEMALE*OBES, INJR*OBES, PNEU*OBES, PREG*OBES, PULM_OBES*OBES, PERI*OBES, RARE*OBES)

In these specifications, AGE, INCOME, INCOME_SQ, MIDWEST, YEAR, and UNDERWGT are defined as in the probability models. MCR, MCD, TRI, and UINS indicate the person's primary source of coverage (Medicare, Medicaid or other public coverage, Tricare, or uninsured); private (commercial) insurance is the omitted coverage category.

Several conditions unrelated to obesity and that occur rarely—rheumatic heart disease (RHEU), cardiomyopathy (CARM), and conduction disorders (COND)—are grouped into a single variable (RARE) to maximize degrees of freedom. Some condition variables—pregnancy (PREG), injury (INJR), pneumonia (PNEU), pulmonary disease not related to obesity (PULM_OBES), acute and other pericardial and endocardial disease (PERI), and rare conditions (RARE)—are interacted with obesity; obesity does not affect the occurrence of these conditions but can affect the health outcomes and cost of treating them.

Similar spending models are used for children. Because HIV-AIDS (HIVA), dementia (DEMT), and acute and other pericardial and endocardial disease (PERI) are rare among children, these

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- stroke (STRO)
- other cardiovascular disease (OCVD)
- depression (DEPR)
- dyslipidemia (DYSL)
- back problems (BACK)
- decubitus ulcers (removed from SKIN)
- other or ill-defined heart disease (OTHH)

[68] 2013–2014 MEPS edits out ICD-9 diagnosis codes that appear in the data fewer than 20 times. For this reason, we are able to control for two conditions (HIVA and PERI) only with respect to the 2012 data used in the 2012–2014 spending models.

conditions are combined with other rare conditions (RARE) and included from the spending models.

The models are edited (via stepwise regression) to remove variables with statistically insignificant associations with average monthly spending ($p \geq 0.15$). Only variables with statistically significant associations with average monthly spending remain in the final specification and contribute to the final spending estimates.

We estimate the change in the per-person-per-month cost of medical services and Rx among persons who use medical services and Rx (respectively) that would occur if no Minnesotan were obese by calculating relativity factors, analogous to the relativity factors estimated for the probability of service use. The service use and Rx use relativity factors (in categories defined by coverage, age, and sex) are calculated from the final regression models described above in each reference year.

The spending relativity factors are defined as the ratio of expected medical service or Rx spending per person per month if all Minnesotans were obese (estimated with OBES = 1) and average monthly medical spending or Rx that would occur if none were obese (estimated with OBES = 0):

- $R_{MED\_OBES} = \frac{(\text{Predicted medical service per person per month}|\ \text{OBES}=1)}{(\text{Predicted medical service per person per month}|\ \text{OBES}=0)}$
- $R_{RX\_OBES} = \frac{(\text{Predicted Rx per person per month}|\ \text{OBES}=1)}{(\text{Predicted Rx per person per month}|\ \text{OBES}=0)}$

In all calculations, the weight of persons who are underweight or pregnant is assumed not to change.[69]

We use these relativity factors to estimate average monthly medical and Rx spending among non-obese persons by solving the following equations for $MED_{NON\text{-}OBES}$ (predicted medical services spending per person per month if OBES = 0) and $Rx_{NON\text{-}OBES}$ (predicted Rx spending per person per month if OBES = 0):

(1) MEDAPCD = (P_OBES * RMED_OBES * MEDNON-OBES + (1- P_OBES) * MEDNON-OBES

⇨ $MED_{NON\text{-}OBES} = MED_{APCD} / (P\_OBES * R_{MED\_OBES} + 1 - P\_OBES)$

[69] Because MEPS does not adjust BMI for stages of pregnancy or otherwise identify obesity during pregnancy, we do not attempt to estimate the potential cost associated with obesity among pregnant women.

(2) RxAPCD = (P_OBES * RRX_OBES * RxNON-OBES + (1- P_OBES) * RxNON-OBES

⇨ $Rx_{NON\text{-}OBES} = Rx_{APCD} / (P\_OBES * R_{RX\_OBES} + 1- P\_OBES)$

In the equations above, MED_{APCD} and Rx_{APCD} are actual medical and Rx spending per person per month among service users in the APCD (whether or not obese), benchmarking the estimates to spending levels in the APCD; P_OBES is the probability of an individual being obese, estimated from BRFSS or NHANES; and R_{MED_OBES} and R_{RX_OBES} are the estimated spending relativity factors.

Average monthly medical and Rx spending associated with obesity are separately calculated as the difference between predicted spending per person per month if no Minnesotan were obese and actual spending per person per month in each year:

(3) (P_MEDAPCD* MEDAPCD) - (P_MEDNON-OBES * MEDNON-OBES)

(4) (P_RxAPCD* RxAPCD) - (P_RxNON-OBES * RxNON-OBES)

C. Estimating total cost

Total medical and Rx spending associated with obesity in each coverage category is calculated as estimated spending per person per monthassociated with obesity among obese persons (by age and sex), annualized over 12 months and multiplied by the estimated number of obese persons in each coverage category. The number of obese Minnesotans (by age and sex) in each coverage category is estimated as the percentage of all Minnesotans reported as obese in BRFSS (adults) or NHANES (children) multiplied by the MEPS percentage of all obese persons in that coverage category and multiplied by the number of persons reported in MHAS in that coverage category. The total number of persons across coverage categories is benchmarked to Minnesota's total population estimates by age and sex to produce final total cost estimates.

VIII. Aggregate spending for selected chronic conditions under age 60

To compare actual and projected spending attributed to selected chronic conditions without double-counting, we developed a separate aggregate estimate of spending attributed to the selected chronic conditions among the population under age 60. This method avoids double-counting spending among persons age 60-64 (attributed spending for these conditions is already incorporated in the estimates developed for the population age 60 or older), and it avoids double counting across conditions among Minnesotans with more than one of the chronic conditions.

We estimate total spending attributed to any (or any combination of) the selected chronic conditions (hypertension, diabetes, dementia, or obesity) by summing across the following estimates:

- For persons with Medicare, private insurance, or Medicaid or other public coverage, we estimate probability-of-use and per-month spending models using the MN APCD and MEPS, as follows:

    - Using the MN APCD, we estimate a probability model that controls jointly for any or any combination of three selected conditions: hypertension or diabetes or dementia. We estimate spending-per-month models (for adults and children by spending level) controlling jointly for any of the conditions, and also for comorbidities unrelated to any of the conditions. Because the model does not control for obesity (which rarely occurs in diagnosis coding), the coefficient estimated for the joint condition indicator picks up spending related to obesity to the extent that it correlates with the joint condition indicator.

    - From MEPS, we model per-month spending attributed to obesity among persons who do not have hypertension, diabetes, or dementia. Obesity is defined as having a diagnosis of obesity or by reference to BMI. The probability and spending models estimated for this population are identical to the models described in Section V.

- For persons enrolled in Tricare or who are uninsured, we estimate probability-of-use and per-month spending models using MEPS. These models control jointly for any of the three selected conditions plus obesity defined by diagnosis or BMI. The spending model further controls for comorbidities unrelated to any of these conditions.

The total cost estimates are calculated by a simulation exercise analogous to that described for the population age 60 or older.

IX. SPENDING PROJECTIONS

We project the 2009 estimates for each condition/behavior to 2015 using the distribution of coverage in Minnesota reported in American Community Survey. The distribution of coverage in each age/sex group is assumed to remain at 2015 levels through 2023. The projections for each condition assume that the prevalence rate within each age/sex group remains at 2009 levels through 2023.

To project the estimates to 2023, we benchmark to Minnesota population projections by age and sex developed by the Minnesota State Demographic Center. Any further changes in the mix

of coverage from 2015 forward or the prevalence of conditions from 2009 forward are driven only by changes in the size and age/sex distribution of the projected population.

Costs in each year are inflated by a price index derived from (1) the medical component of the Bureau of Labor Statistics' Consumer Price Index – Urban Consumers (CPI-U), nationally and for Minneapolis-St. Paul (MSP); and (2) the Centers for Medicare & Medicaid Services National Health Expenditure Accounts (NHEA) price index. The MSP CPI-U reflects medical-component price increases that are steeper than the national CPI-U medical component, consistent with other analyses conducted for and by MDH. Therefore, it is important that projected spending in Minnesota reflect this faster price growth relative to the national average, when comparing with actual spending in 2014 (at actual 2014 prices).

To develop a Minnesota-specific price index for medical services, we assume that pharmacy prices in Minnesota rise at the national average, and remove pharmacy spending in each year from the NHEA-index, the national CPI-U, and the MSP CPI-U.[70] We take the ratio of the resulting ("net") NHEA medical services index to the national net CPI-U to develop an adjustment factor reflecting differences between the two indices in the weighting of the other components of spending, and multiply this factor by the MSP net CPI-U. This adjustment yields a price index for medical services in Minnesota that rises faster than the national NHEA price index, resulting in medical services price growth that is about two percentage points higher in Minnesota than national price growth from 2009 to 2014.

X. METHODOLOGICAL CHALLENGES AND LIMITATIONS

The methods used to produce cost estimates reflect a number of issues related to the reporting of diagnoses in claims and encounter data—including low rates of (or no) diagnostic coding for some conditions, estimates for payers that do not report to the APCD, and the inability to observe some factors that affect health care spending.

A. Diagnostic coding

The estimates of 2009 and 2014 spending associated with the selected conditions and risk behaviors reflect the strengths and limitations of analyses based on claims data. Although paid claims enable identification of detailed diagnoses likely to be more accurate and specific than

[70] The NHEA price index reflects all services purchased during the year; the CPI-U indices reflect only consumer direct spending for medical services. In the NHEA index, pharmacy spending represents 11 percent of total spending; in the CPI-U, pharmacy spending represents 18 percent of total spending. BLS does not publish a consumer price index for pharmacy spending that is separate from the medical component of the CPI-U.

self-reported information, some prevalent conditions—including obesity, smoking status, and prediabetes—are poorly captured in claims data.

In this study, spending attributed to obesity is estimated using relative cost factors derived from the 2009 and 2014 MEPS public use data adjusted to the Midwest population sample. The MEPS data do not represent Minnesota independent of other Midwestern states, nor do they include spending for long-term care for persons who reside in nursing homes or other institutions. As a result, the obesity cost estimates reflect two major assumptions:

- The relative probability of service use and the relative cost of acute care services in Minnesota because of obesity is equal to the average (by age and sex) among all Midwestern states.
- Long-term care costs in the APCD because of obesity are higher in the same proportion as acute care costs.

Our estimates of the medical cost of tobacco exposure also rely on BRFSS and MEPS, and are affected by the same data issues as limit the estimates of obesity. However, in addition, the estimates of tobacco exposure are limited by these surveys' questioning—and the questioning in MEPS, in particular. MEPS asks a single question about the respondent's current smoking status, and asks this question of only respondents age 18 or older. Consequently, we use linked MEPS and NHIS data instead.

Cost estimates for diabetes include only persons with a medical claim and at least one primary or secondary diagnosis of diabetes. However, many people with diabetes might be undiagnosed, and many more might have prediabetes, which does not correspond to a diagnostic code in medical claims data. Although prediabetes is largely addressed by changes in diet and exercise, in some cases a drug to help control glucose might be prescribed. In the 2009 MN APCD, just 0.3 percent of persons with no diabetes diagnosis and 1.0 percent of those with no medical claims in the APCD had any claim for a glucose control drug such as metformin or glipizide. Nevertheless, the indirect costs of persons with prediabetes might exceed their direct cost, and neither is reflected in the estimates.

Lastly, 2013–2014 MEPS removes ICD-9 diagnosis codes that appear in the data fewer than 20 times. For this reason, we are not able to control for some rare conditions such as HIV-AIDS (HIVA) or acute and other pericardial and endocardial disease (PERI) in our 2014 MEPS spending models.

B. Payers that do not report to the MN APCD

Not all Minnesotans are represented in the APCD. Specifically, small private payers do not report claims data to the APCD, nor do several public payers—including Tricare, the Veterans

Health Administration, and the Indian Health Service. Moreover, the APCD does not account for medical expenditures that do not result in claims—including expenditures by uninsured residents and expenditures for care that is not covered.

The estimates are adjusted to account for each payer that does not report. The adjustment for non-reporting small payers assumes that payments pmpm in plans that do not report equal the average among those that do report. The adjustments for Tricare members and uninsured residents, which are based on analysis of medical expenditures among Tricare enrollees and the uninsured represented in the 2009 and 2014 public use MEPS data, assume that the incidence and cost of each chronic condition or risk behavior among Tricare enrollees and the uninsured in Minnesota, relative to the privately insured population, are the same as the average in all Midwest states.

Finally, spending for services and medical equipment not covered by their health insurance plans, as well as covered services beyond annual or lifetime limits on coverage, might not be reported. Before 2014, when federal health care reforms were fully implemented, covered benefits might have varied widely. The largest single omissions from the claims data might be prescription drug and mental health and substance abuse services among persons enrolled in private health insurance plans, as well as long-term care spending among persons not enrolled in Medicaid.

C. Unobserved factors that affect projected health care spending

The estimates control for a large number of diagnoses, as well as a resident's age and gender. However, various characteristics that might affect expenditures—such as race and ethnicity—are not observed. As in any analysis of this type, failure to control for an unobserved characteristic that is systematically related the outcome variable can result in projections that are too high or too low, if that characteristic changes over time.

The projections also do not account for other changes that could occur over the course of a decade—including changes in disease prevalence (other than associated with changes in the age and sex distribution of the population) health insurance coverage (other than aging into Medicare), changes in medical technology that affect cost, the introduction of new drugs that can affect cost, or current high-cost drugs going off-patent. Although such "steady state" assumptions are usual when making projections, they can lead to significant error especially in later years of the projection period.