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Health and Economic Impact and Cost-effectiveness of Produce Prescriptions for Diabetes in 50 U.S. States: A Microsimulation Study

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Produce Prescriptions (PRx) Could Prevent Thousands of Cardiovascular Events and Be Cost-Saving or Highly Cost-Effective Across U.S. States

Approach: validated microsimulation model (diabetes, obesity, cardiovascular disease microsimulation).

Population: adults aged 40–79 years with both diabetes and food insecurity in each U.S. state.

Key Inputs: pooled intervention effects and costs from 20 PRx programs, diet-disease associations, and payer-specific health care expenditures.

Key outcomes: Cardiovascular disease (CVD) events, quality-adjusted life-years (QALYs), health care cost, intervention costs, cost-effectiveness.

Time horizon: 5 years and 10 years. Outcomes and costs were discounted at 3% annually.

The Intervention - What Are Produce Prescriptions (PRx)?
PRx are prescribed by health care providers to give patients access to healthy produce at low or no cost.

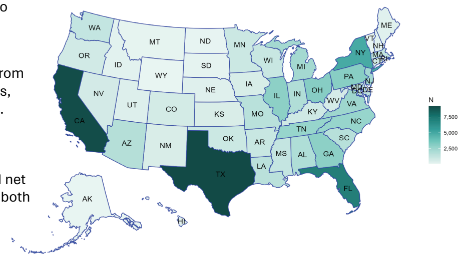
Estimated State-Level Impact of Implementing PRx Over 10 Years

Eligibility
Ranging from 7,000 (Wyoming, Alaska, Vermont) to 693,000 (California) eligible patients per state.

Health Gains
The number of reductions in CVD events ranged from ~100 (Wyoming, Vermont, Alaska) to ~9,000 (Texas, California). Gained up to ~10,000 QALYs per state.

Costs and Savings
From a health care perspective, projected to yield net cost-savings in nearly all states (43/50) and to be both cost-effective (50/50) and highly cost-effective (49/50).

Number of CVD events averted over 10 years, by state



Payer-specific insights
Projected to yield net cost-savings in the greatest number of states for Medicare (48/50), followed by Medicaid (41/50) and private payers (29/50), and cost -effective in all states and highly cost-effective in nearly all states (50/50 Medicare, 48/50 Medicaid, and 48/50 private payers), by payer type.

ARTICLE HIGHLIGHTS

- **Why did we undertake this study?**
  The potential health and economic impacts across all 50 U.S. states, where Medicaid and commercial plans determine coverage, are unclear.
- **What is the specific question we wanted to answer?**
  Can produce prescription (PRx) programs generate meaningful health benefits and achieve cost savings or cost-effectiveness across U.S. states and diverse payer systems?
- **What did we find?**
  PRx for patients with diabetes who have food insecurity may significantly reduce cardiovascular disease events and be cost saving in all 50 states and cost saving or highly cost-effective across payer types.
- **What are the implications of our findings?**
  These findings highlight the potential for PRx to improve health and reduce chronic disease costs in every state.

Health and Economic Impact and Cost-effectiveness of Produce Prescriptions for Diabetes in 50 U.S. States: A Microsimulation Study

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ORIGINAL ARTICLE

OBJECTIVE

Produce prescription (PRx) programs have been shown to result in improved dietary quality, diabetes control, and cardiometabolic outcomes. However, their potential health and economic impacts across 50 U.S. states, where Medicaid and commercial plans determine coverage, are unclear.

RESEARCH DESIGN AND METHODS

Using a validated microsimulation model, we projected the health and economic outcomes of implementing PRx for adults aged 40–79 years with both diabetes and food insecurity in each U.S. state, over 5- and 10-year horizons. The model incorporated state-specific data, pooled intervention effects and costs from 20 PRx programs, diet-disease associations, and payer-specific health care expenditures. Outcomes and costs were discounted at 3% annually. Probabilistic sensitivity analyses accounted for uncertainty.

RESULTS

An estimated 693,000 adults in California to 7,000 in Wyoming were eligible for PRx. Over 10 years, PRx was projected to avert between 9,240 cardiovascular disease (CVD) events (95% uncertainty interval [UI] 4,710–14,500) in Texas and 94 (95% UI 48–147) in Alaska and gain 9,990 (95% UI 4,810–15,500) to 92.2 (95% UI −30.8 to 159) quality-adjusted life-years (QALYs) across states. From a health care perspective, PRx was projected to be net cost-saving in 43 of 50 states and was cost-effective (incremental cost-effectiveness ratio <$150,000/QALY) in all, with New York having the largest net saving ($345 million) and California the largest net costs ($155 million). By insurance type, PRx was most likely to be cost-saving for Medicare beneficiaries, followed by Medicaid and private payers. Similar patterns were observed over 5 years.

CONCLUSIONS

PRx for patients with diabetes and food insecurity could substantially improve health and be cost saving or cost-effective in all U.S. states.

Produce prescription (PRx) programs—providing free or discounted fruits, vegetables, and other produce alongside nutrition education to patients with diet-related

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conditions and unmet social needs—are a burgeoning health system intervention to address nutrition insecurity and its substantial health and economic burdens (1,2). These programs improve dietary quality, diabetes management, and cardiometabolic risk factors, as shown in pre- and postintervention studies and in some, though not all, randomized trials (1,3). Using a validated microsimulation model, we previously demonstrated that implementing PRx programs nationally for eligible patients with diabetes and food insecurity could substantially reduce cardiovascular disease (CVD) events and be highly cost-effective (4). However, that evaluation did not consider state-level effects, where many coverage determinations are made, and relied on 2014–2016 health care cost estimates, which do not account for rapidly rising diabetes costs in recent years due to use of new, expensive, noninsulin, glucose-lowering and antiobesity medications; increasing insulin prices; and higher inpatient hospital stay expenses (5–7).

Although national actions can have broad reach, states are natural innovation sites where new policy approaches are often more rapidly deployed and tested. In the past decade, several states have significantly expanded PRx programs to address food and nutrition insecurity and diet-related disease. For example, 15 states are currently providing or have applied to provide PRx through Medicaid 1115 waivers (8). Medicaid Advantage plans are also increasingly offering food benefits, and commercial payers in various states are piloting and considering expansion of Food Is Medicine therapies. However, the differential health, cost, and equity impacts of PRx programs across states remain unclear. U.S. states vary considerably in demographic characteristics, prevalence of cardiometabolic conditions, life expectancy, and social determinants of health such as poverty and food insecurity (9). Furthermore, health care expenditures differ widely across states due to variations in health care accessibility, utilization, prices, and state-specific policies, including Medicaid expansion (10,11). These factors may meaningfully influence the health effects, economic outcomes, and cost-effectiveness of PRx programs in different states.

To address these knowledge gaps, we evaluated the health and economic impact of PRx programs for patients with diabetes and food insecurity in each U.S. state. We further assessed these effects across different payer populations in each state, including patients covered by Medicare, Medicaid, and commercial plans. Such state-level assessments are crucial for guiding local prioritization and implementation in an era of constrained resources and competing health care priorities.

RESEARCH DESIGN AND METHODS

This study adapted the previously validated Diabetes, Obesity, Cardiovascular Disease Microsimulation (DOC-M) model, a probabilistic, individual-level, health-state transition model, to assess the potential long-term health and economic impacts of PRx in 50 U.S. states (12). As previously described, based on individual-level data on demographics, cardiometabolic risk factors, and lifestyle behaviors, the model projects individual health trajectories as well as economic outcomes (12). By comparing projected outcomes between the intervention and status quo scenarios, the model can estimate incremental changes in the number of CVD events, quality-adjusted life years (QALYs), health care costs, productivity losses, intervention costs, and the cost-effectiveness of policies or interventions (4). The analysis was conducted over time horizons of 5 and 10 years to provide insights relevant to decision-makers. To inform potential implications for public and private payers, we further assessed the impact of PRx by insurance type.

Key model inputs and data sources for this evaluation are summarized in Supplementary Table 1, with further details described in later sections of the article. This study used publicly available, deidentified data sets and, therefore, was exempt from human subjects review.

Population and Data Source

We evaluated U.S. adults aged 40–79 years with both diabetes and food insecurity at baseline. To generate state-specific, individual-level input data for our microsimulation model across 50 states, we pooled 2021–2023 Behavioral Risk Factor Surveillance System (BRFSS) data to increase sample size and reduce sampling error (Supplementary Table 2). To assess potential bias related to the COVID-19 pandemic in 2021, we conducted a sensitivity analysis using only 2022–2023 BRFSS data. Participants provided self-reported data via standardized telephone interviews, including demographics (age, sex, race and ethnicity, education, family income), BMI, and health status (diagnosis of diabetes, coronary heart disease [CHD], stroke, high blood pressure), and smoking (current, past, or never). To correct for self-reporting bias in BMI, we adjusted the self-reported BMI in BRFSS to align with objectively measured BMI distributions from the National Health and Nutrition Examination Survey (NHANES) using established methods (13). For variables not available in the BRFSS but required by the DOC-M model and for current analysis (e.g., laboratory measurements like cholesterol, triglyceride, and blood glucose levels; blood pressure; food security status for eligibility assessment) we used predictive mean matching to impute values from NHANES 2013–2020 data (14).

Intervention Effects

The intervention effects of PRx were estimated based on the average effect of 20 PRx programs, each with least 3 months' duration, derived from de novo random-effects meta-analyses (Supplementary Methods, Text A) (1). On average, PRx programs increased fruit and vegetable consumption by 0.80 servings/day (95% CI, 0.45–1.15), reduced BMI by 0.36 kg/m^2 (95% CI, 0.15–0.55), and reduced HbA_{1c} by 0.63% (95% CI, 0.28–0.98). Although such intervention effects could vary based on factors including amounts of produce provided, provision method (i.e., food box pick-up, delivery, or electronic debit card), types of nutrition education, geographic locations, patient demographics, or duration, the current literature did not allow a rigorous assessment of the impact of these factors on the intervention effect sizes (15). Therefore, our findings should be considered the average effect size of PRx programs currently described, incorporating uncertainty to account for potential heterogeneity in the estimates. In base-case analysis, we assumed all eligible individuals enrolled in the study, with continuing enrollment in the intervention each year without dropout and stable intervention effects over time.

To model the effect of PRx on cardiovascular risks, we incorporated age-specific relative risks of fruits and vegetables on CHD and stroke risk based on meta-analyses of prospective cohorts or randomized clinical trials (Supplementary Table 2) (16,17). These estimates were adjusted for age, sex, BMI and other risk factors to reduce bias from confounding and, therefore, accounted for BMI independent effect. In addition, we modeled the effect of PRx mediated through BMI by incorporating the estimated impact of BMI on cardiovascular outcomes. Detailed methods for reviewing and synthesizing evidence to estimate effect sizes for associations among dietary factors, BMI, and CVD end points, as well as the validity of these findings, have been published (16,17).

Intervention Costs

Intervention costs included the food costs for fruits and vegetables plus all administrative and program delivery costs for program implementation. Food costs (in U.S. dollars [USD] per person per month) were calculated based on the weighted mean food box value or voucher amounts from the 20 studies included in the intervention effect size meta-analyses, adjusted for the proportion of fruits and vegetables in the food box (when other items were included) and the actual redemption rates of the vouchers. Values of the reported incentive offered to participants in each study were converted to a standardized USD-equivalent amount, adjusted for inflation to 2023 dollars. The interventions offered a weighted mean of $47/month of fruits and vegetables to the target population; after considering unused vouchers, patients redeemed a weighted mean of $35.7/month. To account for state variations in food prices, we applied a state-specific grocery price index, which reflects average grocery costs relative to the national average (18).

To estimate administrative costs of implementing PRx, we referred to the cost data from implementing the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (19) and the Supplemental Nutrition Assistance Program (SNAP) (20). WIC and SNAP share similar administrative features with PRx programs, including personnel and training, eligibility certification, quality control, use of the electronic benefit transfer system or food delivery, benefit and retailer redemption and monitoring, nutrition education, and program evaluation. We assumed administrative costs for PRx to be 15% of total PRx program costs— approximately two- to threefold higher than the administrative costs of SNAP (5–8%) but one-third lower than the administrative costs of WIC (21.3%). This assumption reflects the narrower scope of PRx, compared with WIC, which provides only produce, does not require income certification, and does not necessitate establishment of separate clinical institutions (i.e., WIC clinics). Detailed estimation processes are described in Supplementary Methods, Text B).

Health Care Costs

This study applied an updated health care cost prediction algorithm derived from the 2017–2022 Medical Expenditure Panel Survey (MEPS) data to estimate annual health care expenditures for each individual in the simulation model (21). The algorithm accounted for individual demographics (age, sex, race and ethnicity), cardiometabolic conditions (BMI, diabetes, hypertension, CHD, stroke), geographic region (Northeast, Midwest, South, West), and insurance type to capture regional and payer-specific variations. Supplementary Methods, Text C, specifies detailed methods and the estimated parameters.

In addition to health care costs associated with prevalent health conditions, the model also included event- and procedure-specific costs from weighted-average total payments of full discharges across relevant diagnosis-related groups from the 2023 Medicare Inpatient Prospective Payment data (22). For patients with diabetes, the model accounted for diabetes control as measured by HbA_{1c} (an established determinant of health care costs among patients with diabetes independent of other comorbidities such as CVD and hypertension [23]) and applied only the HbA_{1c}-related costs of diabetes excluding CVD-dependent costs to avoid double-counting benefits from fewer CVD outcomes (detailed methods are provided in Supplementary Methods, Text D).

Productivity Costs

For a limited societal perspective, the model accounted for costs of productivity losses due to morbidity and premature death associated with cardiometabolic conditions including diabetes, CHD, stroke, and hypertension (24). Morbidity costs capture the value of lost earnings from decreased productivity due to illness, including inability to work due to poor health or disability and workdays missed due to illness (i.e., absenteeism) among currently employed individuals. Mortality costs represent the value of lost earnings and household productivity from premature death. We did not estimate productivity costs for adults aged 80 years or older, because formal workforce participation in this age group is low. Supplementary Methods, Text D, provides detailed methods and parameter estimates.

Health-Related Quality of Life

To estimate changes in QALYs associated with the intervention, the model incorporated a prediction algorithm derived from 2022 MEPS data to predict individual-level health-related quality of life (HRQoL) (21), measured by the EQ-5D instrument, based on annually updated individual characteristics including demographic, BMI, and chronic disease conditions including diabetes, high blood pressure, and CVD history. The model also incorporated event-specific short-term (1 year) decrements in HRQoL for individuals experiencing an acute CHD event (−0.055) or stroke (−0.3) in a given year (25).

Cost-effectiveness Modeling

Analyses followed the recommendations of the Second Panel on Cost-effectiveness in Health and Medicine (26). We conducted analyses in each state from both a health care perspective, incorporating intervention costs and health care cost-savings, and a limited societal perspective, with additional consideration of productivity savings due to reduced disease burden. All costs were inflated to 2023 U.S. dollars, and costs and QALYs were discounted annually by 3%. Incremental cost-effectiveness ratios (ICERs) were calculated as the net change in costs divided by the net change in QALYs. To account for uncertainty in key model inputs, we conducted probabilistic sensitivity analyses using 1,000 Monte Carlo simulations with uncertainty distributions for all input parameters, including disease incidence and mortality prediction, estimated intervention effects, diet-disease associations (relative risks), intervention costs, health care costs productivity cost prediction, and HRQoL prediction. BRFSS sampling weights were incorporated to provide estimates representative of the noninstitutionalized individuals with diabetes and food insecurity in each simulation. The 95% uncertainty intervals (UIs) for model outcomes were estimated by jointly combining the sampling uncertainty of BRFSS and the uncertainties of multiple input parameters, using the Rubin's rule (27). All analyses were conducted in R, version 4.1.0/4.2.0.

Sensitivity Analysis

Sensitivity analyses were conducted to examine the potential impact of different modeling choices and assumptions. Specifically, we modeled a more conservative enrollment and retention scenario, assuming 50% of eligible individuals enrolled, with a 20% annual dropout rate among participants and 20% annual new enrollment among eligible nonparticipants, allowing for re-entry into the program over time, with no carryover effect when a participant dropped out of the intervention. We also assumed that the administration cost as a proportion of program cost will improve by 25%, from 15% to 18.5%. Separately, we also examined the exclusion of 2021 BRFSS data to address potential COVID-19–related disruptions.

To assess the influence of varying intervention effect on the cost-effectiveness of PRx programs, we also performed a threshold analysis to determine the minimum intervention effect sizes—relative to the base-case estimates—required for the program to remain *1*) cost-saving, *2*) highly cost-effective at a threshold of $50,000/QALY, and *3*) cost-effective at a willingness-to-pay threshold of $150,000/QALY.

Updated National Analysis

We also conducted an updated national analysis of PRx, based on the same DOC-M modeling framework we used previously (4), with updated model inputs in the health care prediction algorithm and productivity costs.

RESULTS

The proportion of adults aged 40–79 years eligible for PRx (with both diabetes and food insecurity) was highest in Mississippi (5.4%), Alabama (5.3%), and Louisiana (4.9%), and lowest in Vermont (2.0%), then Montana and Colorado (both 2.1%). The largest eligible populations were in California (*n* = 693,000), Texas (*n* = 578,000), and Florida (*n* = 425,000), and the smallest in Wyoming, Alaska, and Vermont (*n* = 7,000 in each) (Fig. 1 and Supplementary Table 3). Baseline characteristics of eligible adults varied by states: mean age range: 57 to 62 years; sex: 36–59% female; BMI: 32–36 kg/m^2; race and ethnicity (e.g., % Black ranged from <1% to 89%); insurance coverage (e.g., Medicaid 8–38%; uninsured <0.5–17.6%; private 5.9–43.8%); and CVD prevalence (20–45%) (Supplementary Table 4).

Health Outcomes

Over 10 years of intervention, the greatest CVD event reductions were projected in Texas (*n* = 9,240 events; 95% UI 4,710–14,500), California (*n* = 9,120; 95% UI 4,630–14,400), and Florida (*n* = 7,160; 95% UI 3,510–11,200); the fewest were projected in Alaska (*n* = 105; 95% UI 53–165) and Wyoming (*n* = 94; 95% UI 48–147), reflecting the size of eligible population (Fig. 2 and Supplementary Table 5). QALYs gained followed a similar pattern, from 9,990 (95% UI 4,810–15,500) in California to 92.2 (95% UI 30.8–159) in Alaska (Supplementary Fig. 1). Standardized per 10,000 patients treated, projected CVD events averted over 10 years ranged from 181 (95% UI 89–385) in Florida to 137 (95% UI 69–214) in Idaho (Fig. 2 and Supplementary Table 6). QALYs gained ranged from 166 (95% UI 68.6–279) in New Hampshire to 138 (95% UI −60.9 to −223) in West Virginia (Supplementary Fig. 1).

By baseline insurance, projected health benefits per 10,000 patients treated were generally the highest among individuals on Medicare, followed by those on Medicaid and then private insurance across most states (Supplementary Fig. 2, Supplementary Table 6). Similar geographic patterns of state-level variations were observed for health benefits achieved over a 5-year time horizon (Supplementary Fig. 3).

Economic Outcomes

Over 10 years, projected health care savings ranged from $2.59 billion (B) (95% UI $1.12B–$4.33B) in California to $25.3 million (M) (95% UI $11M–$44.2M) in Alaska. Implementation costs ranged from $2.74 billion (95% UI $2.01B–$3.35B) in California to $25.2 million (95% UI $18.5M–$32.3M) in Alaska (Supplementary Fig. 4 and Supplementary Table 5).

From a health care perspective, which accounts for both implementation costs and health care costs averted, net savings was projected in 43 of 50 states (Fig. 3 and Supplementary Table 5). New York had the highest projected net savings ($297 million; 95% UI −$669M to $1,490M), and California incurred the largest projected net costs ($155 million; 95% UI −$1,790M to $1,830M). The program was highly cost-effective (ICER <$50,000/QALY) in all states except Hawaii, where ICER was $66,500/QALY—well below the commonly accepted $150,000/QALY threshold for cost-effectiveness. From a societal perspective accounting for productivity gains, PRx was projected to be cost-saving in 48 states and highly cost-effective in all except Hawaii (ICER = $53,600/QALY).

Per 10,000 patients treated, health care costs averted ranged from $50.6 million (Massachusetts) to $38.5 million (Oklahoma) (Fig. 3 and Supplementary Table 6). Net costs from a health care perspective ranged from −$11.8 million (Maine) to $10.2 million (Hawaii), and, from a societal perspective, from −$14.1 million to $8.23 million, respectively.

By baseline insurance type and from a health care perspective, PRx was net cost-saving in 41 states for Medicaid, 48 for Medicare, and 29 for private payers (Fig. 4 and Supplementary Table 6). It was cost-effective for all states and payers, and highly cost-effective based on a $50,000/QALY threshold in 48 states for Medicaid, 50 for Medicare, and 48 for private payers. Over a shorter intervention period of 5 years, similar patterns of economic outcomes were observed across states, with 40 of 50 states projected to achieve cost-saving (Supplementary Fig. 5).

Sensitivity Analysis

Under more pragmatic enrollment and retention assumptions, PRx remained cost-saving in 34 states, highly cost-effective in 14, and cost-effective in 2. Net costs from a health care perspective ranged from −$111 million (95% UI

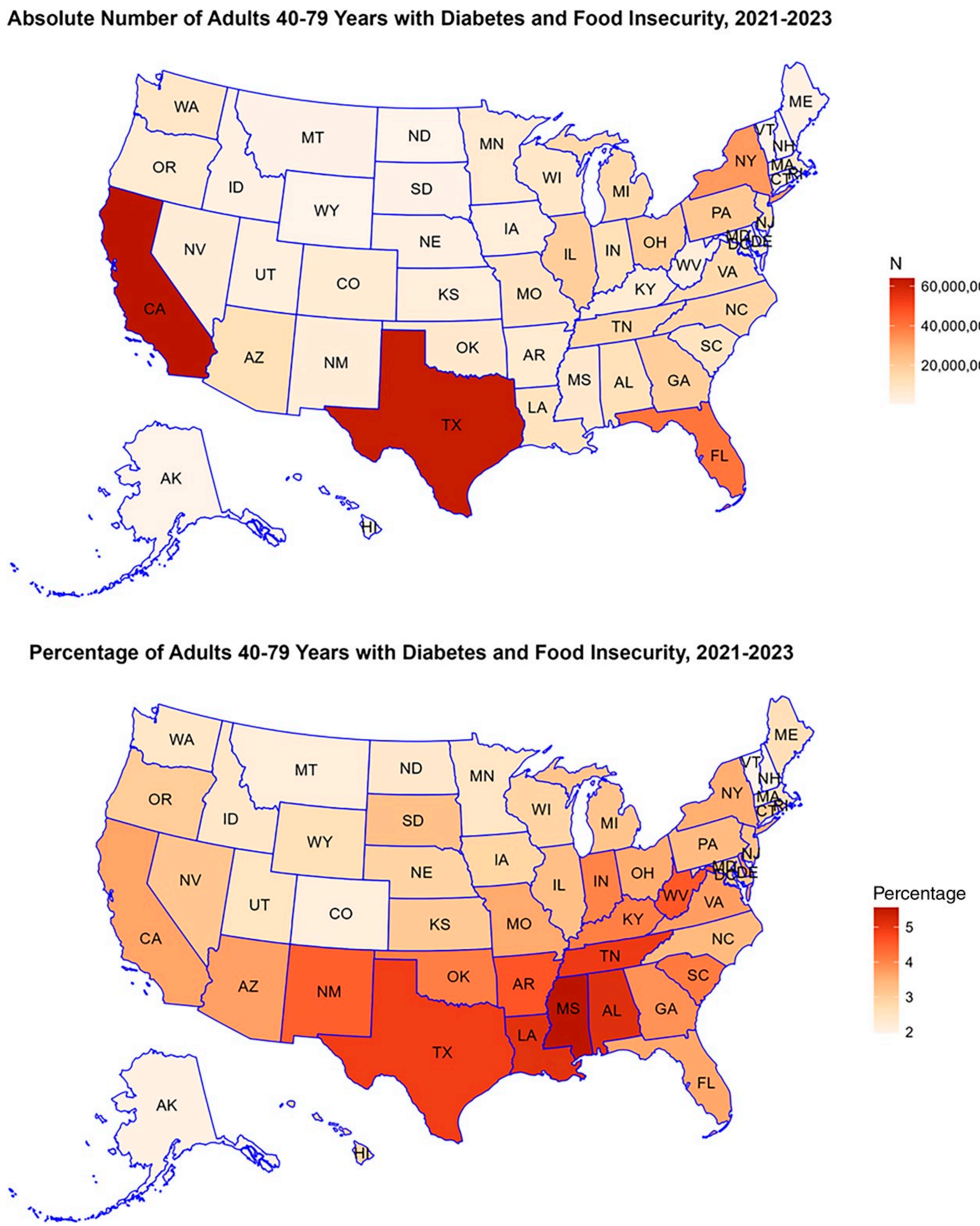

Figure 1—Estimated numbers and proportion of adults aged 40–79 years eligible for produce prescriptions in 50 U.S. states. Adults in each state were eligible if they had both diabetes and food insecurity, estimated from state-level data from the BRFSS 2021–2023 and augmented by predictive means matching from NHANES data. BRFSS sampling weights were incorporated to generate state-representative estimates for each state.

−$681M to $352M) in New York to $117 million (−$635M to $766M) in California (Supplementary Fig. 6). In sensitivity analysis excluding 2021 BRFSS data, results did not appreciably change (Supplementary Fig. 7).

Threshold analyses suggest that the required minimal intervention effect sizes, relative to the base-case estimates, for PRx to maintain cost-saving ranged from 76% in Maine to 125% in Hawaii; to remain highly cost-effective, ranged from 59% (Missouri) to 106% (Hawaii); and for general cost-effectiveness, from 24% (Missouri) to 69% (Hawaii) (Supplementary Table 7).

National Analysis Update

Nationwide, 10-year intervention costs were $26.1B; health care savings, $29.2B; and net savings, $2.68B. Including productivity gains, societal net savings reached $4.17B (Supplementary Table 8).

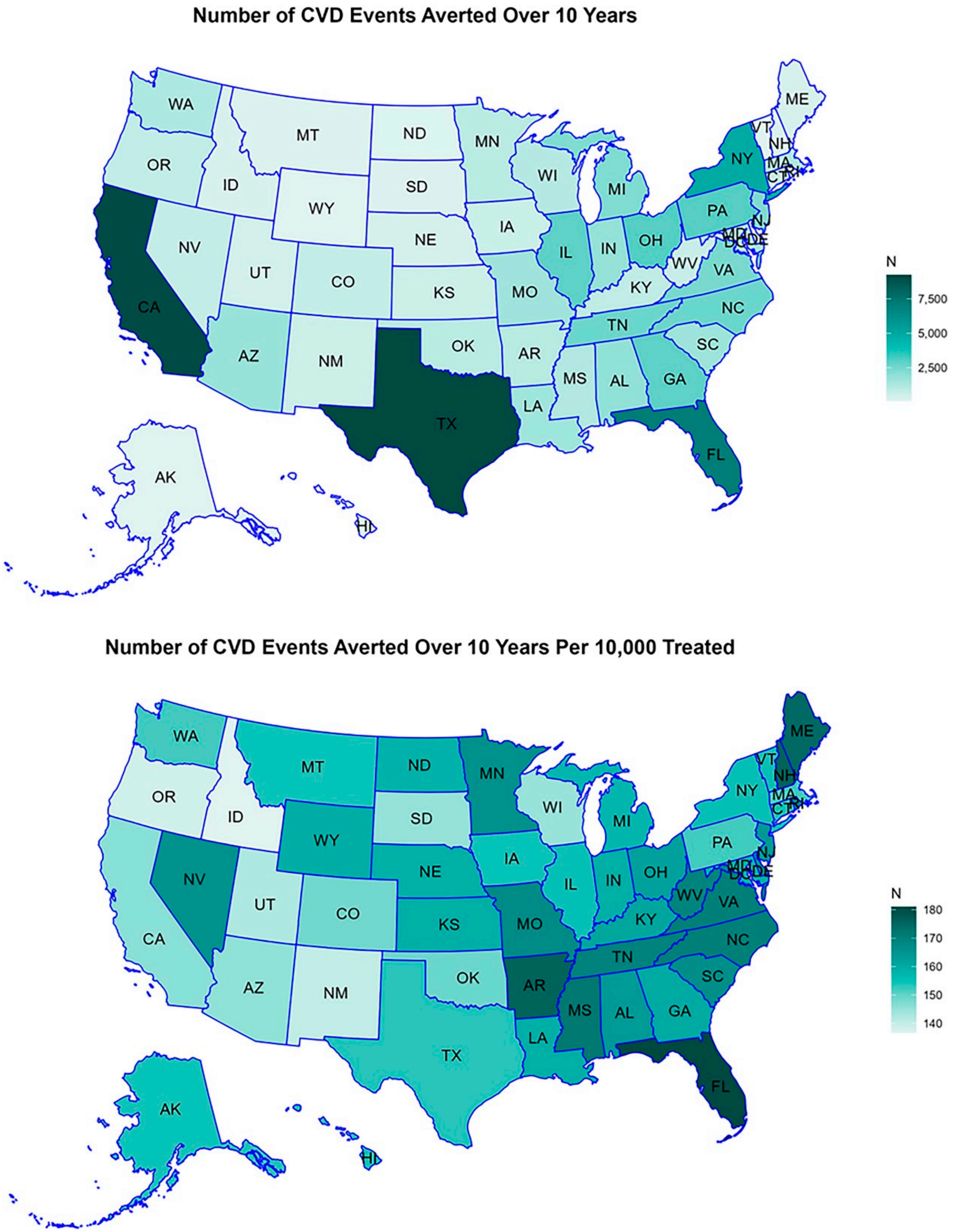

Figure 2—Estimated numbers of CVD events averted by PRx over 10 years in 50 U.S. states. Colors denote the estimated number of CVD events averted, displayed as absolute numbers (upper panel) and per 10,000 patients treated (lower panel). Outcomes were derived using a validated microsimulation model applied to state-specific representative samples of adults aged 40–79 years with diabetes and food insecurity at baseline. The intervention involved a PRx program integrated into the health care system, with eligible patients identified and referred by health care providers. Estimates represent the mean values from 1,000 Monte Carlo simulations.

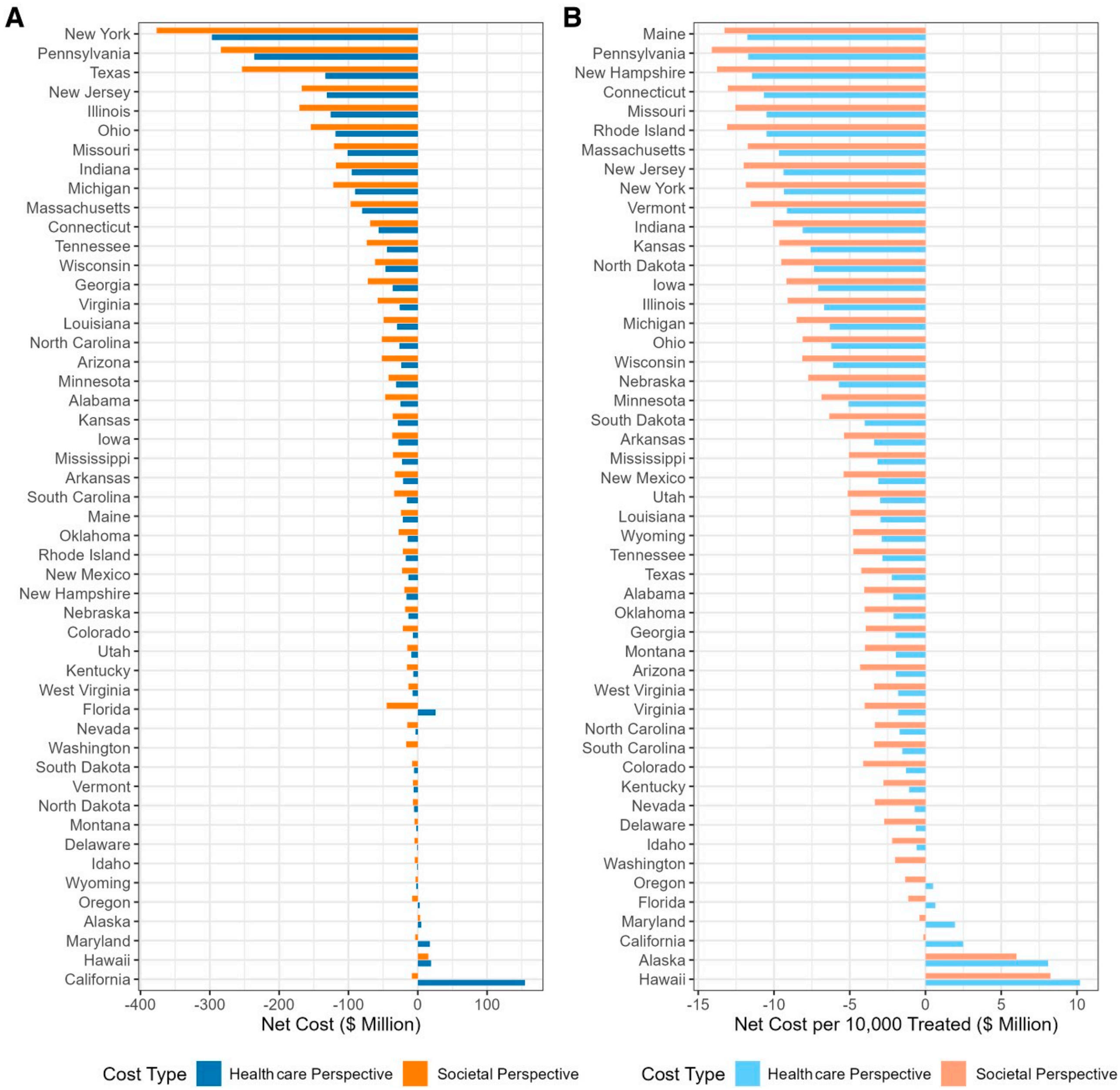

Figure 3—Estimated net costs of PRx over 10 years of intervention in 50 U.S. states. Bars represent the estimated net changes in costs from a health care perspective and a societal perspective, shown in absolute values (*A*) and per 10,000 patients treated (*B*). The health care perspective included total intervention costs minus health care cost-savings. The societal perspective included total intervention costs minus health care cost-savings minus savings from averted productivity losses. Negative values indicate cost savings. Outcomes were derived using a validated microsimulation model applied to state-specific representative samples of adults aged 40–79 years with diabetes and food insecurity at baseline. The intervention involved a produce prescription program integrated into the health care system, with eligible patients identified and referred to by a health care provider. All costs are expressed in 2023 dollars and discounted at an annual rate of 3%. Results represent mean values from 1,000 Monte Carlo simulations.

CONCLUSIONS

This modeling analysis suggests that PRx is a cost-saving or highly cost-effective treatment strategy in most U.S. states to improve nutrition and reduce health and economic burdens over 10 years in adults with diabetes and food insecurity. By insurance type, PRx was most likely to be cost-saving in Medicare populations, followed by Medicaid and private payers.

The proportion of eligible adults varied significantly by state, with highest rates in southern states. This closely aligns with the U.S. Department of Agriculture's state-level estimates of household food insecurity between 2021 and 2023, based on the Current Population Survey Food Security Supplement data, which identified Arkansas, Kentucky, Louisiana, Mississippi, Oklahoma, South Carolina, and Texas as having the highest prevalence (28). These states also largely overlap with states reporting the highest prevalence of diabetes (29,30). This overlapping distribution of diabetes and food insecurity across U.S. states highlights the critical needs for targeted interventions that jointly address food insecurity, poor nutrition, and diabetes, such as PRx.

When evaluated per 10,000 patients treated, the projected numbers of CVD

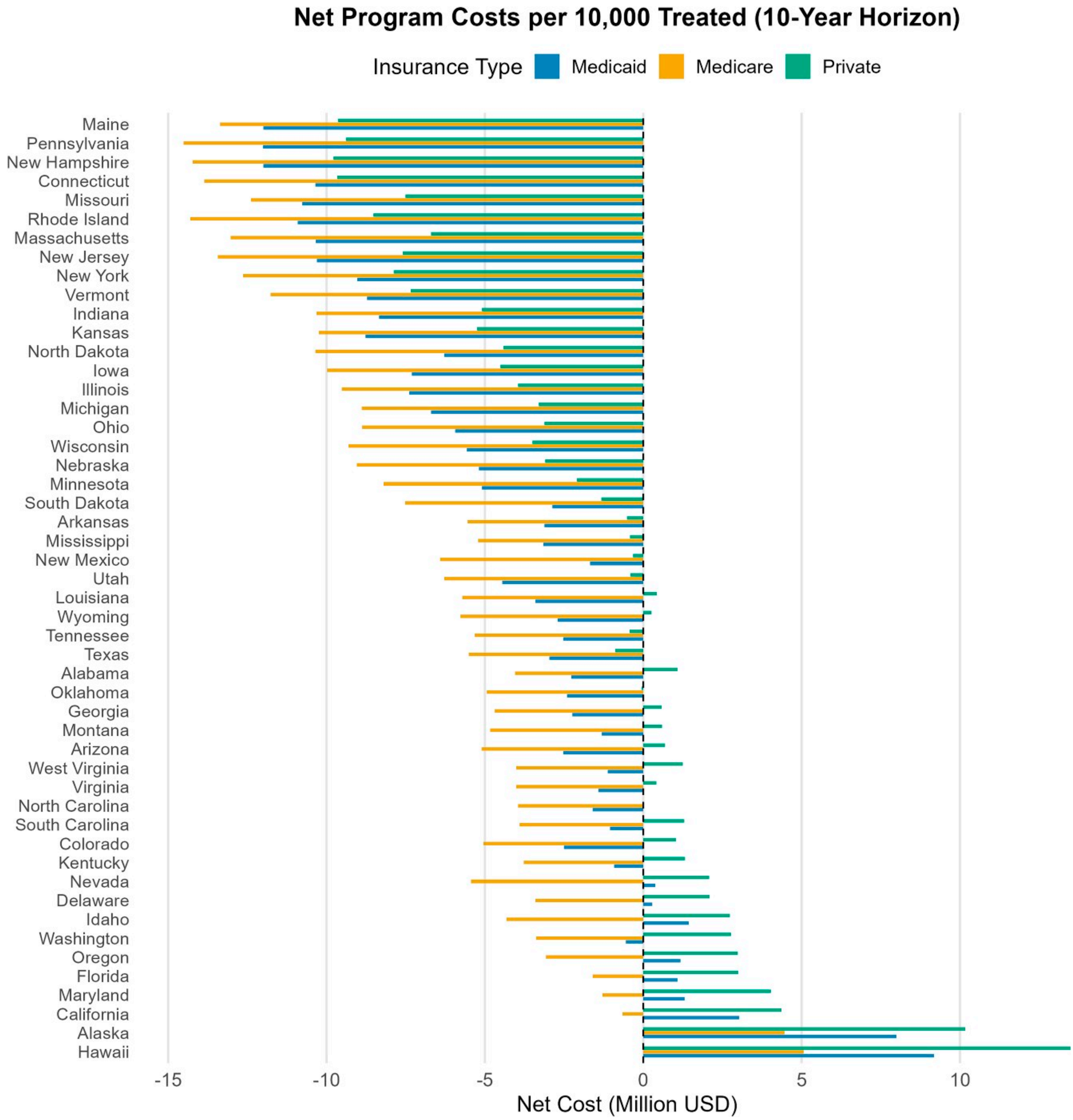

Figure 4—Estimated net costs of produce prescription therapy over 10 years of intervention by baseline insurance type in 50 U.S. states. Bars represent the estimated net changes in costs per 10,000 patients treated, based on a health care perspective (total intervention costs minus health care cost-savings), stratified by baseline insurance type of participants. Negative values indicate cost savings. Outcomes were evaluated based on the base-case scenario that all eligible patients identified received the intervention. All costs are expressed in 2023 dollars and discounted at an annual rate of 3%. Results represent mean values from 1,000 Monte Carlo simulations.

events prevented and health care costs averted varied moderately across states. This consistency in outcomes, despite significant state-level differences in demographic composition, risk factor prevalence, baseline CVD prevalence, and health care costs, supports the generalizability of PRx as a medical therapy. At the same time, our model assumed a similar average effect of PRx on dietary intake, BMI, and HbA_{1c} across states, which may mask potential state-level variation in average efficacy. Demographic characteristics, lifestyles, severity of cardiometabolic conditions, and health care access could each influence PRx efficacy, highlighting the need for further research to explore these factors (15). Generally, the estimated health care savings and net cost savings per 10,000 individuals treated were highest in northeastern states. This was largely influenced by higher estimated baseline health care spending per capita among the eligible population in this region (Supplementary Fig. 8) (31,32) Our findings suggest that interventions like PRx may offer particularly strong economic benefits in regions with higher health care utilization and costs, providing a compelling rationale for investment.

Our findings by insurance type provide new evidence to inform different payers' coverage and reimbursement decisions for PRx programs for individuals with diabetes and food insecurity. The results suggest that, in most states, PRx programs can generate meaningful health improvements and be cost-saving for public programs and be cost-saving or highly cost-effectiveness for private payers. A significant proportion of adults with both diabetes and food insecurity, a proxy for financial strain, were covered by commercial insurance rather than Medicare or Medicaid. Low-income individuals with private insurance are more likely to face barriers to accessing care and report catastrophic out-of-pocket health care expenses compared with their counterparts with public insurance or higher incomes (33,34). Implementing PRx programs within commercial plans could help address critical gaps in health equity, offering improved access to preventive and therapeutic interventions. At the same time, we observed that the per-person health and economic benefits of PRx programs were generally higher among Medicare than Medicaid or private payer beneficiaries, reflecting the older age and higher baseline cardiovascular risks, and higher average health care utilization and costs among the former, with variations among states, reflecting state-specific demographic and health profiles (35). However, current PRx expansion is generally occurring in Medicaid and commercial insurance, not Medicare. Our findings support the need for further research to evaluate PRx in Medicare, such as classifying Food Is Medicine programs as supplemental benefits in Medicare Advantage, or requiring current incentives that support general grocery purchases to be limited to medically supportive or tailored healthy foods.

We found PRx to produce national net savings of ~$3 billion from a health care perspective and $4.5 billion from a societal perspective over 10 years. In prior work, we estimated PRx was highly cost-effective nationally (4). The new findings result from updated data inputs on program costs, efficacy, and population risk, and, in particular, updated health care spending for diabetes care. Between 2012 and 2022, inflation-adjusted national health care costs for diabetes surged by 18%, from $227 to $307 billion (5), resulting from spending on noninsulin glucose-lowering and antiobesity medications, rising insulin prices, and higher inpatient costs (6,7). For example, from 2017 to 2022, inflation-adjusted per capita spending on prescriptions for insulin and other glucose-lowering agents increased by 20% and 25%, respectively (5). These worrisome trends highlight the growing financial burden of diabetes management, reinforcing the need for scalable, cost-saving interventions that can reduce long-term health care expenditures while improving health outcomes.

Strengths of this investigation include use of a validated microsimulation model, incorporation of state-specific representative data, and inclusion of reasoned parameters and assumptions based on evidence synthesis and meta-analyses, increasing confidence in the results. By leveraging data specific to each state, the analysis captures more nuanced impact of interventions across diverse geographic and demographic contexts. Uncertainty was jointly incorporated for all key parameters in probabilistic sensitivity analyses. Health effects, costs, and cost-effectiveness were assessed from both health care and societal perspectives, by insurance coverage, and over different time horizons, providing health care leaders and policymakers a range of plausible outcomes that may occur from expanded coverage of PRx.

As with all decision analyses, our findings have limitations and cannot capture all aspects of real-world practice. Most interventions in our meta-analyses used a pre/post or quasi-experimental design, and additional trials with a randomized design are needed. Intervention effects were based on the pooled effects of 20 PRx programs, which had heterogeneous design features; and our findings should be considered the most plausible average effect. More studies are needed to help identify implementation factors and patient characteristics that might alter efficacy and costs. We did not consider the potential health benefits of PRx for family members as a result of food sharing, which possibly resulted in underestimating the full health and economic benefits. We assumed the benefits of PRx are constant and maintained only during active participation, although some sustained effects may persist beyond program completion, as suggested by emerging evidence. As a result, our estimates may be conservative and underestimate the true long-term health and economic benefits of PRx. The uncertainty intervals in model net costs were wide, reflecting smaller state samples, uncertainties in intervention effect estimation, and uncertainties in state-level health care cost estimation. Health care costs in MEPS exclude individuals in nursing homes and assisted living facilities—a group that represents a particularly high-expenditure group. MEPS also tends to underestimate health care expenditures due to underrepresentation of high-expense cases and underreporting of health care use (36–40). Our results, therefore, underestimate health care savings associated with prevention of institutionalization among enrolled patients as well as with high-utilization patients. Yet despite these limitations, our results provide the most plausible expected health benefits and cost effects of PRx, and the underlying uncertainty, based on the best available data and judicious assumptions.

In conclusion, our investigation estimates that PRx therapy for patients with diabetes and food insecurity may significantly reduce CVD events and be cost-saving or highly cost-effective in all 50 states.

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