**Methods, Supplemental Digital Content 1**

**Reprinted with permission from HealthPartners Institute**

**Model Overview**

A full description of the model parameters and processes can be found in a previous publication (Appendix B).1 ModelHealth: CVD model begins by initializing a hypothetical person with attributes representative of the US population’s distribution, including: age, sex, race/ethnicity, U.S. census region (from the American Community Survey), education, employment status, poverty status, initial insurance status (Current Population Surveys), body mass index (BMI), systolic blood pressure (SBP), low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, diabetes mellitus, cardiovascular disease (CVD) status (National Health and Nutrition Examination Survey), and smoking status (National Health Interview Survey). Initial smoking status (i.e., never smoker, current smoker, recent quitter, or former smoker) was determined by a risk equation that accounted for age, sex, race/ethnicity, and lifetime educational attainment. Initial insurance status was assigned using logistic regression models based on age, sex, race/ethnicity, lifetime education, poverty status, disability status, labor force status, and Census region (based on Current Population Surveys data).

At the beginning of each annual cycle, the model determines whether a simulated person receives the intervention (i.e., in this case, a team-based care intervention involving a pharmacist) based on their eligibility and whether the simulation is for the “intervention” or “control” arm (population details and all else remain equal between simulation arms). For those receiving the intervention, risk factors (i.e., in this case SBP and LDL) will be adjusted accordingly and later affect disease risk. In addition, preventive services run in the background for both simulation arms (i.e., preventive services recommended by U.S. Preventive Services Task Force (USPSTF), including: screening for hypertension, screening for lipid disorders, or aspirin counseling).2-4 Eligibility to receive preventive services was dictated by health and risk factor parameters specific to USPSTF service guidelines. Upon receiving a preventive service, the model than determines if the individual is eligible for treatment consistent with Adult Treatment Panel III and JNC-7 guidelines for dyslipidemia and hypertension, respectively. If eligible, mean and person-specific effects were modeled to estimate reduction in LDL-cholesterol for treatment with HMG-CoA reductase inhibitors (i.e., statins), reduction in SBP for treatment with anti-hypertensive medication, and reduced risk of MI and ischemic stroke and increased risk for gastrointestinal (GI) bleeding and hemorrhagic stroke when using aspirin for primary prevention.

The next step in the annual cycle is to model an individual’s potential for a CVD event(s) using data from the Framingham Heart Study. Each simulated person has the potential to have a myocardial infarction, have an ischemic stroke, have a hemorrhagic stroke, experience angina pectoris, develop congestive heart failure, develop intermittent claudication, develop diabetes, and/or experience a GI bleed. If a person survives a cardiovascular event, then that person is eligible for secondary prevention services including: treatment with statins and antihypertensives for dyslipidemia and hypertension, respectively, and treatment with aspirin for non-myocardial infarction or ischemic stroke events. However, an individual may also experience a fatal cardiovascular event (risk derived from Framingham Heart Study data) or a non-CVD related cause (derived from US life tables) in an annual cycle. A person who dies of any cause or reaches the age of 100 exits the model.

If a person survives a cycle, the individual’s health parameters are transitioned to the next cycle. As each cycle is an annual step, age increments by one year; whereas, biological characteristics (i.e., BMI, SBP, BMI, LDL, and HDL) increment in a two-step process. First, a person faces a probability of increasing, staying the same, or decreasing in a particular risk factor (based on Framingham Heart Study data and Behavioral Risk Factor Surveillance System data). Once this transition modality is chosen by the model, a percentage change is applied to the direction of the transition (specific to the risk factor). Transitions in smoking status involve initiation, cessation, and relapse, derived from National Health Interview Survey and published data. Individuals may also transition to a new payer each year based on their current payer and their age, sex, race/ethnicity, and transitions into and out of disability and the labor force.

The model generated outcomes for the same population in 2 otherwise parallel simulation arms over 5 years and, for the supplemental analysis, over 20 years—one with the intervention strategy implemented and one without (reflecting contemporary hypertension management patterns). Costs of cardiovascular disease and diabetes were derived using data from the Medical Expenditures Panel Survey data. Costs associated with incident CVD events (identified through an inpatient hospital stay) were derived from inpatient hospital stays, outpatient visits, office-based medical provider visits, emergency room visits, prescribed medicines, home health expenses, and other medical expenses. ICD-9 codes were used to identify an incident event of: myocardial infarction, ischemic or hemorrhagic stroke, angina pectoris, congestive heart failure, and intermittent claudication. Ongoing costs were calculated by combining total expenditures for incident events with costs estimated from ICD-9 codes associated with ongoing-care. Costs attributed to diabetes did not distinguish between incident costs or ongoing costs. Total expenditures were estimated using a generalized linear models adjusted for age, sex, and event costs. Marginal disease expenditures were calculated by estimating the difference in population average costs with and without that disease. Costs were apportioned by payer using an insurance sub-model that assigns each simulated individual to a primary payer: private insurance, Medicaid, Medicare (including Medicare/Medicaid dual-eligibles), uninsured, or other/multiple insurance.

**Supplemental Methods Table 1.** Summary of Disease Costs in ModelHealth: CVD

|  |  |  |  |
| --- | --- | --- | --- |
|   | **Incident Costs** |   | **Ongoing Costs** |
|  | Private | Medicare | Medicaid |  | Private | Medicare | Medicaid |
| MI | $46,700  | $32,600  | $24,600  |  | $3,000  | $2,000  | $2,200  |
| Stroke | $22,900  | $16,000  | $12,100  |  | $6,500  | $4,200  | $4,700  |
| AP | $30,600  | $21,300  | $16,100  |  | $5,100  | $3,300  | $3,700  |
| CHF | $37,800  | $26,400  | $19,900  |  | $14,000  | $9,100  | $10,200  |
| IC | $24,100  | $16,800  | $12,700  |  | $7,900  | $5,100  | $5,800  |
| Diabetes | $4,000  | $4,100  | $5,500  |  | $4,000  | $4,100  | $5,500  |

Notes: Ongoing costs are exclusive of drug therapy costs for high cholesterol or hypertension; these costs are accounted for separately in the ModelHealth: CVD.

**Literature search for team-based care interventions involving pharmacists**

 As this study focuses solely on health-related impacts of team-based hypertensive care interventions with pharmacists, an updated review of the literature was conducted using similar methods discussed in our previous publication.1 Many adults with hypertension also have other CVD risk factors (e.g., hypercholesterolemia) and,in addition to improvements in BP, the most current Guide to Community Preventive Services (i.e., Community Guide) review also found that team-based care improved lipid outcomes, particularly LDL.5 Thus, we conducted the literature search to estimate the effectiveness of team-based hypertensive care interventions involving pharmacists on SBP, LDL-cholesterol, and HDL-cholesterol.

Initially, we identified systematic reviews (including Community Guide reviews) of team-based hypertension care interventions; however, the literature search from the most recent review ended in May 2012.5 To incorporate more recent research, an additional PUBMED search was conducted to identify trials of team-based care hypertension interventions from 2012 through 2016. Studies were eligible for inclusion if they met the following criteria: 1) randomized controlled trial (RCT) design, 2) conducted in the United States, 3) enrolled participants with uncontrolled hypertension, and 4) included pharmacists on the team. Twenty RCT’s6-25 met inclusion criteria and reported changes in SBP; whereas, only 5 RCT’s reported effects on LDL and HDL cholesterol.14,18,26-28 The effectiveness of the intervention was determined by calculating the population weighted mean effect for SBP, LDL cholesterol, and HDL cholesterol from applicable trials (Supplemental Methods Tables 1, 2).

Compared to our previous publication, the weighted average intervention effects differed slightly in the current analysis (Supplemental Methods Table 3). This is likely attributed to differences in members included on the care team. Thirteen6-9,12,15-22,25 of the sixteen studies considered for team-based hypertensive care intervention effects on SBP in our previous publication included pharmacists on the care team and were also used for effectiveness estimates in the current analysis. On the other hand, only two studies14,18 in the previous publication included a pharmacist on the care team and was also used to estimate the effectiveness of a team-based hypertensive care intervention on lipid-outcomes.

**Supplemental Methods Table 2.** Summarizing the effectiveness of the team-based hypertension care intervention involving pharmacists to improve systolic blood pressure drawn from the revised literature search

|  |  |  |
| --- | --- | --- |
| **First Author, Year [Reference]** | **# Persons completing the intervention** | **Difference in mean SBP between groups (mm Hg)\*** |
| Bogden, 1998 [6]  | 95 | -12 |
| Borenstein, 2003 [7] | 197 | -11 |
| Carter, 2008 [8] | 179 | -8.7 |
| Carter, 2009 [9] | 402 | -12 |
| Carter, 2015 [10] | 539 | -6.1 |
| Chisholm, 2002 [11] | 23 | -27.5 |
| Edelman, 2010 [16] | 239 | -7.3 |
| Green, 2008 [17] | 519 | -8.9 |
| Hirsch, 2014 [18] | 166 | -3.5 |
| Hunt, 2008 [19] | 463 | -6 |
| Magid, 2011 [20] | 283 | -6 |
| Magid, 2013 [21] | 348 | -12.4 |
| Margolis, 2013 [22] | 388 | -9.7 |
| Mehos, 2000 [12] | 36 | -10.1 |
| Planas, 2009 [13] | 40 | -20.1 |
| Rothman, 2005 [23] | 217 | -9 |
| Scott, 2006 [14] | 131 | -5.5 |
| Soloman, 1998 [24] | 133 | -6.9 |
| Vivian, 2002 [25] | 53 | -14.1 |
| Zillich, 2005 [15] | 117 | -4.5 |

Abbreviations. SBP, systolic blood pressure.

\* Difference in mean SBP is the change in SBP from baseline to the end of the intervention in intervention compared to the control group (e.g., SBP declined -23 mm Hg in intervention group compared to -11 mm Hg in the control group = a difference of -12 mm Hg)

**Supplemental Methods Table 3.** Summarizing the effectiveness of the team-based hypertension care intervention involving pharmacists to improve cholesterol drawn from the revised literature search

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **First Author, Year [Reference]** | **# Persons completing the intervention w/ LDL data** | **Difference in mean LDL between groups (mg/dL)\*** | **# Persons completing the intervention w/ HDL data** | **Difference in mean HDL between groups (mg/dL)\*** |
| Ellis, 2000 [26] | 241 | -10.6 | 282 | -0.1 |
| Doucette, 2009 [28] | 66 | -7.6 | NR | NR |
| Hirsch, 2014 [18] | 166 | -0.4 | 166 | -1.4 |
| Nola, 2000 [27] | 51 | -10.4 | 51 | 3.8 |
| Scott, 2006 [14] | 131 | -11.2 | 131 | 0.7 |

Abbreviations. HDL, high density lipoprotein; LDL, low density lipoprotein; NR, not reported.

\* Difference in mean LDL or HDL is the change in the parameter from baseline to the end of the intervention in intervention compared to the control group (e.g., LDL declined -19.4 mg/dL in intervention group compared to -8.2 mg/dL in the control group = a difference of -11.2 mg/dL)

**Supplemental Methods Table 4**. Comparison of key modeling parameters used to estimate cardiovascular event incidence and associated costs between analyses of team-based hypertension interventions using adjunct or allied health professionals1 to interventions using pharmacists

|  |  |  |
| --- | --- | --- |
| **Key assumptions (parameters) for the intervention** | **Previous Analysis1 involving adjunct or allied health professionals** | **Current Analysis involving****Pharmacists only** |
| Reduction in SBP | 8.1 mm Hg | 8.5 mm Hg |
| Reduction in LDL  | 11.9 mg/dL | 8.1 mg/dL |
| Increase in HDL  | 1.0 mg/dL | - |
| Initial program participation rate | 90% | 90% |
| Persisting Treatment effect | 80% | 80% |
| Average annual enrollment cost | $525 per person enrolled | $525 per person enrolled |

**Supplemental Digital Content 1 References:**

1. Dehmer SP, Baker-Goering MM, Maciosek MV, et al. Modeled health and economic impact of team-based care for hypertension. Am J Prev Med 2016; 50(S1):S34-S44. <https://doi.org/10.1016/j.amepre.2016.01.027>.
2. Screening for high blood pressure: U.S. Preventive Services Task Force reaffirmation recommendation statement. Ann Intern Med. 2007;147(11):783-786. http://dx.doi.org/10.7326/0003-4819-147-11-200712040-00009.
3. U.S. Preventive Services Task Force. Screening for Lipid Disorders in Adults: Recommendation Statement. Agency for Healthcare Research and Quality; 2008.
4. Aspirin for the prevention of cardiovascular disease: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2009;150(6):396-404. http://dx.doi.org/10.7326/0003-4819-150-6-200903170-00008.
5. Proia KK, Thota AB, Njie GJ, et al. Team-based care and improved blood pressure control. Am J Prev Med 2014;47(1):86-99. http://dx.doi.org/10.1016/j.amepre.2014.03.004.
6. Bogden PE, Abbott RD, Williamson P, Onopa JK, Koontz LM. Comparing standard care with a physician and pharmacist team approach for uncontrolled hypertension. J Gen Intern Med 1998;13(11):740-745. https://dx.doi.org/10.1046%2Fj.1525-1497.1998.00225.x.
7. Borenstein JE, Graber G, Saltiel E, et al. Physician-pharmacist comanagement of hypertension: a randomized, comparative trial. Pharmacother 2003;23(2):209-216. https://doi.org/10.1592/phco.23.2.209.32096.
8. Carter BL, Bergus GR, Dawson JD, et al. A cluster randomized trial to evaluate physician/pharmacist collaboration to improve blood pressure control. J Clin Hypertens (Greenwich) 2008;10(4):260-271.
9. Carter BL, Ardery G, Dawson JD, et al. Physician and pharmacist collaboration to improve blood pressure control. Arch Intern Med 2009;169(21):1996-2002. https://doi.org/10.1001/archinternmed.2009.358.
10. Carter BL, Coffey CS, Ardery G, et al. Cluster-randomized trial of a physician/pharmacist collaborative model to improve blood pressure control. Circ Cardiovasc Qual Outcomes. 2015;8(3):235-243. https://doi.org/10.1161/CIRCOUTCOMES.114.001283.
11. Chisholm MA, Mulloy LL, Jagadeesan M, Martin BC, DiPiro JT. Effect of clinical pharmacy services on the blood pressure of African-American renal transplant patients. Ethn Dis 2002;12(3):392-397.
12. Mehos BM, Saseen JJ, MacLaughlin EJ. Effect of pharmacist intervention and initiation of home blood pressure monitoring in patients with uncontrolled hypertension. Pharmacother 2000;20(11):1384-1389.
13. Planas LG, Crosby KM, Mitchell KD, Farmer KC. Evaluation of a hypertension medication therapy management program in patients with diabetes. J Am Pharm Assoc 2009;49(2):164-170. https://doi.org/10.1331/JAPhA.2009.08164.
14. Scott DM, Boyd ST, Stephan M, Augustine SC, Reardon TP. Outcomes of pharmacist-managed diabetes care services in a community health center. Am J Health Syst Pharm 2006;63(21):2116-2122. https://doi.org/10.2146/ajhp060040.
15. Zillich AJ, Sutherland JM, Kumbera PA, Carter BL. Hypertension outcomes through blood pressure monitoring and evaluation by pharmacists (HOME study). J Gen Intern Med 2005;20(12):1091-1096. https://doi.org/10.1111/j.1525-1497.2005.0226.x.
16. Edelman D, Fredrickson SK, Melnyk SD, et al. Medical clinics versus usual care for patients with both diabetes and hypertension: a randomized trial. Ann Intern Med 2010;152(11):689-696. https://doi.org/10.7326/0003-4819-152-11-201006010-00001.
17. Green BB, Cook AJ, Ralston JD, et al. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial. JAMA 2008;299(24):2857-2867. https://doi.org/[10.1001/jama.299.24.2857](https://dx.doi.org/10.1001/jama.299.24.2857).
18. Hirsch JD, Steers N, Adler DS, et al. Primary care-based, pharmacist-physician collaborative medication-therapy management of hypertension: a randomized, pragmatic trial. Clin Ther 2014;36(9):1244-1254. https://doi.org/10.1016/j.clinthera.2014.06.030.
19. Hunt JS, Siemienczuk J, Pape G, et al. A randomized controlled trial of team-based care: impact of physician-pharmacist collaboration on uncontrolled hypertension. J Gen Intern Med 2008;23(12):1966-1972. . https://doi.org/10.1007/s11606-008-0791-x.
20. Magid DJ, Ho PM, Olson KL, et al. A multimodal blood pressure control intervention in 3 healthcare systems. Am J Manag Care 2011;17(4):e96-103.
21. Magid DJ, Olson KL, Billups SJ, Wagner NM, Lyons EE, Kroner BA. A pharmacist-led, American Heart Association Heart360 Web-enabled home blood pressure monitoring program. Circ Cardiovasc Qual Outcomes 2013;6(2):157-163.
22. Margolis KL, Asche SE, Bergdall AR, et al. Effect of home blood pressure telemonitoring and pharmacist management on blood pressure control: a cluster randomized clinical trial. JAMA 2013;310(1):46-56. https://doi.org/10.1001/jama.2013.6549.
23. Rothman RL, Malone R, Bryant B, et al. A randomized trial of a primary care-based disease management program to improve cardiovascular risk factors and glycated hemoglobin levels in patients with diabetes. Am J Med 2005;118(3):276-284. https://doi.org/10.1016/j.amjmed.2004.09.017.
24. Solomon DK, Portner TS, Bass GE, et al. Clinical and economic outcomes in the hypertension and COPD arms of a multicenter outcomes study. J Am Pharm Assoc (Wash) 1998;38(5):574-585. https://doi.org/ https://doi.org/10.1016/S1086-5802(16)30371-0.
25. Vivian EM. Improving blood pressure control in a pharmacist-managed hypertension clinic. Pharmacother 2002;22(12):1533-1540. https://doi.org/10.1592/phco.22.17.1533.34127.
26. Ellis SL, Carter BL, Malone DC, et al. Clinical and economic impact of ambulatory care clinical pharmacists in management of dyslipidemia in older adults: the IMPROVE study. Impact of Managed Pharmaceutical Care on Resource Utilization and Outcomes in Veterans Affairs Medical Centers. Pharmacother 2000;20(12):1508-1516.
27. Nola KM, Gourley DR, Portner TS, et al. Clinical and humanistic outcomes of a lipid management program in the community pharmacy setting. J Am Pharm Assoc (Wash) 2000;40(2):166-173. https://doi.org/10.1016/S1086-5802(16)31060-9.
28. Doucette WR, Witry MJ, Farris KB, McDonough RP. Community pharmacist-provided extended diabetes care. Ann Pharmacother 2009;43(5):882-889. https://doi.org/10.1345%2Faph.1L605.