Published in final edited form as:

Med Care. 2016 May ; 54(5): 474–482. doi:10.1097/MLR.0000000000000506.

Massachusetts Health Reform was Cost Saving for Individuals with New Venous Thromboembolism: A Cost-effectiveness Analysis

Alok Kapoor, MD, MSc, Nicholas Shaffer, MPH, Amresh Hanchate, PhD, Mark Roberts, MD, MPP, and Kenneth Smith, MD, MS

From the University of Massachusetts Medical School (A.K.), Worcester, MA; Boston Medical Center (N.S.), Boston, MA; Section of General Internal Medicine, Boston University School of Medicine (A.H.), Boston, MA; Department of Health Policy and Management, Division of General Internal Medicine, University of Pittsburgh School of Medicine, Pittsburgh, PA (M.R.); Section of Decision Sciences and Clinical Systems Modeling, University of Pittsburgh School of Medicine, Pittsburgh, PA (K.S.)

Abstract

Background—Patients with venous thromboembolism (VTE) require access to comprehensive physician and pharmacy benefits to prevent recurrence and hemorrhage. Prior to 2006, Massachusetts provided these benefits through a program restricted to safety net hospitals called Free Care. Providing portable health insurance through Massachusetts health reform could improve outcomes for uninsured with VTE but its cost-effectiveness is unknown.

Methods and Results—We constructed a Markov decision analysis model comparing our conceptualization of the Massachusetts health reform (“health reform strategy”) to no health reform strategy for a patient beginning warfarin for new episode of VTE. In the model, a patient may develop recurrent VTE or develop hemorrhage or stop warfarin after 6 months if no event occurs. To measure effectiveness, we analyzed laboratory data from Boston Medical Center, the largest safety net hospital in Massachusetts. Specifically, we measured the probability of having a subtherapeutic warfarin level for patients newly insured compared to those on Free Care pre-reform adjusting for secular trends. To calculate inpatient costs, we used the Health Care Utilization Project (HCUP). We then calculated the incremental cost effectiveness ratio (ICER) for the health reform strategy adjusted to 2014 USD per quality adjusted life year (QALY) and performed sensitivity analyses. The health reform strategy cost less and gained more QALYS than the no health reform strategy. Our result was most sensitive to the odds that Health Reform protected against a subtherapeutic warfarin level, the cost of Health Reform, and the percentage of total health care costs attributable to VTE in Massachusetts.

Conclusions—The health reform strategy cost less and was more effective than the no health reform strategy for patients with VTE.

Correspondence to Alok Kapoor, MD, MSc, Division of Geriatric Medicine, University of Massachusetts Medical School, 365 Plantation Street, Suite 100, Worcester, MA 01605. P: (508) 334-1000. F: (617) 963-7482. Alok.Kapoor@umassmemorial.org.

Conflicts of Interest: None

Keywords

venous thromboembolism; health reform; health insurance

Venous thromboembolism (VTE) comprised of deep vein thrombosis (DVT) and pulmonary embolism (PE) is the third most common cardiovascular condition with an estimated annual incidence of 900,000 in the US.¹ Close monitoring of the treatment (historically warfarin anticoagulation) is critical in these patients for preventing recurrent VTE and hemorrhage. Patients with VTE lacking health insurance have more constrained access to medications, anticoagulation clinics, primary care, and home care services. This constrained access can increase the rate of recurrent VTE and hemorrhage for patients with new episodes of VTE. In 2006, Massachusetts implemented landmark legislation which we will entitle “Health Reform” (in capitals throughout). The legislation improved access to these important care elements² and the utilization of health services in general.^{3,4} This legislation shifted government subsidies away from institutional-based support (Free Care funds provided to safety-net hospitals and affiliated community health centers) into individual-based coverage through expanded Medicaid coverage as well as new insurance plan offerings similar to those currently offered nationally through insurance exchanges.⁵ These new plans provide portable and comprehensive coverage, including access to local, retail pharmacies and home care/visiting nurse services. Prior to Health Reform, patients covered by Free Care had access restricted to primary care, hospital care, and pharmacy at a safety net hospital or community health center. Accessing a safety net facility required patients to travel long distances as opposed to visiting a local facility. Complete coverage with Free Care was available to legal state residents making less than 200% of the federal poverty line; partial coverage was available for those making between 200% and 400% of the federal poverty line.⁶

Whereas the benefits of Health Reform for individuals with VTE appear to be clear (i.e. easier access to medication, outpatient visits, home care nursing), the cost implications are uncertain. Although the annual cost of Health Reform per individual was high - \$3230 (adjusted to 2014USD) per Free Care patient newly insured - the proportion attributable to VTE care and costs saved with avoiding hospitalizations related to VTE and hemorrhage events has not been studied.⁵ The exact number of recurrent VTE or hemorrhage events for patients with free care is not available readily because of lack of databases which capture inpatient, ambulatory care, and laboratory care such as would be necessary to compare stability of INR values (i.e. measure of anticoagulation control) among patients with various insurance types. Markov decision analysis can allow us to extrapolate longer-term costs and effects related to these events based on INR data available from Boston Medical Center. In order to understand the cost-effectiveness of health reform we first compared INR data of patients newly insured after Health Reform with Free Care patients pre-reform. We then performed a Markov decision analysis to measure the cost-effectiveness of Health Reform for patients with VTE.

METHODS

We constructed a decision tree and Markov model to estimate differences in cost and effectiveness between two strategies for providing anticoagulation to patients with a first VTE episode. In one strategy, we calculated the cost and effectiveness of providing anticoagulation in the context of insurance coverage with Health Reform. In the other strategy, coverage exists as Massachusetts previously provided through Free Care funds. We modeled a 5-year time horizon, a reasonable period over which to understand long-term implications of Health Reform on anticoagulation control, divided into three month cycles. By dividing our analysis into three month cycles, we only permit one event (recurrent VTE, hemorrhage, death) per cycle consistent with Markov modeling methodology. We believe this is reasonable given the overall low rate of any single event. We assumed a health system economic perspective – including all direct costs, including hospital, outpatient, and pharmacy as well as all relevant health benefits related to VTE.

In Figure 1a, we depict the trajectory of patients with VTE who “enter the model,” for the purpose of our analysis, in the acute anticoagulation health state and proceed from left to right. (Figure 1a) Initially, in the base case, we assume that all patients are 50 years old, the average age of our patients at Boston Medical Center among those aged 18 to 64 (i.e. those eligible for Health Reform). After an initial mortality risk due to VTE or other causes, we sort patients into three therapeutic categories based on INR testing, the method used to determine if patients are receiving the correct warfarin dose. INR values <2 indicate a subtherapeutic dose, values of 2–3 indicating a therapeutic dose, and values >3 indicating a supratherapeutic dose. After this branch point, patients could develop recurrent VTE or hemorrhage, with their probabilities depending on which therapeutic category applied. This is, in effect, how we operationalize the effect of Health Reform - more patients in the therapeutic range leading to fewer recurrent VTE and hemorrhage events. (Figure 1b) If the net cost of the intervention is small or if the initial costs are offset completely by prevention of recurrent VTE and hemorrhage events, the health reform strategy will be cost-effective.

For each probability estimate we searched OVID Medline (1950 until 2014), spoke with experts, and reviewed the documents of authorities, such as the Centers for Disease Control and Prevention (CDC). For each parameter, we chose the highest quality evidence available but when there was uncertainty about the true value among equivalent data, we made a conservative choice that biased against the health reform strategy. To determine the effectiveness of Health Reform, we analyzed laboratory data of patients receiving anticoagulation at our home institution, Boston Medical Center and affiliated health centers from July 2000 until December 2011. More specifically, we determined the odds ratio of being subtherapeutic or supratherapeutic on warfarin for the newly insured compared with the pre-reform Free Care patients for a three-month period. (see Appendix I for more details) Because we found that the health reform strategy was neutral (i.e. $OR=0.99$) when considering the development of supratherapeutic INR levels, we focus our attention on the prevention of subtherapeutic INR levels. For the probability of recurrent VTE or new hemorrhage with anticoagulation initiation, we relied on a meta-analysis performed on a subset of studies in which patients with VTE received warfarin anticoagulation.⁷ In this meta-analysis, the authors calculated the rate of VTE and bleeding stratified by therapeutic

status of warfarin -i.e. subtherapeutic, therapeutic, or supratherapeutic. (Table 1 for further details).

Utilities and Tolls

We consulted the Tufts Cost-Effectiveness Analysis Registry⁸ to obtain the utility for patients with VTE on anticoagulation. Multiple publications with utilities derived from both standard gamble and time trade-off techniques suggested that the value is approximately 0.99 (i.e. 1% difference from Well state). For acute VTE or hemorrhage events requiring hospitalization, we assess a toll as described in the Analysis section below.

Costs

We identified the incremental cost of health reform strategy based on the costs of shifting away from Free Care.⁵ This equaled \$791 million (adjusted to 2014 USD) to cover 245,000 Free Care patients, or approximately \$3230 per person. As health insurance covers a wide range of services, to identify the share of Health Reform costs attributable to VTE, to derive the incremental cost of the health reform strategy, we measured the share of all health care costs attributable to VTE care using inpatient data compiled by the Agency for Healthcare Research and Quality (AHRQ).⁹ Specifically, we divided the total cost of VTE hospitalizations (\$1.25 million) by the total cost of hospitalizations for all diagnoses (\$309 million) for patients on Medicaid aged 45–64 in 2011 (given our base case assumption of treating a 50 year old patient); this quotient suggested 0.32% of the healthcare dollar is attributable to VTE. Multiplying 0.32% by the added cost of an individual covered by Health Reform (\$3230) resulted in an incremental cost of the health reform strategy attributable to VTE care of approximately \$6. In sensitivity analysis, we varied this cost up to \$10, based on variation of VTE and total cost components of the ratio.

We used HCUP discharge data for hospitalization costs related to VTE (mainly PE) and major hemorrhage. For outpatient costs of care, we used an analysis by Lin et al. who, using 2008–2010 Medicare data, calculated VTE-related care costs for first and subsequent months of care following VTE, including warfarin costs.¹⁰ Costs are higher initially, since the difficulty of establishing a therapeutic warfarin level requires more provider visits. Although our source data might overestimate costs for younger Medicaid beneficiaries, we felt it was a fair approximation and then tested our assumption in sensitivity analysis.

We adjusted all costs to 2014 USD using the Medical Care Consumer Price Index for All Urban Consumers.¹¹

Analysis

First, we calculated costs and effectiveness accumulated for each 3 month cycle for each strategy. We then aggregated these over a total of 20 cycles, or 5 years. After the first year, we discounted both cost and effectiveness at 3% per year consistent with prevailing guidelines.^{12,13} To calculate effectiveness in quality adjusted life years, we aggregate time spent in a health state by its associated utility. We then subtract this value by the tolls for days “lost” in the hospital with recurrent VTE and hemorrhage. This requires converting effectiveness of each strategy measured in QALYs into quality adjusted life days, subtracting

by the number of days over which the patient is typically hospitalized for all events (essentially equating days in the hospital with no value), and then converting the difference back to QALYs to get a net effectiveness for each strategy. This follows standard practice.¹⁴

We calculated the incremental cost effectiveness ratio (ICER) as the difference in cost between strategies divided by the difference in their effectiveness measured in quality adjusted life years (QALYs). We interpret this ratio as the cost to achieve an additional QALY. Policy makers are interested in the ICER value because it accounts for the possibility of less expensive or more efficient options available when selecting from competing programs.¹⁵ In cases where a strategy cost less and is more effective than a comparator strategy, the first strategy is said to dominate the comparator. Although there exists no official threshold, \$100,000 / QALY is a threshold often cited above which decision analysts would claim an intervention not to be cost-effective.¹⁶ Interventions < 50,000 / QALY are generally cost-effective and interventions with ICER between 50,000–100,000 / QALY have an indeterminate cost-effectiveness.

We conducted 1-way analysis to assess the impact of uncertainty in individual parameters on the ICER for health reform. We also performed probabilistic sensitivity analysis, where the analyst assigns distributions for each parameter and then samples them simultaneously to assess the joint effect of input parameter uncertainty. More specifically, we constructed distributions for the important parameters in cases where parameter variation led to differences in results \$5000/QALY in 1-way analysis following a prior example.¹⁷ We simultaneously sampled from distributions for nine variables that we found to be influential in one way sensitivity analysis. More specifically we used beta distributions for probabilities, gamma distributions for costs, and lognormal distributions for relative risks following guidance in the literature¹⁸ (technical appendix with actual distributions available upon request). To obtain a stable cost-effectiveness result, we ran the model three separate times for 20,000 iterations (i.e. resampling the nine distributions 20,000 times and putting those values into the model along with the constant value for the remaining variables).

We conducted all cost-effectiveness analyses in TreeAge Pro HealthCare 2014.¹⁹

RESULTS

In the base case 50-year-old patient, the health reform strategy cost \$15 less and was 0.0013 QALYs more effective than the non-health reform strategy leading to an ICER = −11,500 USD/QALY. Thus, health reform dominated the no health reform strategy. In Figure 1B, we tracked the trajectory of 100 patients with VTE eligible to benefit each year from Health Reform in Massachusetts. According to our results, by five years, in the health reform strategy, 18.3% will have died, 9.10% would be on anticoagulation for recurrent events, and 71.5% would have had no further events (Well state); by small contrast, in the no health reform strategy, the respective percentages would be 18.3%, 9.12%, and 71.5%. In a sensitivity analysis (Figure 2), the odds ratio of Health Reform protecting against a subtherapeutic warfarin level (i.e., Health Reform effectiveness) was the most influential parameter. At an odds ratio >0.86 (base case 0.78), Health Reform was no longer cost saving (ICER > \$0/QALY). At an odds ratio 0.95, Health Reform cost >\$100,000 /QALY gained.

Another important variable was the yearly cost of insuring Free Care patients with Health Reform. At a cost > \$4,800 (base case \$3,230) per person, Health Reform was no longer dominant and at \$8,000 it cost \$45,168 /QALY. Other important parameters include the percentage of costs attributable to VTE versus all care in Massachusetts, the 3 month probability of recurrent VTE when warfarin is therapeutic, the 3 month probability of being subtherapeutic on warfarin for Free Care patients prior to Health Reform, and the cost of a VTE admission.

In probabilistic sensitivity analysis, the health reform strategy was dominant (i.e., ICER threshold < \$0 /QALY) in 61% of model iterations, cost less than \$50,000/QALY in 74% of iterations, and less than \$100,000/QALY, 78% of the time. (Figure 3)

DISCUSSION

We found that health reform strategy cost less and was more effective than (i.e. dominated) the no health reform strategy. Results were most sensitive to the odds that Health Reform was protective against a subtherapeutic warfarin level, Health Reform cost, and the percentage of total health care costs attributable to VTE. In probabilistic sensitivity analysis, the health reform strategy was dominant in 61% of simulations.

We are unaware of other economic analyses of health insurance reform with respect to patients with VTE. Our approach to modeling Health Reform effectiveness through the intermediate outcome of sub-therapeutic anticoagulation is consistent with other cost-effectiveness analyses of anticoagulation management strategies.^{20,21,22} Among them, Lafata et al. analyzed the role of INR patient self-testing (PST) compared with anticoagulation clinic based care.²⁰ They modeled the incremental cost as \$107 annually, which was more costly than our intervention (\$6). Their PST estimates suggested a more than fourfold decrease in the probability of being sub-therapeutic, which translates to an odds ratio of 0.18 compared with our odds ratio of 0.78. They therefore found PST dominant compared with anticoagulation clinic management. Their findings hinge on the inclusion of patient costs, which we did not include in our analysis. We believe patient costs would decrease through more convenient care (decreased transportation time and lost wages traveling to safety net hospital for outpatient care and medications) and that the health reform strategy would have been even more favorable with their inclusion but do not have direct evidence to support this suggestion.

There are significant implications to our findings. Although providing insurance only had a small savings in terms of VTE (\$15 per person or approximately \$6000 per year for the state of Massachusetts based on our projection of approximately 400 patients with VTE who would be benefit from Health Reform), the aggregation of health savings across the multitude of conditions health reform would address would be sizable. Health Reform would likely be cost-effective or even cost-saving for conditions similar to anticoagulation which are sensitive to local pharmacy access and home nursing. These are the services afforded by comprehensive, portable health insurance that were not available to Free Care patients prior to Health Reform. Advanced congestive heart failure with its requirement for careful titration of diuretic and blood pressure medication could be another target condition which

may be responsive to Health Reform. Similarly the effectiveness gained in the state of Massachusetts for VTE would be relatively small (0.52 QALYs per year), but across multiple conditions the impact would likely be substantial. In general, we should adopt proposed interventions that cost less and gain effectiveness compared with the status quo.²³ Health Reform falls into this category assuming what we found holds true across multiple other conditions. We welcome further investigation to replicate our approach in other conditions.

Beyond Massachusetts, health insurance reform may prove even more cost effective for patients requiring anticoagulation and other insurance-responsive conditions. The safety net system for Free Care patients that preceded Health Reform was relatively robust, particularly in the Boston area from where we sampled our laboratory data for establishing levels of subtherapeutic warfarin. To that point, the percentage of anticoagulation episodes associated with a subtherapeutic warfarin level in Free Care patients pre-reform was only two percentage points lower than in the insured and pre-reform (20% vs. 22%) in our analysis. (Table 1) In other parts of Massachusetts and other states where safety net programs are less robust, benefits to VTE patients may be greater.

There are several limitations to our findings. We had no data on recurrent VTE and hemorrhage for patients in Free Care patients and newly insured populations used to measure Health Reform effectiveness. We measured effectiveness through the probability of being subtherapeutic on warfarin using data exclusively from Boston Medical Center and its affiliated community health centers. Capturing sufficient numbers of Free Care patients in Massachusetts over the duration of anticoagulation for measurement of definitive outcomes would be infeasible in the absence of all payer outpatient claims data in Massachusetts covering the pre- and post-reform periods. In our analysis, there is also a potential for confounding by indication. We rely on patients accessing healthcare in the form of INR testing and diagnosis of VTE in order to identify them. If Free Care patients with VTE did not come for testing, or came infrequently, we would not have captured them in our analyses. If we had a direct source for outcomes information, like an all payer combined inpatient and outpatient claims database, we believe the rate would have been able to detect and even higher rates of recurrent VTE and hemorrhage among Free Care patients than we computed with the indirect method of assessing warfarin adherence.

Another limitation is that our results from Boston Medical Center may not be generalizable to health systems in other parts of Massachusetts. Boston Medical Center is the largest safety net hospital in Massachusetts and comprised a large proportion of Free Care patients and newly insured considered in our analysis. Although a single health system experience could be confounded by secular quality improvements, only quality control efforts specifically designed to assist newly insured patients preferential to commercial insurance patients could bias our findings. We are unaware of any such quality control efforts at Boston Medical Center over this time period. We measured the decreased risk of being subtherapeutic for the newly insured controlling for secular trends in the insured with a difference in differences approach. Our analysis is the first (of which we are aware) to demonstrate the effectiveness of Massachusetts Health Reform in a discrete medical condition using actual clinical data. Other studies compare Massachusetts state discharge,

claims data with similar data from other states and infer effectiveness through examining narrowing of disparities among vulnerable groups based on race and socioeconomic status.^{24,25} We welcome other studies exploring the impact of Health Reform on anticoagulation and other discrete medical conditions, particularly those sampling from multiple health systems using individual patient insurance information.

In addition, we must temper our conclusion that the health reform strategy was cost-effective based on the fact that even at \$100,000 /QALY only 78% of the simulations in probabilistic sensitivity analysis confirm that Health Reform was cost-effective. This is only 17% higher than the 61% of simulations for which Health Reform was dominant suggesting a relatively narrow window of values for some input parameters before our cost-effectiveness conclusions change. To this point, as the odds ratio for Health Reform protecting against a subtherapeutic warfarin varied over a relatively narrow range (0.86 – 0.95) in sensitivity analysis, the cost effectiveness result went from \$0 up to \$100,000/QALY. If more anticoagulation episodes could be analyzed, we could have employed a narrower distribution for the odds ratio parameter in the probabilistic analysis, perhaps causing fewer simulations in which the ICER was not cost-effective. Nevertheless, the rather small incremental effectiveness associated with the health reform strategy in the base case (0.0013 QALYs) makes the analysis quite sensitive to the variable of health reform protecting against a subtherapeutic warfarin level. The analysis is much less sensitive to other variables in the model. Moreover, in 61% of simulations, i.e. the majority of the time, the health reform strategy dominated the no health reform strategy, a situation in which policymakers should generally adopt an intervention.²⁶

Finally, we recognize that the advent of new oral anticoagulants could change the cost-effectiveness of Health Reform. Another cost-effectiveness study²⁷ has already reported that rivaroxaban dominates warfarin suggesting that providing health insurance with access to rivaroxaban would also dominate not providing insurance. Many patients will still remain on warfarin and for those patients our result will still apply.

In conclusion, Massachusetts Health Reform cost less and was more effective than no health reform in the context of our base case patient with VTE and also in the majority of probabilistic sensitivity analysis simulations. Our results suggest that Health Reform might be cost-effective for other conditions with similar resource needs and in other areas of the state and nation in similar safety net hospital settings that would be affected by health insurance reform. Our analytic approach, which adjusted for secular trends and performed extensive sensitivity analyses, bolsters the validity and robustness of these findings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

None

Funding: Center for Cardiovascular Outcomes Research

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Figure 1a. Decision Analysis Pathway for Patient with New Episode of VTE Being Treated with Warfarin Anticoagulation

Circles represent chance events whereas triangles represent outcomes that lead to recursive, Markov model (Figure 1b) – Death, VTE recurrent, VTE no AC, VTE acute. In the initial pathway depicted above, there is first a risk of death from background causes or VTE. In the next branch point, we segregate patients into relative probability of being suprathera- peutic, subtherapeutic, or therapeutic based on data from Free Care patients prior to Health Reform versus patients previously on Free Care who became newly insured post reform. The therapeutic category determines the subsequent risk for more VTE or major bleeding depicted by the next set of branch points. Finally a patient can continue anticoagulation during the first three month cycle versus complete anticoagulation if already having completed two cycles (6 months being the mean duration of therapy in our population)

Abbreviations: VTE = venous thromboembolism, AC = anticoagulation

Figure 1b. Markov Model of Health States Occupancies and Interim Cost and Effectiveness for No Health Reform Strategy vs. Health Reform Strategy^x

All patients start in the VTE Acute state. After three months of anticoagulation, patients could end up in the well, death, VTE no AC (such as after intracranial bleeding), or VTE Recurrent states. Thereafter, we assumed patients in the VTE recurrent state moved to the VTE Chronic on AC state but could stay in VTE Recurrent state if they developed another VTE, could die (Death state), or develop intracranial hemorrhage and then no longer receive anticoagulation (VTE no AC state). Next to each health state, we list the percentage of patients occupying that health state at the end of each three month cycle. Black values represent percentage of patients in health reform strategy and gray values represent percentage in no health reform strategy. We depict transitions possible in the next cycle with straight arrows until the five-year mark at which point we no longer cycle patients and therefore have removed arrows. Prior to the five-year mark, patients may also remain in the same state if no new event occurs; we represent this with circular arrows. To calculate cost-effectiveness of the health reform intervention we aggregate costs and quality adjusted life years accrued during each cycle according to which state the patient occupied. The cost-effectiveness can be calculated at each time point as the incremental cost effectiveness ratio which is the difference in cumulative costs divided by the difference in cumulative effectiveness. After five years, the health reform strategy cost approximately \$1500 less and achieved 0.13 more QALYs compared with the no health reform strategy making it dominant compared to the no health reform strategy. Further details of the results of each of the 20, three month cycles available upon request made to the authors.

Abbreviations: VTE = venous thromboembolism, AC = anticoagulation, ICER = incremental cost effectiveness ratio, USD = US dollars, QALY quality adjusted life-year

¥ Black typeface indicates values for health reform strategy; gray typeface indicates values for no health reform strategy

* In 2014 US dollars

† In quality adjusted life years

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Figure 2. Cost-Effectiveness of Health Reform Strategy over Varying Values of Most Influential Model Parameters

* Value in the parentheses represents value of input parameter in the base case which corresponds with the vertical line and then the value of the parameter for the left or lower bound of the bar followed by value of the parameter for the right or upper bound.

➔ Indicates result extends beyond threshold of \$100,000/QALY

Abbreviations: Prob = probability, USD = United States Dollar, QALYs =quality adjusted life years

Figure 3. Percentage of Simulations in Which Health Reform Strategy Was Cost-Effective over Varying Cost-Effectiveness Threshold

The health reform strategy was dominant (i.e., ICER threshold < \$0 /QALY) in 61% model iterations, cost less than \$50,000/QALY in 74% of iterations, and less than \$100,000/QALY, 78% of the time.

Abbreviations: QALYs =quality adjusted life years

Table 1

Parameter List, Baseline Estimate, Range for Sensitivity Analysis, and Comment.

Parameter List	Baseline Estimate	Range for Sensitivity Analysis [£]	Comments/Citations
Probabilities (for 3 month duration unless otherwise specified)			
** Being subtherapeutic if Free Care	0.22	0.1–0.5	Boston Medical Center data warehouse data (7/1/2000–12/31/2011). * This is equivalent to saying that 22% of anticoagulation episodes had a subtherapeutic warfarin level for patients on Free Care.
Being supratherapeutic if Free Care	0.11	0.03–0.2	Boston Medical Center data warehouse data (7/1/2000–12/31/2011). *
** Major hemorrhage when warfarin therapeutic [†]	0.0025	0–0.05	Systemic review of outcomes among patients prescribed warfarin. ¹
** Recurrent VTE when warfarin therapeutic	0.0090	0.0055–0.0387	Systemic review of outcomes among patients prescribed warfarin. ¹
Death from VTE within 3 months of prior VTE	0.095	0.02–0.12	Linear Interpolation of the 1 month probability (0.075) and 3 month probability (0.184) for 50–59 year age group from Quebec VTE study which is an epidemiologic study which followed 65,000 individuals with incident VTE. ²
Death from VTE month 4 and beyond after initial VTE	0.025	0–0.1	CA state database analysis looking at the death from VTE in individuals surviving first 6 months assumes no change from month 4 to month 7. ³
Death from all causes	0.0024	0–0.000888	CDC Life table for white males. Used white male given that baseline rates were calculated for recurrence in white males in CA state. ⁴
Major hemorrhage is intracranial	0.42	0.05–0.4	Based on 15,300 person-years of warfarin exposure from Anticoagulation and Risk Factors In Atrial Fibrillation (ATRIA). Study of patients insured by Kaiser Northern California. ⁵
Odds Ratios			
** Health Reform protecting against subtherapeutic warfarin level for the newly insured compared with pre-reform Free Care	0.78	0.5–0.95	Based on multinomial model using clinical data warehouse adjusting for secular changes in the constantly insured. * Using this odds ratio, for the base case, we found that in 20% of anticoagulation episodes, patients newly insured through Health Reform had subtherapeutic warfarin levels.
** Health Reform protecting against supratherapeutic warfarin level for the newly insured compared with pre-reform Free Care	0.99	0.8–1.2	Based on multinomial model using clinical data warehouse adjusting for secular changes in the constantly insured. *
Relative Risks			
Major hemorrhage when warfarin subtherapeutic compared to therapeutic	1.3	0.5–1.5	Systematic review that meta-analyzed studies reporting risk of hemorrhage in individuals with VTE being treated with warfarin. ¹
Major hemorrhage when warfarin supratherapeutic compared to therapeutic	5.4	2.0–10.0	Systematic review that meta-analyzed studies reporting risk of hemorrhage in individuals with VTE being treated with warfarin. ¹
** Recurrent VTE when warfarin subtherapeutic compared to therapeutic	4.1	2.2–8.0	Systematic review that meta-analyzed studies reporting risk of hemorrhage in individuals with VTE being treated with warfarin. ¹
Recurrent VTE when warfarin supratherapeutic compared to therapeutic	0.6	0.22–1.0	Systematic review that meta-analyzed studies reporting risk of hemorrhage in individuals with VTE being treated with warfarin. ¹

Parameter List	Baseline Estimate	Range for Sensitivity Analysis [£]	Comments/Citations
Recurrent VTE when not anticoagulated compared to anticoagulated	2.0	1.0–4.0	Value based on expert opinion of the authors.
Utilities (yearly utility)			
Well	1.00	0.92–1.00 ⁶	Tufts CEA Registry ⁷
VTE on anticoagulation	0.99	0.92–1.00 ⁶	Tufts CEA Registry ⁶
VTE no anticoagulation	0.99	0.92–1.00 ⁶	Assuming this is same as utility of VTE given short horizon of five years initially.
Death	0	0 ⁶	Assumed utility of 0 consistent with typical practice. ⁶
Tolls (in QALYs)⁸			
VTE	–0.012	–0.02 to –0.005	Average LOS for Medicaid patients 4.4 days. ⁸
Non intracranial bleed	–0.013	–0.2 to 0	Average LOS for Medicaid patients 4.8 days. ⁷
Intracranial bleed	–0.016	–0.1 to –0.005	Average LOS for Medicaid patients 5.8 days. ⁷
Cost^{//}			
Yearly cost of insuring those on Free Care	3230	0–10,000	Massachusetts Taxpayers' Foundation. ⁹
Non-intracranial bleed admission to hospital	15,130	5,000–25,000	Average admission cost Medicaid insured individuals hospitalized in MA aged 45–64 2011 HCUP. ⁷
Intracranial bleed admission to hospital	15,565	5,000–50,000	Average admission cost Medicaid insured individuals hospitalized in MA aged 45–64 2011 HCUP. ⁷
** VTE admission to hospital	9,578	5,000–20,000	Average admission cost Medicaid insured individuals hospitalized in MA for DVT or PE aged 45–64 2011 HCUP. ⁷
Death from VTE	9,578	5,000–20,000	VTE hospitalization used. ⁷
Anticoagulation initial three months	1,220	500–2,000	Derived from analysis by Lin et al using Medicare reimbursement data. ¹⁰
** Anticoagulation month 4 and beyond	231	100–500	Derived from analysis by Lin et al. using Medicare reimbursement data. ⁹
MA state cost for VTE hospitalizations over one year	1.25×10^6	n/a [¥]	Using HCUPnet 2011 database for adults aged 45–64 on Medicaid. ⁷
MA state cost for all hospitalizations over one year	3.91×10^8	n/a	Using HCUPnet 2011 database for adults aged 45–64 on Medicaid. ⁷
** %MA state total costs attributable to VTE	0.2%	0.1–1.0%	Ratio of two above rows for cost of VTE divided by cost of all hospitalizations

Abbreviations: VTE = Venous Thromboembolism; CA = California; CEA = Cost-Effectiveness Analysis; QALY = Quality-Adjusted Life Year; LOS = Length of Stay; USD = United States Dollar; MA = Massachusetts; DVT = Deep Vein Thrombosis; PE = Pulmonary Embolism; HCUP = Healthcare Cost and Utilization Project.

[£]We constructed ranges based on plausible values for a given parameter. The citation used for the base case estimate generally informed our selection of the range.

**Denotes an influential parameter included in Figure 2.

*Data warehouse includes clinical data from electronic medical record and billing data for patients seen at Boston Medical Center and affiliated health centers

To calculate this probability we must convert the percentage of patients subtherapeutic if free care into a rate and then convert the odds ratio to a risk ratio and then multiply those two values. That results in a rate that we must then convert back into a probability.

[†]Values chosen for this value and others in the table are not specifically those on Free Care or those without insurance as would be desired for the pre-reform context. Such data does not exist readily.

[§]Computed by subtracting days lost in the hospital (using length of stay data from nationwide inpatient sample) from total number of days in cycle (i.e. 365/4).

^{//}All costs converted to 2014 USD based on the medical care CPI from the Bureau of Labor Statistics.¹¹

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