

Supplementary Material*

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- I. Additional Modeling Details**
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- III. Physician Compensation**
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* This supplementary material was provided by the authors to give readers further details on their article. The material was reviewed but not copyedited.

Supplement

A Cost Analysis of the American Board of Internal Medicine's Maintenance-of-Certification Program

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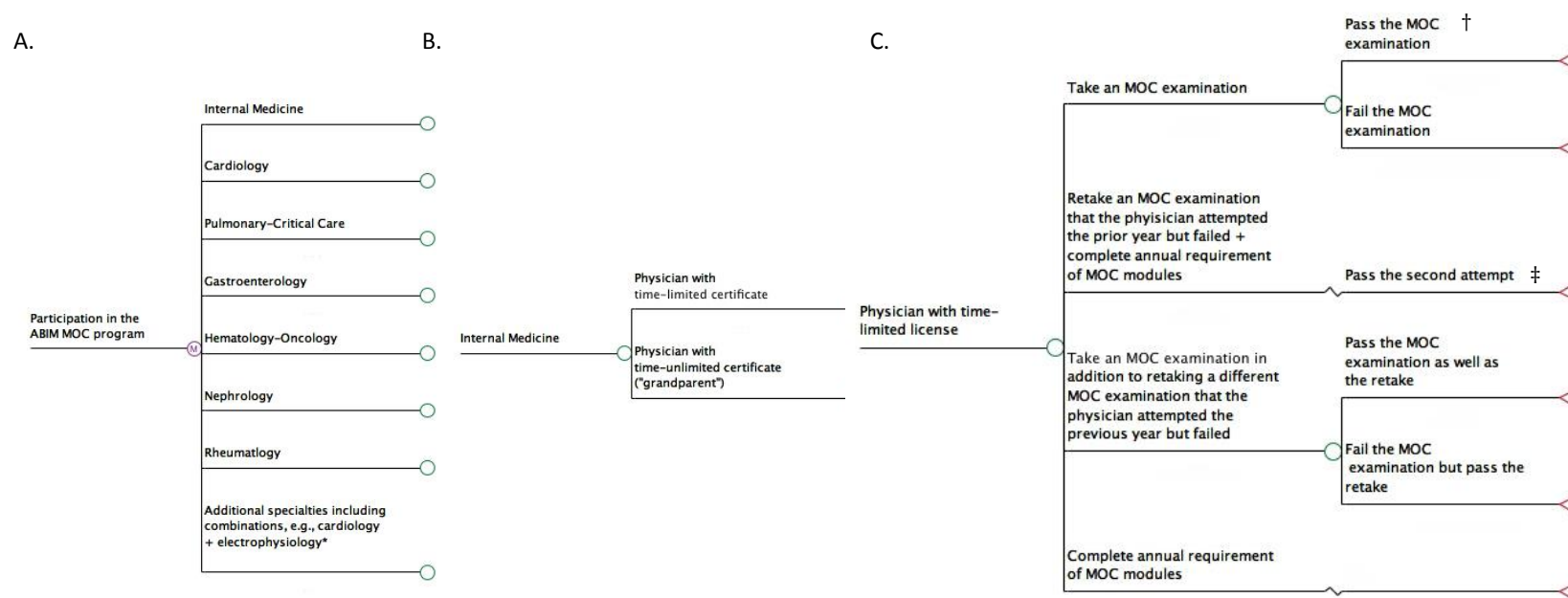
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I. Additional Modeling Details

- We developed a discrete-time Markov model of the entire cohort of ABIM-certified internists, hospitalists, and subspecialists in the United States (Supplement Figure 1). MOC-related testing costs (annual fees payable to ABIM) and time costs (monetary value of physician time spent on MOC) were estimated in one-year cycles, and timing of these costs was accounted for by using a 3% annual discount rate. We used a societal perspective and a 10-year analytic horizon.
- We utilized Monte Carlo microsimulations to estimate the individual variability in MOC costs. For each specialty, we performed 10,000 simulations of individuals through the decision model. Each simulation drew a random value for physician wage and the number of hours that the physician would spend annually on MOC from pre-specified statistical distributions (Supplement Table 1). This process was repeated 10,000 times for each certification, generating 10,000 estimates of MOC-related costs over a ten-year time period. The 2.5th and 97.5th percentile values were used to construct our 95% confidence intervals.
- We also performed 10,000 probabilistic simulations per specialty to estimate the distribution of cumulative costs by specialty. Each simulation drew a value of mean physician wage in that specialty and the mean number of hours spent on MOC annually from pre-specified statistical distributions (Supplement Table 1). The process then used expected value calculations for estimating the cumulative cost of MOC for that specialty using those estimates of mean wage and time spent on MOC. This process was repeated 10,000 times for each specialty, generating 10,000 estimates of MOC-related costs. The 2.5th and 97.5th percentile values were used to construct our 95% confidence intervals.

Supplement Figure 1. Schema of Decision model. We modeled the entire cohort of board-certified internists, hospitalists, and internal medicine subspecialists in order to evaluate the economic impact of the American Board of Internal Medicine's Maintenance of Certification (MOC) program (Panel A), including physicians who currently hold time-limited licenses and those who hold time-unlimited licenses ("grandparents", Panel B). In any year, a physician can take an MOC examination or complete MOC modules. A certain proportion of physicians who take the MOC examination will fail their initial attempt; we assumed these physicians would retake the examination the following year and pass on the second attempt (Panel C). Physicians holding multiple board certifications (e.g., pulmonary, critical care, and sleep) would take multiple MOC examinations over the 10-year analytic horizon of the model. All testing and time costs were discounted at 3% per year.



*A physician may need to take as many as three recertification examinations (e.g.; internal medicine, cardiology, and cardiac electrophysiology).

† We modeled specialty-specific pass rates for each recertification examination.

‡ We modeled only one repeat examination per specialty for a physician who fails an initial attempt at a recertification examination.

II. Number of Physicians and Physician Characteristics

- The ABIM periodically publishes a summary of the number of valid certifications by specialty (1). However, ABIM does not release the number of clinically active physicians (given some have likely retired) or the number of physicians holding more than one certificate (e.g. a cardiologist who retains her internal medicine certification). Furthermore, ABIM does not release details regarding atypical combinations of certificates (e.g. number of cardiologists also certified in critical care). ABIM declined our request for additional data (personal communication).
- We used publicly available data to model the entire cohort of board-certified internists and subspecialists in the United States. We estimated the number of physicians with active certifications based on the following: (a) the total number of valid certificates (1) (b) the number of candidates certified annually by the ABIM since 1980 and assuming a 35-year professional career (2); (b) the assumption that certificates between 1970 and 1979 contain a combination of valid certificates of retired physicians (70%) and physicians who are deceased (30%) (3,4); (d) the percentage of time-limited physicians in each specialty who were also enrolled in the internal medicine MOC program in 2014 (5); and (e) specific rules regarding requirements for subspecialty certifications (e.g., diplomates in cardiovascular electrophysiology and interventional cardiology are currently required to retain their certification in cardiology but the internal medicine certification is optional). Physicians certified in adolescent medicine, hospice medicine and sports medicine are required to maintain a second certification; we made the simplifying assumption that the second certificate was in internal medicine (6). We assumed that some proportion of physicians certified in sleep medicine were also board-certified in pulmonary medicine, while the remainder was certified in pulmonary medicine and critical care. We assumed that the ratio of physicians certified in sleep and pulmonary medicine to those certified in sleep, pulmonary medicine, and critical care was identical to the ratio of physicians certified in pulmonary medicine (without sleep medicine) to those certified in pulmonary medicine and critical care (without sleep medicine). These data are presented in Supplement Table 1.
- Physicians who were first certified in internal medicine or its subspecialties before 1990 were issued time-unlimited certificates (“grandparents”), and did not have any MOC requirements under 2013 MOC (7). Critical care and geriatric medicine have had time-limited certification since inception in 1987 and 1988, respectively. Under the 2015 MOC program, participation of grandparents in

MOC remains optional, but those who choose not to enroll in MOC would be labeled as “not participating in MOC” on the ABIM website (8).

- ABIM does not publish the number of physicians with active time-unlimited licenses. We estimated the number of grandparents currently in the workforce based on the number of certifications issued in the years prior to 1990 (3), assuming an average 35-year medical career. The proportion of grandparents currently enrolled in MOC is not publicly available. By May 2014, 21% of physicians with time-unlimited licenses had enrolled in MOC; there have been no further updates on grandparent enrollment (9). In our base case, we assumed that all grandparents who expect to be in the workforce for five or more years (i.e., are at least five years away from retirement) would participate in MOC (~53% of all grandparents). In sensitivity analyses, we vary the fraction of the physicians with time-unlimited certificates who choose to participate in MOC from 21% (assuming no additional enrollment since May 2014) to 100% (assuming all grandparents enroll). In each scenario, we modeled decreasing proportions of grandparents over the ten-year period based on their timing of their initial certification and a 35-year career. Note that assuming that fewer grandparents enroll does not materially affect the total cost to the individual physician but lowers cumulative costs.

Table 1. Physician Characteristics*

Specialty	Number of Physicians	Number of Grandparents	Wage (\$)	Annual Wage (\$)†	Total Hourly Compensation (\$)‡	Standard Error (\$)	Standard Deviation (\$)
General internal medicine physicians	144,013	26,065	91.60	190,528	122.74	2.09	38.38
Hospitalists	679	0	97.76	203,334	130.99	2.23	32.46
General cardiologists	15,418	6,891	170.29	354,211	228.19	3.88	62.71
Interventional cardiologists	6,003	0	207.18	430,938	277.62	4.72	84.87
Cardiac electrophysiologists	2,318	0	210.17	437,154	281.63	4.79	95.22
Advanced heart failure cardiologists	815	0	170.29	354,211	228.19	3.88	62.71
Endocrinologists	6,027	1,438	87.23	181,446	116.89	1.99	34.85
Gastroenterologists	12,787	3,524	188.31	391,681	252.33	4.29	84.24
Hepatologists	559	0	138.03	287,108	184.96	3.14	28.5
Geriatricians	4,640	0	82.50	171,590	110.54	1.88	33.58
Hematologists	1,188	264	169.93	353,446	227.7	3.87	76.83
Oncologists	6,411	1,798	185.46	385,747	248.51	4.22	80.71
Hematologists and oncologists	5,678	1,263	169.93	353,446	227.7	3.87	76.83
Hospice and palliative care physicians	4,170	0	77.02	160,198	103.2	1.75	23.71
Infectious disease physicians	7,337	1,571	94.07	195,669	126.06	2.14	38.57
Nephrologists	9,019	1,808	126.69	263,514	169.76	2.89	62.8
Pulmonologists	2,646	1,344	129.93	270,256	174.11	2.96	50.01
Critical care medicine physicians	1,877	0	142.51	296,428	190.97	3.25	45.04
Pulmonologist and critical care medicine physicians	8,086	0	147.18	306,138	197.22	3.35	57.04
Pulmonologist and sleep medicine physicians	1,458	0	117.90	245,233	157.99	2.69	47.93
Pulmonologist, critical care	2,094	0	117.90	245,233	157.99	2.69	62.71

medicine and sleep medicine							
Physicians							
Rheumatologists	4,893	1,568	98.94	205,786	132.57	2.25	42.03
Adolescent medicine physicians	39	0	71.83	149,400	96.25	1.64	23.49
Sports medicine physicians	201	0	103.24	214,749	138.35	2.35	40.91

* Estimated; see text for details

† Average annual wage was calculated from the wage rate and an estimate 2,080 work week from BLS. The average annual wage was not used to calculate results for our analysis (except as displayed in Figure 2 in the manuscript) and is only provided to contextualize the hourly wage

‡ Total hourly compensation = Hourly Wage + Benefits. In the base case, we assumed a benefits rate of 34% of wage. See text for details.

III. Physician Compensation

- We estimated the wage of the general internist based on data from the Bureau of Labor Statistics (BLS) Occupational Employment Statistics (10). Next, we estimated the wage of subspecialists by multiplying the wage of the general internist from BLS with wage ratios for internal medicine subspecialties from the Medical Group Management Association (MGMA) Physician Compensation and Production Survey (a survey of 60,100 providers in more than 170 specialties across the United States, (11)). See Supplement Table 1 for details.
- The BLS estimates of wage are “straight-time, gross pay, exclusive of premium pay, and include base rate, cost-of-living allowances, guaranteed pay, and incentive pay, but exclude overtime pay, severance pay, shift differentials, nonproduction bonuses, and employer cost for supplementary benefits” (12). The cost of benefits was estimated at 34% of wage (the ratio of employer benefit costs excluding paid leave to wages (13)). Physicians who are employed (rather than self-employed) receive paid leave and therefore have higher benefits-related costs. In sensitivity analyses, we examine the impact of varying the cost of benefits from 0% (no benefits) to 50% of the wage.
- We assumed wages are normal distributed, and used the relative standard error reported in BLS surveys to construct the 95% confidence intervals for the specialty- and subspecialty-specific mean wage for the cumulative analyses. For the analyses estimating costs to individual physicians, we modeled individual variability in wage. BLS does not provide estimates of standard deviation; we therefore used the relative standard deviation (standard deviation as a percent of mean wage) in the MGMA surveys and applied them to our calculated mean wages. We truncated the normal distribution to its 95% confidence interval to avoid negative wages. Detailed wage-related input parameters, i.e., mean hourly wage by specialty, mean hourly total compensation (wage + 34% benefits), standard error of the hourly wage (to estimate the distribution of the population mean for analyses of cumulative costs by specialty), and standard deviation of the hourly wage (to estimate the distribution of the wage for individual physicians) are shown in Supplement Table 1.
- BLS estimates that the average number of hours worked in a year = 40 hours per week*52 weeks = 2080 hours. This number did not directly enter the model and does not affect the total cost of MOC, but we use this in two places to contextualize our results. In Supplement Table 1 and Figure 2, we multiply

hourly wage by 2080 hours per year to estimate total annual compensation before benefits.

IV. Recertification Examinations

- We assumed that current specialty-specific pass rates for recertification examinations would continue (14). Physicians who failed an initial attempt at the recertification examination would retest the following year and pass on this second attempt. This is a simplifying assumption: ABIM's data suggest that while the vast majority of physicians will pass the examination in one or two attempts, a small minority of physicians will require more than two attempts. We did not model the minority of physicians who do not pass the examination after multiple attempts and who would, in the real world, face the following consequences: physicians with time-unlimited certificates would be listed on the ABIM website as "not meeting MOC requirements" and, physicians with time-limited certificates would eventually have a lapse in certification. Our simplifying assumption therefore underestimates MOC-related costs for the small group of physicians who will need three or more attempts to pass the recertification examination.
- For internal medicine subspecialties where recertification pass rates are not available because the specialty certification has existed for less than ten years, we applied the pass rate for the general internal medicine exam (14). Similarly, for cardiovascular and gastroenterology subspecialties for which recertification pass rates are not available, we applied the pass rates for the general cardiology and gastroenterology recertification exams respectively (14).
- In the base case, we assumed that physicians spend a total of 37.5 hours preparing for and taking the examination (three times as long as it would take to complete one MOC module), with an additional 4.5 hours for registration, documentation, and travel. Given that the examination itself is of 8-10 hours, this is likely an underestimate of the total time spent on the examination. Furthermore, we did not model the tuition fees and time costs related to board review courses that many physicians take in preparation for a recertification examination. These alone can add up to several thousand dollars in a ten-year cycle.

V. MOC Modules

- In the 2015 MOC, physicians are required to complete 100 MOC points in 5 years, with “at least some MOC activity every two years (6,15). We assumed physicians would aim to complete 20 points a year, thus spreading out the workload evenly, with the exception of recertification examinations, which must be taken every ten years. We modeled that each first attempt at a recertification exam would meet one year of requirements (20 points) in the 2015 program.
- Physicians receive 20 MOC points for each recertification exam in a 10-year period (6). Thus physicians holding one, two, and three certificates receive 20, 40, and 60 MOC points respectively for taking the examination(s), and need an additional 180, 160, and 140 MOC points respectively to meet their MOC requirements over a 10-year period. These additional MOC points are obtained by completing ABIM MOC modules.
- In the 2013 MOC, the majority (74%) of providers waited until the ninth year of the ten-year program prior to preparing any components of the MOC program (16) We therefore modeled that physicians perform their 100 MOC points in the same year as their recertification exam in a ten year cycle. For physicians with multiple certifications, we modeled that they completed all of their MOC in an exam year, which we assumed was their first exam of a ten-year cycle.
- We assumed a physician would spend 12.5 hours each year on the MOC modules (mid-point of the range of 5 to 20 hours estimated by ABIM) (17,18). We assumed that the number of hours required for MOC annually followed a normal distribution with the range of 5-20 hours representing a 95% CI and a mean of 12.5 hours. This was based on ABIM estimates of the number of hours required to complete MOC annually in non-test years. We utilized a truncated normal distribution, not allowing values less than 5 hours or greater than 20 hours.
- In addition to the time required to complete MOC modules, we assumed that physicians would need additional time to select the activity, prepare for the activity, and complete relevant documentation to obtain MOC credit. We assumed that this would take 1.5 hours for each MOC module.

VI. Testing Costs and Time Costs

- Physicians have the choice of paying their MOC fees to ABIM as a lump sum (for a decade) or in ten annual interest-free installments (6,15). We assumed that physicians would choose to pay their dues in annual installments.
- Time costs captured the market value of the time physicians spent completing MOC and related documentation. The alternative use of this time, i.e., whether the time spent on MOC would have otherwise been spent on additional clinical work or leisure, is not theoretically relevant to determining its economic value, which is assumed to be at least equal to wage rate plus benefits. The intuition is as follows: a physician has a choice of spending one hour of her time on clinical work or on leisure. If she chooses to spend that hour on clinical work, she gets remunerated at the rate of her hourly wage plus benefits. If she chooses to use that hour for leisure instead, she foregoes the hourly wage and benefits – this suggests that she values that hour spent on leisure at least as much as her hourly wage and benefits. In economics terminology, the marginal value of leisure is equal to or greater than the wage plus benefits. We modeled the value of physician's time as being equal to the hourly wage plus benefits in the base case, and tested this assumption in a sensitivity analysis by varying the value of a physician's MOC time at 75% through 125% of the value of her clinical time.

VII. Obtaining MOC Credit for Continuing Medical Education (CME) Activities

- A key concession made by ABIM in February 2015 is that physicians can now earn MOC points from CME activities that they were already undertaking (19). ABIM's only guidance on this issue has been that it will recognize "CME activities for which there is evidence that they drive learning and/or change practice" and "many forms of passive CME do not meet that standard" (8). The Accreditation Council for Continuing Medical Education publishes summary data on the kinds of CME activities physicians undertake (Supplement Table 2) (20). Several of the categories of CME activities listed in Supplement Table 2 such as enduring materials (e.g. American College of Physicians' MKSAP) and in-person courses (e.g., a professional society's annual meeting) already offer MOC or are likely to do so in the future. However, the dominant form of CME nationally is participation in "regularly scheduled series" such as grand rounds, tumor boards, and morbidity and mortality conferences, accounting for 75% of physician-hours (20). These do not typically offer MOC points and are unlikely to do so in the near future. In the base case, we assumed that 25% of CME activities earn MOC credit, and varied this parameter in sensitivity analyses from 0% (equivalent to the 2014 MOC) to 50% (a high degree of integration that is possible but unlikely).
- In order to estimate the MOC credit that a physician could obtain from pre-existing CME activities under the 2015 MOC, we used state-specific CME requirements (21) weighted by the number of active physicians in each state. For instance, if a board-certified physician was required to perform 100 CME credits under the 2013 MOC, we assumed that a quarter of these CME credits would also earn MOC points in the 2015 MOC.
- The ABIM website currently lists a maximum of 10 AMA PRA Category 1 Credit per medical knowledge module and 10 MOC points, and most ABIM practice improvement modules are listed as providing a maximum of 20 AMA PRA Category 1 Credits and 20 MOC points (22,23). Therefore, we assumed that accredited CME activities would provide an equivalent number of MOC points.
- Increases in the proportion of CME activities that generate MOC credit decrease the additional time that must be dedicated to complete MOC modules. As the proportion of CME activities that also generated MOC credit increased (from a base case of 25%), the number of MOC modules and, by extension, the time required to complete them, declined exponentially. Supplement Figure 2 shows this exponential relationship for physicians with one-, two-, and three-

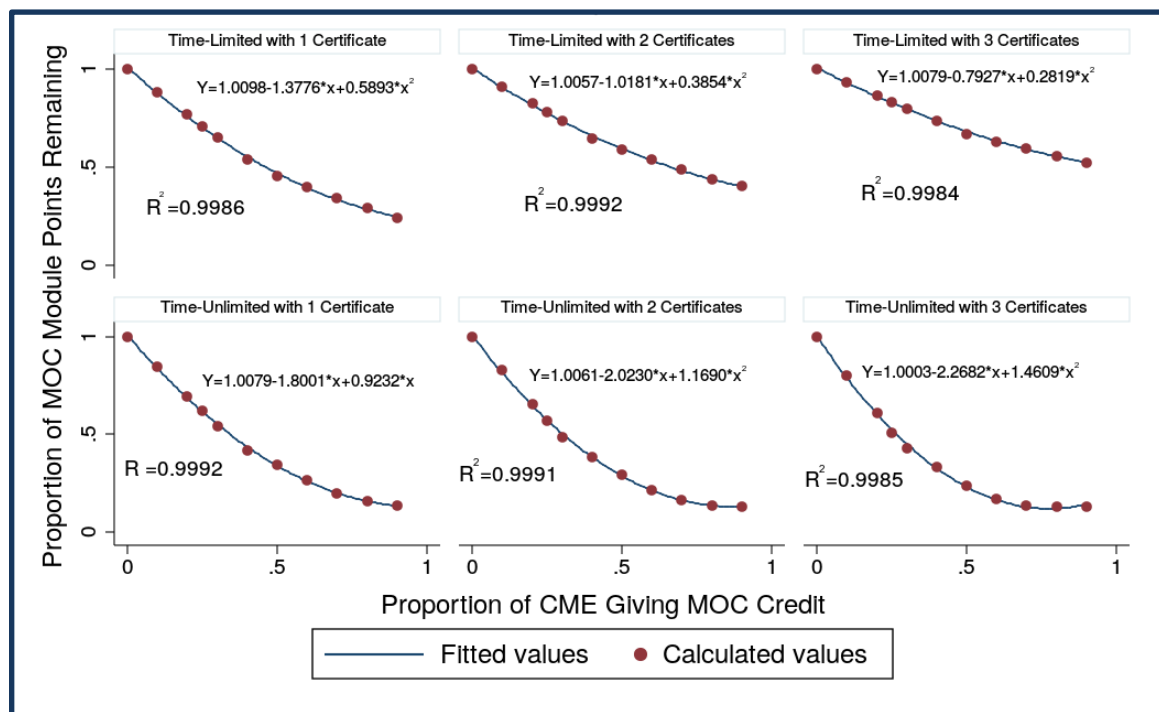
certificates in time-limited and time-unlimited physicians ($R^2 > 0.99$ for all six curves). We incorporated this exponential relationship into the model and performed sensitivity analyses to examine the impact of varying the proportion of CME activities that generate MOC credit.

Supplement Table 2. Continuing Medical Education Activities Approved by the Accreditation Council for Continuing Medical Education

CME Category	Examples	Proportion of Physician Participants (calculated)	Proportion of Physician-Hours (calculated)
Regularly Scheduled Series	Grand rounds, Tumor Boards, Morbidity and Mortality Conferences	33.4%	75.5%
Courses (In-person)	Annual meeting, conferences, seminar	14.8%	9.0%
Internet (Live)	Real-time online course	0.6%	0.1%
Test-Item Writing	Board exams, medical school exam	0.01%	0.01%
Committee Learning	Involvement in a committee with topic that would be taught in other scenarios	0.1%	0.01%
Performance Improvement	Measure performance, improve deficiency with education, integrate to practice, recheck performance	0.5%	0.8%
Internet Searching and Learning	Identify a problem in practice and search online; point-of-care learning	1.1%	1.1%
Internet (Enduring Materials)	Interactive educational module, podcast, recorded presentation	31.2%	6.2%
Enduring Materials	MKSAP	9.7%	5.6%
Learning from Teaching	Teaching activities	0.03%	0.04%
Journal CME	Read article, reflect or discuss, and complete questions	8.4%	1.4%
Manuscript Review	Pre-publication review of journal articles	0.3%	0.1%

* Source: http://www.accme.org/sites/default/files/630_20140715_2013_Annual_Report.pdf (20)

Supplement Figure 2. Association Between MOC Requirements and the Proportion of Current CME Activities that Earning MOC Credit. As the proportion of current CME activities that earn MOC credit increases (x-axis), the proportion of additional MOC module points that the physician must complete to meet MOC requirements declines exponentially. This relationship holds (with R^2 values >0.99) both for physicians with time-limited and time-unlimited licenses, independent of whether they have one, two, or three certifications. These equations were built into the model to allow sensitivity analyses to examine the impact of the increasing or decreasing the proportion of CME activities that earn MOC credit. .



VIII. Sensitivity Analyses

- We performed deterministic and probabilistic sensitivity analyses to explore the impact of uncertainty in the input parameters.
- In one-way sensitivity analyses, we examine the impact of varying one input parameter while holding all others constant (Figure 1). The sensitivity analyses presented there include:
 - The annual number of hours required for MOC (base case: 12.5, range: 5-40)
 - The hours required for MOC documentation (base case: 1.5 per module, range: 0.75-3)
 - The proportion of grandparents enrolling in MOC (base case: all expecting to be in the workforce for five or more years ~53%, range: 21-100%)
 - The percentage of CME activities that also earn MOC credit (base case: 25%, range: 0-50%).
 - The value of physician time required for MOC (base case: 100% of hourly wage + benefits; range: 75%-125%)
 - The annual change in real (inflation-adjusted) change in physician income over the study period (base case: 0%, range: -3%-3%)
 - Discount rate (base case: 3%, range: 0-5%).
- Figure 2 in the manuscript represents a three-way analysis of the total costs of the 2015 MOC program for internists while simultaneously varying (a) the number of hours of MOC required annually, (b) the number of certificates, and (c) the physician wage.
- Finally, a probabilistic sensitivity analysis of the total cost of MOC for an individual internal medicine physician is presented below. This was run as 100,000 microsimulations through the model with per-trial sampling of the following variables: hours of MOC, the physician wage, the number of hours of documentation required, the relative number of hours required in an exam year, real wage changes for physicians, the relative value of physician time compared to wages, and the percentage of CME giving MOC credit. Supplement figure 3 demonstrates the probability the MOC-related costs for an individual physician (y-axis) will exceed a certain threshold (x-axis) accounting for variability in model parameters. Supplement Table lists the statistical distributions used in this analysis.

Supplement Table 3. Distributions Parameters

Variable	Distribution	Mean	Standard Deviation	Range
Hours required to complete annual requirement of MOC modules in a non-exam year	Normal	12.50	3.83	5 to 20
Proportion of CME that also earns MOC credit	Normal	0.25	0.13	0 to 0.5
Number of hours spent on MOC-related documentation	Normal	1.50	0.38	0.75 to 2.25
Ratio of MOC Hours in an exam year to a non-exam year	Normal	3	0.77	1.5 to 4.5
Relative value of physician MOC time compared with clinical time	Normal	1	0.13	0.75 to 1.25
Physician wage (individual analyses)	Normal	Specialty-specific*	Specialty-specific standard deviation*	Specialty-specific*
Physician wage (cumulative analyses)	Normal	Specialty-specific*	Specialty-specific standard error*	Specialty-specific*

* See Supplement Table 1 for specialty-specific wage (mean, standard deviation, and standard error).

IX. Additional Results

Supplement Table 4. Incremental Costs of ABIM Maintenance-of-Certification over Ten Years (2015-2024)*

Specialty	Incremental Cost of 2015 MOC, Individual Physician (US dollars) †			Incremental Cost of 2015 MOC, Aggregated by Subspecialty (US dollars, millions) †		
	Testing Costs, Mean (95% CI)‡	Time Costs, Mean (95% CI)§	Total Costs, Mean (95% CI)¶	Testing Costs‡,¶	Time Costs, Mean (95% CI)§	Total Costs, Mean (95% CI)¶,**
All internal medicine physicians	638 (-121–3102)	4404 (403–25 653)	5042 (761–28 414)	146	1,075 (568–1,574)	1,221 (714–1,719)
General internal medicine physicians and hospitalists	341 (-131–1705)	3432 (460–15 651)	3772 (606–17 402)	42	458 (250–661)	500 (293–704)
Subspecialists	1068 (289–3479)	5850 (312–38 041)	6918 (1096–41 488)	103	617 (319–912)	721 (422–1,015)
Cardiologists	1307 (337–3490)	8707 (409–45 061)	10 014 (1431–48 448)	29	208 (107–308)	237 (136–337)
General cardiologists	1495 (289–3490)	12 571 (1036–50 910)	14 066 (1642–54 388)	19	167 (85–248)	187 (104–267)
Interventional cardiologists	1035 (646–1248)	3244 (229–9141)	4279 (1288–10 152)	7	27 (15–39)	34 (22–46)
Cardiac electrophysiologists	1026 (607–1248)	3222 (172–9543)	4248 (1206–10 590)	3	11 (6–15)	13 (8–18)
Advanced heart failure cardiologists	1040 (701–1248)	2650 (195–7410)	3690 (1260–8406)	1	3 (2–4)	4 (3–5)
Endocrinologists	1046	4075	5120	6	23	29

	(279–3490)	(420–22 648)	(1039–25 870)		(12–34)	(18–40)
Gastroenterologists and hepatologists	1127 (279–3490)	9617 (609–53 084)	10744 (1320–56 295)	13	119 (61–175)	132 (75–188)
Gastroenterologists	1123 (279–3490)	10 027 (701–55 819)	11 150 (1330–59 007)	13	117 (61–173)	130 (73–186)
Hepatologists	1028 (588–1248)	2042 (169–5200)	3070 (1183–6183)	1	2 (1–2)	2 (2–3)
Geriatricians	689 (299–804)	1654 (303–4228)	2344 (951–4938)	3	10 (5–14)	13 (9–17)
Hematologists and oncologists	1069 (289–4592)	6045 (221–44 236)	7115 (1158–48 523)	9	57 (30–84)	67 (40–94)
Hospice and palliative care physicians	672 (147–804)	1440 (412–3444)	2111 (924–4158)	3	8 (4–11)	11 (7–14)
Infectious disease physicians	952 (299–3479)	3621 (376–22 476)	4573 (1028–25 690)	6	25 (13–37)	31 (19–43)
Nephrologists	874 (269–3,479)	4403 (124–27 091)	5278 (816–30 192)	7	39 (20–56)	45 (27–63)
Pulmonary, critical care, and sleep medicine physicians	1,031 (368–3,102)	2992 (175–15 153)	4023 (1191–18 273)	17	58 (31–85)	75 (48–102)
Rheumatologists	994 (269–3,479)	4247 (397–24 512)	5241 (1006–27 650)	4	18 (9–26)	22 (13–30)
Other††	672 (147–804)	1844 (387–4676)	2516 (978–5403)	0	1 (0–1)	1 (0–1)

ABIM = American Board of Internal Medicine; CI = confidence interval.

* Incremental Costs = Cost of 2015 MOC – Cost of 2013 MOC.

† Values may not be exact due to rounding. Costs are in 2015 U.S. dollars, and future costs are discounted at 3% per year.

‡ All fees payable to the American Board of Internal Medicine for participation in the MOC program, including recertification examinations, retesting after a failed initial examination, and access to MOC modules.

§ Value of physician time dedicated to meeting MOC requirements. In the base case, this was assumed to equal the hourly wage plus the cost of fringe benefits.

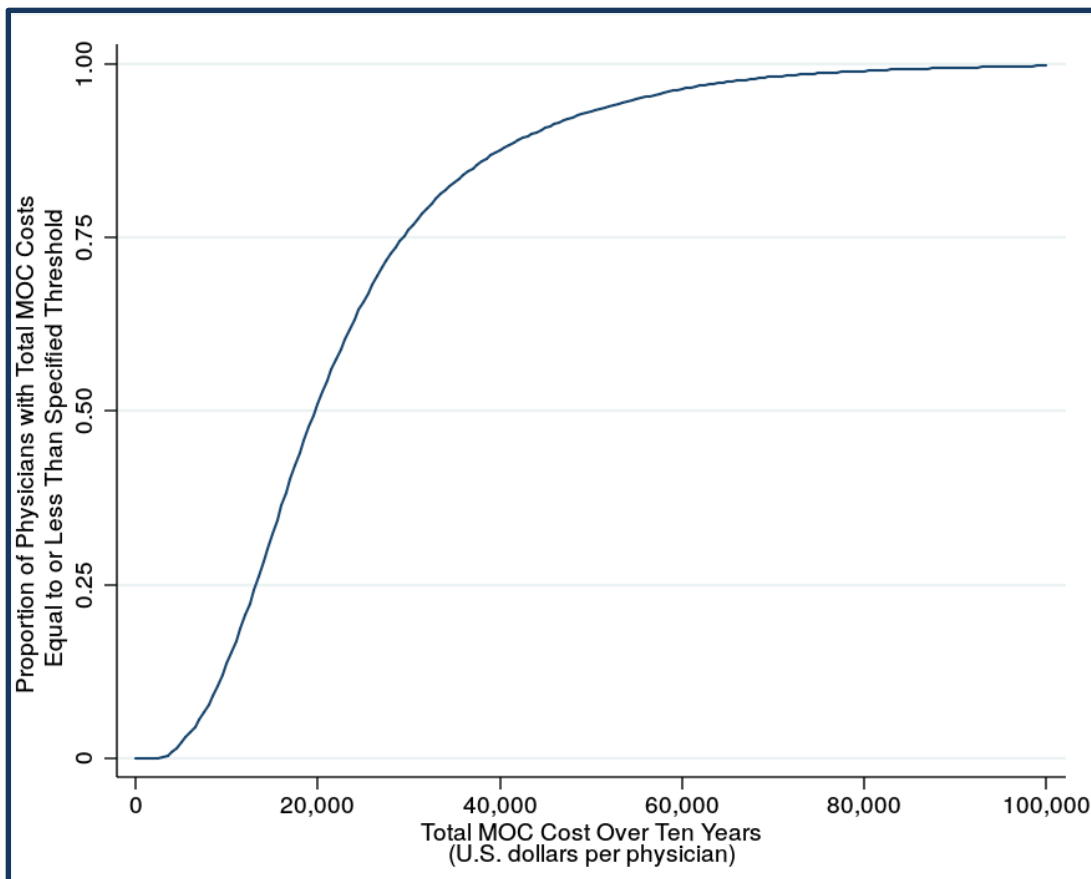
|| Testing costs plus time costs.

¶ Confidence intervals not available for aggregate testing costs because MOC fees are precisely defined for a given group of physicians.

** $p < 0.001$ for comparisons of total costs under the 2015 MOC with total costs under the 2013 MOC.

†† Includes adolescent medicine physicians and sport medicine physicians.

Supplement Figure 3. Individual Variability in Total Maintenance-of-Certification (MOC) Costs over Ten Years. For this analysis, we modeled 100,000 microsimulations through the model while simultaneously (and probabilistically) varying several input parameters.* The graph below shows that there is substantial individual variability in MOC costs, with half the physicians in the cohort facing MOC (discounted) costs of more than \$20,000 over ten years.†



*Parameters varied for this analysis: Hours required for MOC each year, wage, proportion of current continuing medical education activities that also earn MOC credit, hours required for documentation of MOC activities, total time required for preparing for and taking a recertification exam, annual change in real physician wage, and value of a physician's MOC time relative to clinical time.

† Costs in 2015 U.S. dollars. Future costs are discounted at 3% a year.

X. Technical/Coding Details Regarding TreeAge Model

In order to allow the cohort of ABIM-certified physicians to change over the duration of the study, the TreeAge model is designed to be dynamic. By definition, dynamic models require non-coherent probabilities at chance nodes (i.e., transition probabilities at a chance node may not equal 1). For additional details and an illustrative example of a dynamic model, please see page 506 of the TreeAge 2014 user manual:

<http://installers.treeagesoftware.com/treeagepro/15.1.0/20150102/TP-Manual-TP2015.pdf>

The model has been coded so that it can run a large number of different analyses (e.g., individual or aggregate costs by subspecialty or number of board certifications). The TreeAge model is available to interested readers upon request.

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