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Primary Care Physician Shortages Could Be Eliminated Through Use Of Teams, Nonphysicians, And Electronic Communication

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ABSTRACT **Most existing estimates of the shortage of primary care physicians are based on simple ratios, such as one physician for every 2,500 patients. These estimates do not consider the impact of such ratios on patients' ability to get timely access to care. They also do not quantify the impact of changing patient demographics on the demand side and alternative methods of delivering care on the supply side. We used simulation methods to provide estimates of the number of primary care physicians needed, based on a comprehensive analysis considering access, demographics, and changing practice patterns. We show that the implementation of some increasingly popular operational changes in the ways clinicians deliver care—including the use of teams or "pods," better information technology and sharing of data, and the use of nonphysicians—have the potential to offset completely the increase in demand for physician services while improving access to care, thereby averting a primary care physician shortage.**

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A consensus exists in the United States that the current shortage of primary care physicians will worsen over the next ten years as the nation's population grows and ages and as insurance coverage expands as a result of the Affordable Care Act.[1–3] Most estimates of required numbers of primary care physicians are based on simple ratios, such as one physician for every 2,500 people. Such estimates attempt to equate the average daily patient demand with the supply of physician appointment capacity.[4] Yet these ratios ignore the issue of timely access to care, which has been widely recognized as an important dimension of health care quality.[5]

The ability to offer patients same-day or next-day appointments has been demonstrated to be generally beneficial by decreasing delays and wasted capacity and increasing patient and physician satisfaction.[4,6] For this reason, "open scheduling," which is also known as "advanced access," was one of seven principles originally used to describe patient-centered medical homes.[7,8]

To achieve such an "advanced access" system, patient panel sizes need to account for the randomness in the daily arrival patterns of patients' requests for appointments. Given this uncertain patient demand, physician supply that simply matches the average patient demand for appointments will result in unacceptably long appointment backlogs. Therefore, patient panel sizes that allow for timely access will probably be smaller than those suggested by many of these simple ratios.[9]

This insight suggests that primary care physician shortages may be worse than predicted. However, it is important to note that the insight also assumes a traditional model of patients being cared for by a single physician.

This type of practice is disappearing as physicians are increasingly joining in group practices and being employed by hospital systems.[10–12]

Data from the 2008 National Ambulatory Medical Care Survey[13] suggest that the proportion of primary care physicians in solo practice dropped from 39 percent in 2003 to 33 percent in 2008. The shift can be attributed to the economic benefit of sharing the administrative burden of dealing with payers, the costs of converting to an electronic health record system,[14] and the trend toward more coordinated and available care in patient-centered medical homes.[15,16]

Another change in the traditional primary care physician model is the increased use of nonphysician professionals such as nurse practitioners and physician assistants. Nurse practitioners now account for 19 percent of the US primary care workforce, and physician assistants account for 7 percent.[17] Several studies have explored these practitioners' ability to handle a sizable portion of primary care visits.[18–20]

In this article we show that estimates of primary care physician shortages can be mitigated or even eliminated by operational practices that are becoming more common. These practices can be adopted even more broadly as physician practices increase in size, medical homes emerge, the use of alternative care providers increases, and health information technology advances.

Our results are based on a simulation study that focuses on calculating patient panel sizes consistent with speedy access to primary care services. The simulation used primary care data from the National Ambulatory Medical Care Survey[13] and data from the Medical Expenditure Panel Survey[21] to estimate patient demand rates and appointment durations.

As we discuss, ensuring timely access to primary care will add to the shortage of primary care physicians that previous estimates have predicted, if physicians practice as solo practitioners in the traditional manner. However, if partial physician "pooling" or what is sometimes called a "shared practice" approach is adopted, patient panels can be greatly increased without compromising timely access to care.

Furthermore, if we include the impact of diverting a fraction of patient appointments to nonphysician professionals or of addressing some of the demand through electronic communication channels, the predicted physician shortage essentially evaporates.

Study Data And Methods

MODELING DEMAND AND SUPPLY IN OUTPATIENT CARE At the center of our analysis is a notion of a "patient panel," a number of patients associated with a physician in a typical practice. We use the term "typical practice" as a convenient model for analysis rather than a reflection of any actual practice of outpatient care.

Clearly, physician practices differ widely in terms of patient panel composition, practicing style, hours, and other factors. Our aim is not to represent any specific practice but rather to demonstrate how timely access to care and the impact of new operational practices affect panel sizes. However, although our analysis focuses on the number of patients that can be handled by an "average" full-time primary care physician, our methods can be easily applied to any specific practice by adjusting the model parameters.

DAILY DEMAND FOR APPOINTMENTS AND APPOINTMENT CAPACITY We considered a full-time-equivalent physician who has a capacity of serving a given number of patient appointments per day (denoted in our analyses by A). Using realistic values of A, we built a simulation model that estimated the patient panel size consistent with timely access to care. The key parameters in our simulation were the patient daily demand probability distribution and the daily appointment slot capacity (A).

To estimate patient demand probabilities, we used data from two sources: the National Ambulatory Medical Care Survey[13] and the Medical Expenditure Panel Survey.[21] The details of our probabilistic model of demand are presented in the online Appendix.[22]

On the supply side, we consider a full-time-equivalent physician who spends forty hours each week seeing patients in the office (eight hours a day, five days a week).[23] In 2008 the average duration of the face-to-face part of a patient visit to a primary care physician was 19.01 minutes for the entire patient population and 19.7 for adult patients, so twenty minutes per visit appears to be the lowest reasonable estimate for the duration of a single patient appointment. This translates into a value of A as twenty-four appointment slots per day.

In some practices, patients are scheduled over a ten-hour day and as often as every fifteen minutes, creating the potential to have as many as forty appointment slots per day. However, in view of physician breaks and interruptions and the need to spend more time with new patients and sicker patients, we adopted a conservative estimate of twenty-eight slots per day as a maximum.

SIMULATION DESCRIPTION Using our model of daily demand for appointments and the number of appointment slots per day, our simulation calculated the probability distribution of the delay that a patient might encounter in obtaining an appointment for any given patient panel size. Our study focused on estimating and comparing patient panel sizes per physician, under various

operational assumptions, that were consistent with achieving a specified level of access, defined as the fraction of patients who are able to get a same-day appointment.

We first considered the traditional solo-practitioner model of primary care. We then demonstrated that allowing for a minimum amount of physician pooling as well as for the use of nonphysician health care professionals or the use of electronic communication, or both, to handle some fraction of physician visits can result in considerably larger patient panels.

Specifically, we answered the following two questions: First, what sizes of patient panels are manageable—that is, compatible with delivering a reasonable level of access to care? Second, how is a manageable patient panel size affected by partial physician pooling in a group practice and by partial diversion of patient demand to other types of care providers or by the use of electronic communications?

To answer these questions, we considered two levels of timely access. The first, defined as "advanced access," assumed that 75 percent of patients would be able to get a same-day appointment. This is consistent with the original concept of advanced access as offering a same-day appointment to anyone who wants one[4] and with data indicating that approximately 25 percent of patients do not desire a same-day appointment.[24]

The second level adopted a more moderate view of timely access by assuming that only patients with a new problem or chronic problem flare-up should get a same-day appointment. According to data from the National Ambulatory Medical Care Survey,[13] 46.4 percent of all primary care visits correspond to these two categories. So we also considered patient panel sizes consistent with the assumption that 50 percent of patients receive a same-day appointment, which we call "moderate access."

Study Results

Exhibit 1 provides the answer to the first question above. It demonstrates the impact of demand variability on patient panel sizes consistent with timely access under three scenarios regarding the number of available appointments per day: twenty, twenty-four, and twenty-eight.

The first value, "matching expected demand," is provided for reference and is calculated by setting the expected daily demand for appointments equal to the daily appointment capacity *A*. Recall that at this patient panel size there is no "slack" appointment capacity to accommodate daily fluctuations in patient demand levels, so delays will grow indefinitely.

The second value, "advanced access," corresponds to the patient panel size that ensures that 75 percent of patients can receive a same-day appointment and is based on our simulation. The third value, "moderate access," also based on our simulation, identifies the panel size consistent with 50 percent of patients' obtaining a same-day appointment.

In the presence of demand uncertainty, patient panel sizes compatible with timely access to care are 5–33 percent smaller than the panel sizes (in the "matching expected demand" row) that ignore this variability (Exhibit 1). We note that the actual panel sizes associated with the moderate-access scenario are likely to be smaller than the estimates shown here, as a result of the increased level of cancellations and resulting wasted physician utilization associated with longer waits for appointments.[6]

To assess the impact of physician pooling and diversion of demand, we ran the simulation comparing the values of "advanced" and "moderate" access for three different settings with respect to the degree of partial physician pooling in a group physician practice and five different settings with respect to the portion of patient requests that can be handled by a nonphysician provider or by electronic communication, for a total of fifteen combinations (Exhibit 2).

In the first, "Solo," setting, patients could be served only by their own physician even if another physician had available appointment slots. In the "Pool 2" setting, we assumed that all patients had a designated primary care physician, but that when they needed immediate care and their physician was not available, they were seen by another designated physician who had access to their medical records and who shared information with their physician.

The "Pool 3" setting operated similarly to "Pool 2" except that there were two other physicians who could see the patients of any given primary care physician. This type of practice is becoming increasingly common.[25]

For example, Crystal Run Healthcare, a National Committee for Quality Assurance–

EXHIBIT 1

Comparison Of Primary Care Practices' Patient Panel Sizes, By Daily Appointment Capacity

	Appointment slots per day		
Appointment capacity	**20**	**24**	**28**
Matching expected demand	2,419	2,902	3,386
Advanced access	1,853	2,315	2,781
Moderate access	2,149	2,624	3,228

SOURCE Authors' analysis. **NOTES** Appointment slots per day are described in the text as *A*. For explanations of "matching expected demand," "advanced access," and "moderate access," see the text.

EXHIBIT 2

"Advanced Access" Patient Panel Sizes Under Varying Degrees Of Physician Pooling And Patient Demand Diversion In Primary Care Practices

Patient diversion fraction/ physician pooling	Patient panel size, by number of appointment slots per day		
	20	24	28
ZERO			
Solo	1,853	2,315	2,781
Pool 2	2,095	2,568	3,044
Pool 3	2,187	2,665	3,143
10 PERCENT			
Solo	2,110	2,626	3,145
Pool 2	2,358	2,886	3,414
Pool 3	2,453	2,984	3,516
20 PERCENT			
Solo	2,433	3,016	3,603
Pool 2	2,688	3,282	3,878
Pool 3	2,785	3,383	3,982
30 PERCENT			
Solo	2,850	3,519	4,192
Pool 2	3,112	3,793	4,476
Pool 3	3,211	3,897	4,582
40 PERCENT			
Solo	3,408	4,193	4,982
Pool 2	3,680	4,476	5,274
Pool 3	3,783	4,582	5,384

SOURCE Authors' analysis. **NOTE** Patient diversion fraction and physician pooling are explained in the text.

recognized Level 3 patient-centered medical home, has "medical neighborhoods" with groups of three to eight primary care physicians who practice in this pooled fashion. Using this model, this organization has been able to achieve panel sizes of more than 3,200 patients (Gregory Spencer, chief information officer, Crystal Run Healthcare, personal communication, June 28, 2011).

Other practices, such as Clinica Family Health Services,[26] have adopted the use of primary care teams or "pods" that group physicians to ensure better access while maintaining continuity of care through electronic health records.[27,28] The primary care practices studied by Patricia Parkerton and colleagues in Washington State[29] provide examples of a "shared practice" approach under which physicians accept joint responsibility for patient care. This research work shows that such practices achieve better outcomes and higher patient satisfaction compared to more traditional models.

The use of primary care teams, which may include more than one physician, is clearly compatible with the objectives of patient-centered medical homes, which strive to provide increased access to care.[8] Geisinger Health System uses a "shared practice" approach as part of its ProvenCare Navigator medical home model, with groups of two to four primary care physicians supported by nonphysician professionals and a single electronic health record as well as a personal health record system (Thomas R. Graf, associate chief medical officer, Geisinger Health System, personal communication, September 27, 2012).

For each panel-sharing setting, we considered five levels of the number of patient requests that can be handled by a nonphysician provider or by electronic communication (Exhibit 2). Several studies have shown that the potential portion of patient visits that could be diverted is substantial.

For example, one study estimated that the fraction of primary care visits that could be handled by a nurse practitioner is between 9.2 percent and 18.1 percent.[19] Other reports estimate that nurse practitioners and physician assistants could deliver up to 70 percent of office-based primary care.[30] A study by Kaiser Permanente showed that primary care visits decreased 25.3 percent after implementation of an electronic health record that facilitated the substitution of telephone calls for patient visits.[31]

As Exhibits 2 and 3 indicate, partial physician pooling in a group practice greatly increases the size of patient panels compatible with "advanced access" or "moderate access." These exhibits also illustrate that as can be expected, the use of nonphysician providers and electronic health records can expand manageable patient panel sizes.

These modeling conclusions are supported by what has been observed in practice. For example, a study by Kaiser Permanente showed that forming teams of two primary care physicians and one nurse practitioner, with the nurse practitioner seeing patients from both physicians' panels, resulted in more timely access, as well as greater patient satisfaction.[28]

Forecasting The Need For Primary Care Physicians

We next used the patient panel sizes calculated above to estimate the need for primary care physicians in coming years. This estimation involved forecasting the growth in the population requiring primary care services.

To do so, we followed the estimates from Adam Hofer and colleagues' analysis of coverage expansion under the Affordable Care Act[1] and Jack Colwill and colleagues' estimate of generalist physician supply.[32] In particular, Colwill and colleagues estimate that the overall volume of ambulatory patient visits will increase 29 percent between 2005 and 2025, as a result of growth and aging of the population. This number is

equivalent to annual cumulative growth of 1.28 percent.

We also included an estimate of the additional demand for primary care services resulting from a projected 5–8 percent expansion of the pool of insured patients between 2011 and 2019 as the Affordable Care Act is implemented.[1] Using the midpoint of this interval, 6.5 percent, we obtained an annualized cumulative rate of increase of 0.79 percent.

For our estimation, we added the annualized growth rates from the Hofer and Colwill studies[1,32] and rounded the result to obtain an annual total rate of 2 percent. To summarize, we started with 261 million insured patients in 2012 and increased this number by 2 percent in each of the subsequent years.

The required number of full-time-equivalent primary care physicians depends on the desired level of access to care and the mode of physician practice—that is, the way of matching the demand for services with the supply of physician capacity. For example, as Exhibit 1 indicates, under the traditional single-physician practice model, ignoring patient access considerations, the current population of patients would require 89,983 full-time-equivalent primary care physicians (261 million divided by 2,902).

We express this requirement in full-time equivalents. This estimate, of course, is much smaller than the available estimates of the total number of physicians associated with primary care.

For example, the Government Accountability Office estimated that there were 264,068 primary care physicians in the United States in 2005,[2] many of whom practiced far below the full-time equivalent. Under the same single-physician practice model, providing advanced access to care would require almost 25 percent more full-time-equivalent physicians: 112,743 (261 million divided by 2,315). Yet if the "Pool 3" approach, with 20 percent demand diversion, is applied, the required number of full-time-equivalent physicians drops to 77,150 (261 million divided by 3,383; see Exhibit 2).

Exhibit 4 shows projections of future need for primary care physicians, expressed in full-time equivalents, under the assumption of 2 percent annual growth in the insured patient population, for the three modes of service delivery discussed above. Overall requirements for primary care physicians are likely to increase as the overall insured patient population increases. However, reasonable adjustments to physician practice styles that are already being implemented in many locations can reduce these requirements by as much as 30 percent.

We next estimated the impact of patient pooling and demand diversion on the forecast primary care physician shortage, based on our simulation model. As previously mentioned, demand for primary care physicians is projected to increase at a 2 percent annual rate because of growth and aging of the population combined

EXHIBIT 3

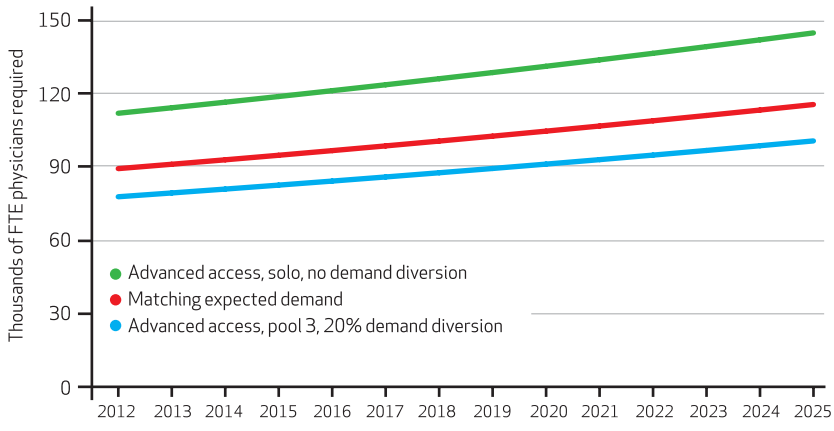
"Moderate Access" Patient Panel Sizes Under Varying Degrees Of Physician Pooling And Patient Demand Diversion In Primary Care Practices

Patient diversion fraction/ physician pooling	Patient panel size, by number of appointment slots per day		
	20	24	28
ZERO			
Solo	2,149	2,624	3,228
Pool 2	2,268	2,748	3,275
Pool 3	2,313	2,794	3,762
10 PERCENT			
Solo	2,413	2,942	3,472
Pool 2	2,534	3,068	3,603
Pool 3	2,580	3,115	3,650
20 PERCENT			
Solo	2,743	3,339	3,937
Pool 2	2,868	3,469	4,070
Pool 3	2,914	3,516	4,119
30 PERCENT			
Solo	3,169	3,852	4,536
Pool 2	3,297	3,984	4,672
Pool 3	3,344	4,033	4,722
40 PERCENT			
Solo	3,738	4,536	5,336
Pool 2	3,870	4,672	5,475
Pool 3	3,918	4,722	5,527

SOURCE Authors' analysis. **NOTE** Patient diversion fraction and physician pooling are explained in the text.

EXHIBIT 4

Projected Requirements For Full-Time-Equivalent (FTE) Primary Care Physicians Under Different Physician Productivity Modes, 2012–25



SOURCE Authors' analysis. **NOTE** Access levels, physician pooling, and demand diversion are explained in the text.

with insurance coverage expansion,[1,32] which translates into 51.0 percent growth in twenty years. However, the supply of generalists for adult care, adjusted for age and sex, is estimated to increase by only 2 percent in twenty years if the number of generalist physician graduates continues to decline as indicated in past years.[32]

Thus, to maintain the current primary care service level in the coming twenty years, the average patient panel size needs to increase by 48 percent (1.51/1.02 – 1). However, this calculation is based on the assumption of a dedicated solo physician model of practice. Assuming that the daily number of appointment slots per physician is twenty-four, our simulation model indicates that this projected shortage can be completely eliminated either by the use of pools (or pods) of three physicians and a 20.9 percent diversion rate, or by a combination of pairwise pooling and a 23.1 percent diversion rate, while providing a high level of access to care.

Limitations

There are two significant limitations to these findings. First, these analyses are based on aggregate national estimates, and there is evidence of regional primary care physician shortages attributable to variations in physician supply relative to population in a given area.[33]

Second, nurse practitioners and physician assistants are restricted by scope-of-practice acts, which vary by state and which may limit the ability to use these providers to deliver primary care as indicated by our analyses.[17,18] So, although our findings point to a future in which the primary care physician supply is adequate in the aggregate, regional shortages may persist, particularly if the roles of nurse practitioners and physician assistants are not expanded.

Discussion

Our research used a method of estimating the size of patient panels compatible with timely access to care, based on explicit accounting for the randomness of the patient demand process. In particular, without any compensating measures, we demonstrated that manageable sizes of patient panels are much smaller than those indicated by simple matching of expected demand and available supply.

We also show that two simple approaches to managing primary care practice—physician pooling and demand diversion—can generate substantial compensating effects on patient panel sizes. More specifically, we show that by implementing partial pooling of patients by two or three physicians and diverting as little as 20 percent of patient demand to nonphysician professionals or using electronic health record–enabled electronic communication, or both, most if not all of the projected primary care physician shortage could be eliminated.

Given the trend toward larger physician practices, growth in patient-centered medical homes,[16] team-based care, and adoption of electronic health record systems encouraged by federal incentives, these operational enhancements seem entirely plausible, if not conservative. For example, the number of physicians participating in a patient-centered medical home rose from 214 in 28 practices in 2008 to 7,676 in more than 1,500 practices by 2010.[16]

Growth in the supply of nurse practitioners has outpaced population growth, and the principal primary care tracks of adult health, pediatrics, family health, women's health, and gerontology account for 85 percent of nurse practitioner graduates.[17] Also, some research indicates that nurse practitioners can provide care for at least 60 percent of patients needing primary care[18] with outcomes comparable to those achieved by physicians.[34]

In addition, the use of nonphysician professionals to deal with more routine problems and the decreased need to respond to urgent requests for care that comes with shared practice can increase the attractiveness of primary care careers for new physicians, adding to the forecast supply. In fact, recent data suggest that this trend may have already begun. The number of graduating US medical school students who will enter primary care specialties increased for the second year in a row in 2011, according to the National Resident Matching Program. The number of M.D. seniors in the United States matched to family medicine positions rose by 11 percent over 2010 levels.[35]

In fact, the recent growth in numbers of primary care providers, including physicians, nurse practitioners, and physician assistants, has caused some researchers to voice doubt that the United States is actually experiencing an imminent shortage of primary care providers.[17]

Are there any problems or obstacles to achieving these efficiencies? The principal concern with the use of pooled physician practices is that it could result in reduced continuity of care for patients. However, continuity of care is facilitated by the increasing adoption of electronic health records, which enable clinicians to update a patient's clinical data continuously and which can be easily accessed by other clinicians.[14]

In addition, when patients cannot get an appointment with their own physician in a nonshared practice environment, they often turn to emergency departments or clinics that do

not have access to their medical record and do not generally communicate with the primary care physician. Therefore, a shared practice can actually increase continuity of care relative to a solo practice.

One study[29] looked at the impact of primary care continuity and coordination on patient outcomes based on the data of 194 primary care practitioners. It concluded that continuity was not associated with any change in patient outcomes, while practice coordination, measured by shared practice, team tenure, and practice size, was significantly positively associated with some good outcomes.

In addition, it is important to note that constraining patient panel sizes to be small enough that a large percentage of patients can receive same-day or next-day appointments increases the likelihood that a patient can get an appointment with his or her own physician, hence increasing continuity of care.[4] This observation, along with the reduced rate of appointment cancellations and increased physician utilization associated with more timely access, supports the adoption of patient panel sizes consistent with a higher (for example, 75 percent) likelihood of same-day appointments.

Another obstacle to achieving the efficiencies indicated by our work might be the increased time needed by physicians to engage in activities to improve the coordination of care. However, we can use our model to estimate the impact of this additional demand on physicians' time by considering scenarios with fewer appointment slots.

For example, if we assume that, on average, physicians have only twenty rather than twenty-four slots per day because of the time needed to engage in coordination activities, our findings indicate that eliminating the projected primary care physician shortage would require the use of either pools (or pods) of three physicians and a 34.1 percent diversion rate, or a combination of pairwise pooling and a 35.9 percent diversion rate.

Finally, although physicians are increasingly practicing in multiphysician practices, they might not be engaging in a purely shared practice model as reflected in our simulations. For example, although physicians may agree that they will "cover" for one another on their days off, they may otherwise act as independent providers. In addition, if physician pods are too large or if patients are not adequately introduced to the idea of team-based care, they might not accept an appointment with another physician or nonphysician provider when offered an appointment.

This situation is a concern at Geisinger Health System, which uses physician pods and nonphysician providers in all of its primary care practices, but with no standard model for the size of provider teams and the roles of their members. Geisinger is currently investigating ways, consistent with the ideas in this article, to better design and use provider teams and electronic communications to increase patient panel sizes from an average of 2,500 patients to 5,000 patients (Graf, personal communication).

We have predicated our analyses on a full-time-equivalent basis. The results can be affected by trends in part-time practices and how much time physicians spend in other health care delivery venues, such as nursing homes. However, the increasing use of hospitalists, who can reduce the time that primary care physicians spend visiting their patients in the hospital,[10] could have a positive impact on increasing primary care office-based capacity.

This discussion underlines the fact that many factors will determine whether a primary care physician shortage may exist in any given geographic area and, if one does exist, how large it may be. It is important to note that our methods can be used regionally to help identify where operational or regulatory factors may be particularly important in mitigating shortages by increasing effective primary care physician capacity.

Conclusion

Our study demonstrates that as health systems are increasingly confronted with pressure to contain costs while improving access and coordination of care, the use of primary care physician pools supported by nonphysician professionals and electronic health records can be an efficient and effective approach to increasing patient panel sizes without compromising access. Given the current trends toward adoption of these practices, the widely perceived national primary care physician shortage that has been forecast may, in fact, be greatly overestimated. ■

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NOTES

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22 To access the Appendix, click on the Appendix link in the box to the right of the article online.
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In this month's *Health Affairs*, Linda Green and her coauthors tackle the predicted shortage of primary care physicians and present a simulation that suggests that the future could actually look quite different. They show that the implementation of some increasingly popular operational changes in the ways clinicians deliver care—including the use of teams or "pods," better information technology and sharing of data, and the use of nonphysicians—has the potential to offset completely the projected increase in demand for physician services. At the same time, patients' access to care would probably improve, as a result of such features as electronic communication and same-day scheduling of appointments.

Green holds numerous positions at Columbia University, including the Armand G. Erpf Professor of Business at the Columbia Business School, founder and codirector of the Columbia Alliance for Healthcare Management, and faculty director of the Healthcare and Pharmaceutical Management Program at the Columbia Business School.

Green also consults on a number of projects, including the Columbia-Bassett Program in the College of Physicians and Surgeons, which is a unique track in which medical students learn about the US health care system and quality improvement and, in their clinical curriculum, follow patients longitudinally.

Green is a fellow of the Institute for Operations Research and the Management Sciences and a winner of the 2011 best paper of its Section on Public Programs, Services, and Needs. She earned a doctorate in operations research from Yale University and a master's degree in mathematics from New York University.

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