Chapter Title: **Managing Physician Panels in Primary Care**

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1. Introduction

Primary care providers (PCPs) are typically the first point of contact between patients and health systems. From a patient's perspective, PCPs provide the majority of care they receive during their lifetime and are responsible for a variety of health services including preventive medicine, patient education, routine physical exams, and the coordination of complex episodes in which patients are referred to medical specialties for secondary and tertiary care. The benefits of a strong primary care system are well documented in the clinical literature. Shi, Starfield and Macinko (2005) show that increased access to primary care 1) improves access to health services for relatively deprived population groups; 2) has a strong positive relationship with prevention and early management of health problems; and 3) leads to increased familiarity with patients and, consequently, to less wasteful expenditures due to inappropriate specialist care.

Despite the reported benefits of primary care a recent study by the American College of Physicians (2006) reports that primary care in the United States "is at grave risk of collapse due to a dysfunctional financing and delivery system." They also emphasize the growing demand for primary care (by 2015, "an estimated 150 million Americans will have at least one chronic condition"), and the steady decline in the supply of primary care physicians over the last decade. This looming crisis in primary care is also at the heart of the policy debate in US healthcare as the nation attempts to reform the healthcare system and provide the roughly 45 million uninsured patients with coverage. As the case of Massachusetts has shown, universal coverage will further strain primary care, as newly insured patients request access to doctors. Several prominent media outlets such as *New York Times* and *National Public Radio* recently reported on the severe

shortage in primary care physicians in Massachusetts (Sack, 2008 and Brown, 2008). The shortage has been attributed to the state's goal of achieving universal coverage.

Timely access to care and patient-physician continuity have been adversely affected due to these broader trends. The Institute of Medicine (2001) has reported "timeliness" as one of the six key "aims for improvement" in its major report on quality of healthcare. In one study, nearly 33 % of patients cited "inability to get an appointment soon as a significant obstacle to care" (Strunk and Cunningham, 2002). More recently, Rust et al. (2008) report that the inability to get a timely appointment to a primary care physician increases the likelihood of patients visiting the ER. This hinders the appropriate management of chronic diseases that could have been effectively treated in a primary care setting. It is also important that patients see their own physician in order to maintain continuity of care. Indeed, continuity of care is considered one of the hallmarks of primary care. Gill and Mainous (1999) point to several studies which show that patients who regularly see their own providers are 1) more satisfied with their care; 2) more likely to take medications correctly; 3) more likely to have problems correctly identified by their physician; and 4) less likely to be hospitalized. Gill et al. (2000) show a link between lack of continuity and increased emergency department use. Thus, timely access and continuity of care not only have a positive effect on a patient's health, they are also instrumental in reducing healthcare costs.

In this chapter, we look at a case study concerning the Primary Care Internal Medicine (PCIM) practice at the Mayo Clinic in Rochester, Minnesota. Our focus is on improving timely access and continuity of care. The rest of the chapter is organized as follows. We first provide background on the operational aspects of primary care practices and review the relevant

literature. We then discuss methods of classifying patients with regard to their appointment request patterns. Next, we investigate how these classifications play a role in the design of a physician's *panel*, where a panel is the set of patients a physician is responsible for. We discuss how timely access and continuity of care can be improved simultaneously by optimizing a physician's panel. Finally, we discuss some of the emerging trends in primary care and their operational implications.

2. Background and literature

Primary care practices include family physicians, general internists, and pediatricians. In the United States, more than 66 % of all practices are group practices (Hing et al. 2004). As stated earlier, each physician has a *panel*, which is the set of patients he/she is responsible for. Fostering the relationship between a physician and his patients – improving patient-physician continuity in other words – is one of the foundations of primary care. Patient appointments are typically classifiable into two types 1) Urgent or acute appointments; 2) Non-urgent appointments or appointments generally meant for annual exams and to monitor chronic conditions. Physician appointments are generally for 20-minute slots and reimbursement to physicians in primary care (for most practices in the United States) is based largely on the number of 20-minute visits. A physician working full time typically sees about 24 patients a day.

The traditional model of appointment scheduling involved scheduling urgent requests as soon as possible - typically on the same day - while postponing non-urgent visits. However, in recent years, a new paradigm called "advanced access" or "open access" has been adopted by practices

nation-wide (Murray and Berwick (2003) and Murray et al. (2003)). Under advanced access, all patients who call are given same-day appointments: physicians are encouraged to "do today's work today". Thus the booking of appointments well into the future, which happens frequently for non-urgent appointments, is avoided to a certain extent.

The adoption of open access, which promises patients same-day appointments, has prompted a series of questions. What should physician panel sizes be to allow open access? What if patients prefer to have appointments at some future time rather than see a doctor the same day? These questions have necessitated the use of queuing and stochastic optimization approaches that provide guidelines to practices. For instance, Green et al. (2007) investigate the link between panel sizes and the probability of "overflow" or extra work for a physician under advanced access. They propose a simple probability model that estimates the number of extra appointments that a physician could be expected to see per day as function of her panel size. The principal message of their work is that for advanced access to work, supply needs to be in sufficiently higher than demand to offset the effect of variability. Green and Savin (2008) use a queuing model to determine the effect of no-shows on a physician's panel size. They develop analytical queuing expressions that allow the estimation of physician backlog as a function of panel size and no-show rates. In their model, no show rates increase as the backlog increases; this results in the paradoxical situation where physicians have low utilization even though backlogs are high -- this is because patients, because they have had to wait for long, do not show up.

Gupta et al. (2006) conduct an empirical study of clinics in the Minneapolis metropolitan area that adopted open access. They provide statistics on call volumes, backlogs, number of visits

with own physician (which measures continuity) and discuss options for increasing capacity at the level of the physician and clinic. Kopach et al. (2007) use discrete event simulation to study the effects of clinical characteristics in an open access scheduling environment on various performance measures such as continuity and overbooking. One of their primary conclusions is that continuity is care is affected adversely as the fraction of patients on open access increases. The authors mention provider groups (or physicians and support staff) working in teams as a solution to the problem. Gupta and Wang (2006) explicitly model many of the key elements of a primary care clinic. They consider scheduling the workday of a clinic in the presence of 1) Multiple physicians 2) Two types of appointments: same-day as well as non-urgent appointments 3) Patient preferences for the a specific slot in a day and also a preference for physicians. The objective is to maximize the clinic's revenue. They use a Markov Decision Process (MDP) model to obtain booking policies that provide limits on when to accept or deny requests for appointments from patients.

In this chapter we investigate the effect of panel size and composition on timely access and continuity of care in a primary care group practice. While the effect of the size of a physician's panel has been studied before, there has been no discussion of the type of patients in a physician's panel and its effect on access measures. For instance, females in the age group 55-60 are likely to request twice the number of appointments when compared to males in the group 25-30 (Murray, Davies and Boushon, 2007). We first illustrate the differences in appointment request patterns between different categories of patients using examples. We then discuss how the information about patient categories and their appointment request rates are relevant to the design of a primary care physician's panel. Our examples are from the Primary Care Internal

Medicine Practice (PCIM) at the Mayo Clinic in Rochester, Minnesota. The PCIM practice is located in downtown Rochester. In all there are 40 physicians in the practice with a total of 20,230 empanelled patients. The majority of the patients are middle aged or elderly, but the practice also includes young patients between 18 and 40 (pediatric patients are seen in a different practice).

3. Patient Classifications

Many factors such as age, health status, geographic location, patterns of historical appointments (appointment types, urgent vs. non-urgent requests, etc.) can be used to define a classification of patient types. The examples we present include two different types of categorizations: the first, a simple categorization based on age and gender, and the second a categorization obtained using classification and regression trees (CART). The purpose of such classifications is to reflect the reality that patient request rates from the different categories may vary significantly.

The first classification uses twenty eight categories based on age and gender starting with separate groups for males and females aged 18-23 (patients aged less than 18 are seen by a separate pediatric practice), and with the rest of the categories being in five-year increments. The last two groups are patients aged over 83.

Consider for example the empirical distribution of the fraction of total patients in a given category requesting appointments in a week. We contrast the histograms of two different categories: Males in the 48-53 age group and Females in 73-78 age group. The histograms are

based on the weekly visits for the years 2004-2006.

Figures 1 and 2 show the histograms for groups 48-53 M and 73-78 F respectively. The data can be interpreted as follows. There are in total 708 patients from category 48-53 M empanelled within the PCIM practice. Figure 1 shows that an average of 4.8% of these patients will request appointments in a given week. On some weeks as many as 8% of these patients will request appointments.

In contrast, 986 patients from category 73-78 F are enrolled in PCIM (278 more patients than in 48-53 M). Furthermore, from Figure 2, on average 8.4% of these patients request appointments in a week (as compared to 4.8 for 7M). Thus, not only is the category size larger but a greater fraction of 73-78 F patients request appointments.
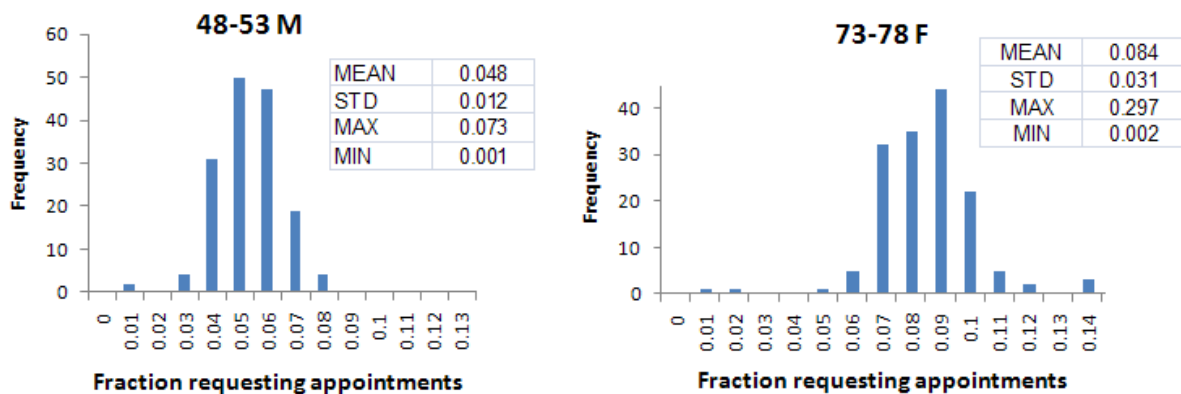

Figure 1. Comparison of categories two age and gender categories with regard to fraction total patients requesting appointments per week

While age and gender serves as a simple proxy for appointment request behaviour, specific chronic conditions or diseases may also be useful indicators. Further analysis of the same PCIM patients using CART analysis revealed that in addition to age and gender, cornonary artery disease (CAD), hypertension and depression were significant indicators of high appointment request rates. As an example, the following figure shows the distribution of the fraction of total patients requesting appointments from two different categories, which we refer to below as categories 1 and 2. Category 1 is comprised of female patients less than 53 years old (2865 total), with none of the aforementioned three conditions. Category 2 is comprised of patients, both male and female, aged above 69 (789 total) and who have coronary artery disease (CAD). The distributions are clearly different. The mean of the second is double the mean of the first; the second also has a broader distribution compared to the first.

Identifying different categories of patients is thus important for understanding patterns in patient demand. Different patients may have different needs: younger patients may not value continuity as much as older patients; patients with chronic conditions need regular follow-up appointments. The classification of patients helps a practice effectively segment its patients and plan its care delivery models.

Furthermore, classification helps in the design of a physician's panel, which we discuss in the next section. This has an important policy implication. Currently, physicians are reimbursed based on the number of visits. But there are "pay for performance" intiatives (Bohmer and Lee, 2009) underway that reimburse not only based on visits but also based on the preventive measures promoted in the population and quantifiable improvement in health outcomes. Any

such payment scheme would have to adjust for the type of patients in a physician's panel and
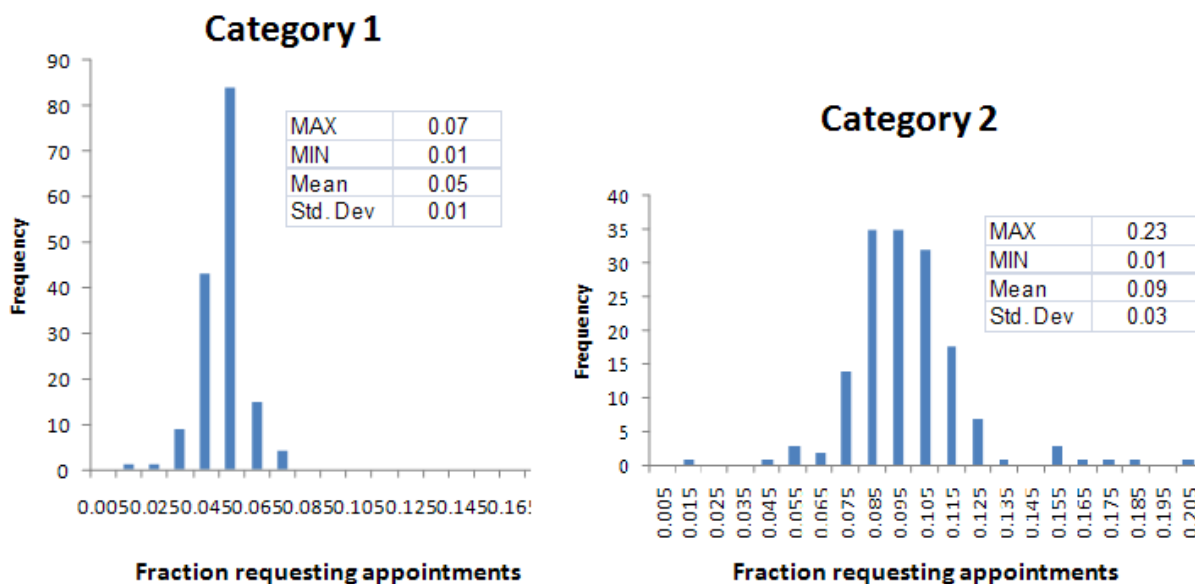
mix of diseases.

Figure 2. Comparison of categories 1 and 2 with regard to fraction total patients requesting appointments per week

4. Managing physician panels

Each primary care physician has a panel which is the set of patients she is responsible for. The

demand for appointments a physician has from day to day is a function of the size of the panel. A

physician working full time typically has 1500-2000 patients in her panel. But how many

patients can one physician accommodate? This has become an important question in primary

care (Murray and Berwick, 2003). However, based on our observations of differing appointment

request patterns among patient categories, it appears size alone may not be sufficient.

Consider the example of a primary care physician working at the Primary Care Internal Medicine (PCIM) practice at the Mayo Clinic in Rochester, Minnesota. This physician has 1200 patients in her panel. Using a classification which uses age and gender, CAD, hypertension, depression as indicators (obtained using CART) we can determine how many patients are from each category. Then, using historical information on the distribution of visit rates from each category (as illustrated in Figure 2), it is possible, using a simple simulation, to obtain the distribution of the number of appointments that the physician can expect in a week. For example, the histogram of weekly appointments for this particular physician is shown in Figure 3. The histogram is based on 50,000 observations obtained from the simulation.
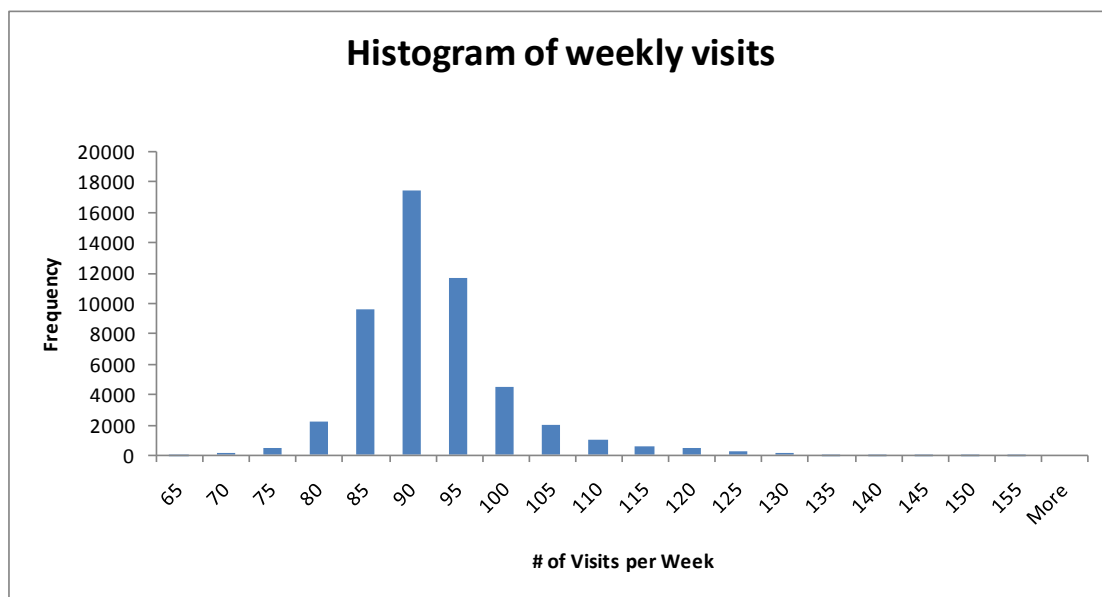

Figure 3. Empirical distribution of weekly appointments for a typical PCIM physician

Can this physician take on more patients, assuming the mix of patients remains the same? Table 1 shows summary statistics on the number of expected appointment requests in a week for different panel sizes, for the same physician. We also provide the proportion of the estimated distribution that is less than 120. The rationale for choosing this as a reference point is as

follows. If the physician works an eight hour day, then she will have 24 appointments since slots in primary care in the United States are 20 minutes long (even if appointments end up being longer or shorter, as often happens, this is the length of time the physician is billed for). In a week therefore, she will have approximately 120 slots. Note that this is a conservative estimate since it assumes that the physician is available to see patients all days a week; it also assumes that the physician will accommodate administrative activities, dictations, telephone follow-ups and lunch in time other than the allotted 8 hours to see patients.

Table 1 shows the proportion of requests are less than 120 for each of the panel size. If this statistic is small, then this means that a significant proportion of the estimated distribution of the total weekly appointments is greater than 120, which in turn implies the physician will either have to put in an unreasonable amount of overtime, or her patients will have to wait, see other physicians, or visit an emergency room. All these are inefficient, high cost alternatives. Similar statistics can be provided for other limits on the total number of available weekly physician appointments.

Panel Size	Mean	Std. Dev	Maximum	Minimum	Less than 120
1,200	89.71	7.68	153.72	60.32	99.40%
1,400	104.67	8.96	179.34	70.37	94.18%
1,600	119.67	10.56	204.96	78.53	59.57%
1,800	134.57	11.52	230.58	90.48	5.35%
2,000	149.55	12.80	256.20	100.53	0.36%

Table 1. Statistics on expected number of weekly visits for a PCIM physician under the different panel sizes

Table 1 also shows that the average number of appointments increases linearly as the panel size

increases. But the proportion of the distribution below 120 decreases non-linearly. At 1600

patients, the mean is 120 appointments per week, but only 60% of the distribution is below 120.

Clinics thus should be careful about planning physician panel sizes with just averages. Recall

that 120 is an estimate on the high side; for smaller total available weekly slots, panel sizes larger

than 1500 will be untenable. This analysis shows that while nationwide panels tend to be

between 1500-2000, the mix of disease conditions and the corresponding demand at PCIM imply

that a panel size beyond 1500 will not result in an acceptable level of service.

The above discussion pertains to capacity planning at the level of one physician. Most practices,

however, are group practices, consisting of more than one physician. Providing timely access and

continuity can be viewed as an *optimization* problem, as shown in Figure 4. The question is: how

many patients from each category should be assigned to each physician's panel? The x_{ij} variables

in the figure represent the number of patients assigned from patient category i to physician panel

j. In other words, the x_{ij} variables determine the design of physician panels. The demand for any

physician j in any week t, denoted in the figure by d_{it} is clearly a function of how the x_{ij} variables

are chosen. Physicians with significant backlogs typically have panels that have a large number

of chronically ill patients. Because these patients are unable to obtain timely appointments, they

tend to see other physicians. What if the panels were to be redesigned – that is if the excess

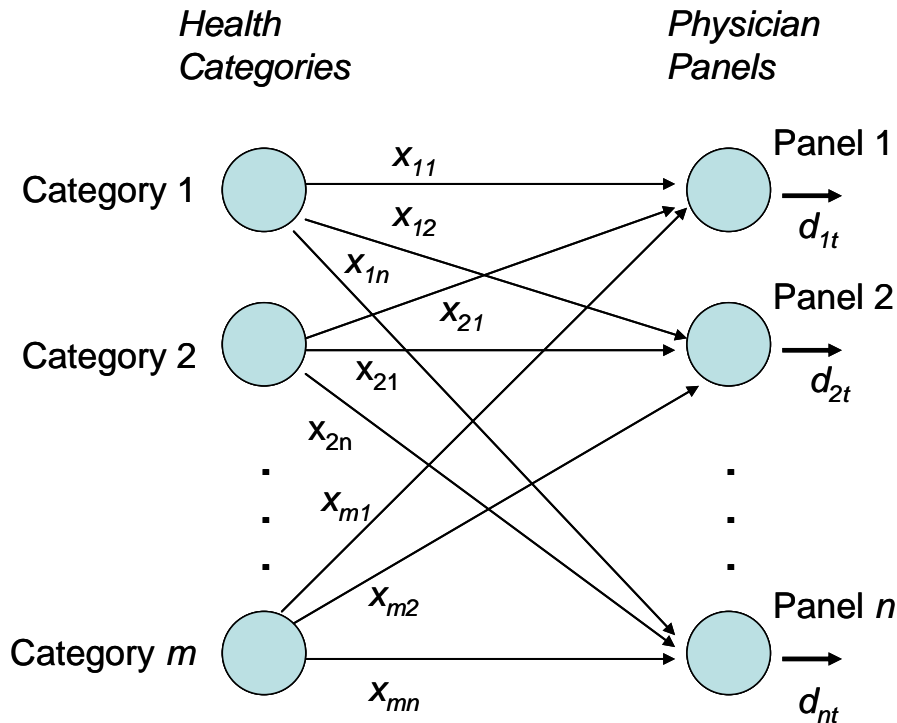demand were to be redistributed to other physicians who have some capacity?

Figure 4. Panel design framed as an optimization problem

Balasubramanian et al. (2007) considered the panel design question using a simulation optimization framework. They propose a panel design genetic algorithm (PDGA) to generate optimal designs and test it using data from the Mayo Clinic PCIM group practice. For health categories, a simple age and gender classification is used. Each panel design in the PDGA population is evaluated over 52 weeks to calculate waiting time in weeks and average number of redirections to physicians that are not the patient's own. These redirections are viewed as losses in continuity, since an unfamiliar physician will now have to understand the medical history of the patient. This may result in additional follow-up appointments with the patient's own physician, or diagnosis and medication errors.

The simulation works as follows: physician calendars start empty (no appointments) in the first

period and move from period to period. In each period, patients request appointments from their

PCPs. Patient requests in each period are satisfied on a first-come-first-served basis: requests

originating in earlier periods are filled first. Ties between requests arising in the same period to a

given physician panel are broken arbitrarily. If the capacity for a particular panel is exhausted,

patients have one of two options: to see another provider within the same period or to wait for a

future period to see their PCP. We assume that a fixed proportion of patients (40%) are willing to

see other providers in the same period. These requests are filled by physicians who have

available capacity. For each panel design we truncate the first ten weeks of data to remove the

initial transient and use 50 replications to obtain our estimates.

The results of the genetic algorithm are compared to the existing panel configuration in the

practice, as shown in Table 2 and Figure 5. Average wait time is improved by more than 30%,

while average number of weekly redirections to other physicians is reduced by more than 50%.

Figure 4 shows graphically the differences in wait times involved in the two solutions. The x-

axis indicates the number of weeks. The y-axis indicates the average number of patients who

waited i weeks or more, where i is the corresponding value on the x axis. The PDGA solution

performs significantly better but the differences taper off as the number of weeks increases.

	Wait Time	Redirections
	Current Design	
Mean	6.82	531.10
Std.Dev	0.21	26.43
Upper 95% CI	6.87	538.43
Lower 95 % CI	6.76	523.78
	PDGA Solution	
Mean	4.50	230.13
Std.Dev	0.18	26.77
Upper 95% CI	4.55	237.55
Lower 95 % CI	4.44	222.71

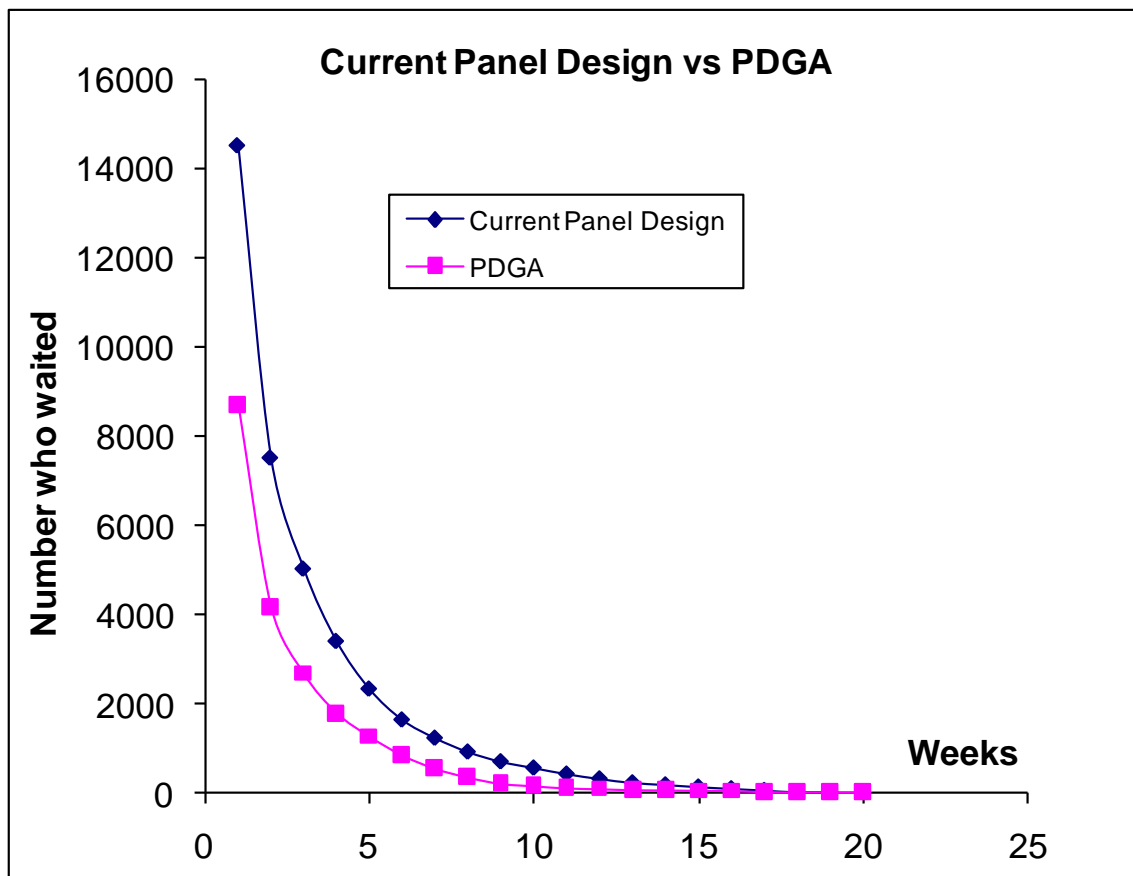**Table 2. Comparison of GA design with current practice**

Figure 5. Comparison of number of weeks waited for the two designs

Thus, panel redesign shows promise. However, there are several unaddressed issues. Patient and physician preferences about panel choices and compositions have not been considered. We assume that the population of patients remains static during the simulation – that is no patients leave the system (due to move or death), or no new patients enter the system. Finally, while the current design can be significantly improved upon, changing panel allocations is difficult in practice. Altering the panel configuration can only be done in the long term, and the practice can use the rate of new patients entering and existing patients leaving to adjust panels so that they are closer to the PDGA solution. Patient and physicians preferences can also be considered in the process. Models that consider such transitions and preferences will be focus of our future research.

5. Emerging trends in primary care

4.4.1. Team care

Primary care physicians are reimbursed less than most other specialties, which discourages medical students from careers in primary care. This is one of main reasons for the current nationwide shortage in primary care (Bodenheimer and Grumbach, 2007). As a result many practices are using support staff such as mid-level physician assistants (PAs) and nurse practitioners (NPs), to fill the void. Indeed, in recent years, there have been increasing calls in the primary care community for practices to adopt the concept of *team care*. The Institute of Medicine (2001) in its report *Crossing the Quality Chasm: New Health System for the Twenty First Century* envisions primary care teams playing a central role. Bodenheimer and Grumbach

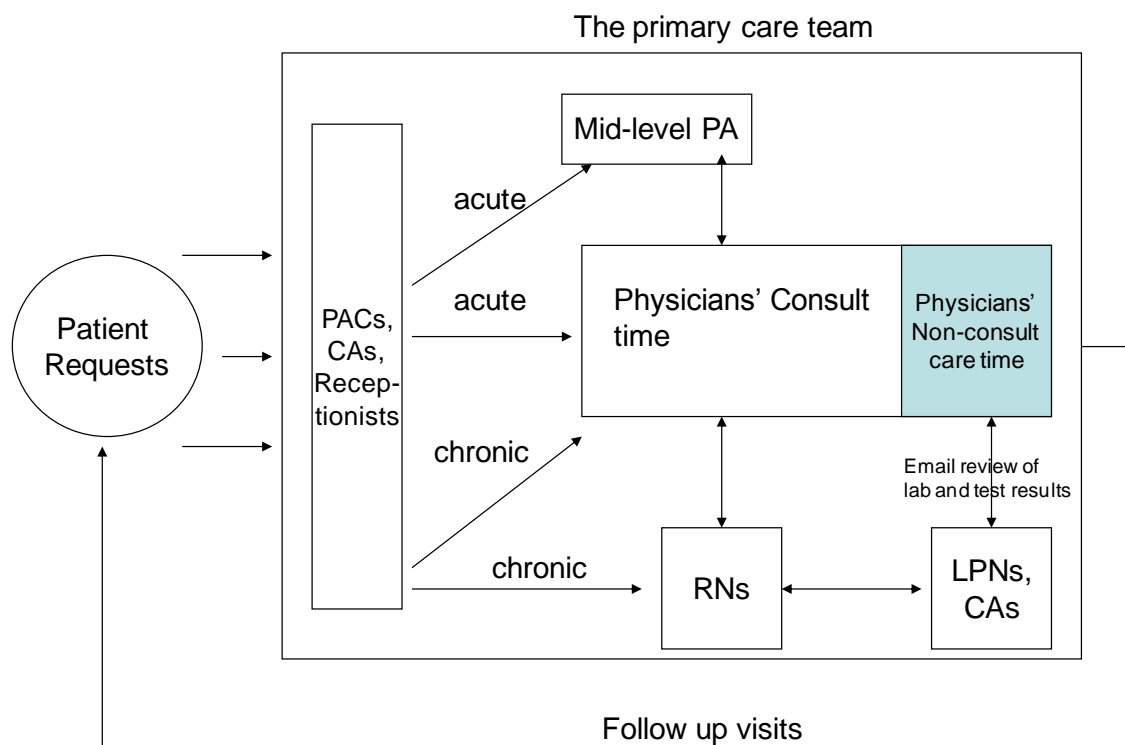(2003) report several examples of clinics that have adopted team care.

Figure 6. The team care model in primary care

Team care relies heavily on the effective use of support staff. Support staff includes clinical assistants (CAs), receptionists, patient appointment coordinators (PACs), and licensed practical nurses (LPNs). The structure and flows within the framework of a primary team are shown in Figure 6. While a patient's PCP will still be her main point of contact, and will coordinate her care, she may be seen by other clinicians in the team. This pooling of the team's capacity allows it to better absorb fluctuations in demand, and also direct requests based on the acuity of the case. Future work on patient appointment scheduling in primary care has to consider this team aspect rather than focusing primarily on physicians.

4.4.2 The Patient-Centered Medical Home

In recent years, prominent physician organizations have been calling for a fundamental transformation in how primary care is practiced. Specifically, they have been advocating for a *Patient-Centered Medical Home (PCMH)* which they define as "an approach to primary care… that facilitates partnerships between individual patients, and their personal physicians, and when appropriate, the patient's family" (AAFP/AAP/ACP/AOA, 2007). The medical home attempts to counter the increasing fragmentation and lack of coordination that is prevalent in the US healthcare system, by making primary care practices the central point of care. Each patient will have a personal physician, but the physician will also coordinate and will stay informed of the patient's care across other parts of the system: subspecialty care, hospitals, home health agencies and nursing homes. The medical home model of care will use information technology and electronic medical records to achieve this coordination.

As discussed earlier, physician reimbursement in most practices is currently based on the number of visits. In a medical home, "face-to-face" visits will be complemented by visits with other members of the care team such as nurses and physician assistants; some exchanges may happen over email and phone. The reimbursement of physicians will thus have to account for "non-visit" care time. This leads to a number of operational questions, since a "capacity" of a clinic now assumes a flexible form rather than being centered solely on physician visits. Furthermore, medical home reimbursement will also "recognize case-mix differences in the patient population being treated within the practice" [AAFP/AAP/ACP/AOA, 2007]. Such a payment scheme adjusts for the type of disease burdens prevalent in the population. Our discussion in section 4.2 regarding patient classifications thus becomes important.

5. Summary and Conclusions

In summary we have illustrated approaches for patient appointment scheduling in primary care using a case study involving the Primary Care Internal Medicine (PCIM) practice at the Mayo Clinic in Rochester Minnesota. Salient features of our approach include 1) the recognition of the differences in appointments request patterns between patient groups, 2) the use of patient classifications for the effective design of an individual physician's panel, and 3) the discussion of a simulation-optimization framework to redesign panels in a group practice. We have also briefly discussed some of the emerging trends in primary care, specifically team care and the patient-centered medical home. Our future work will focused in developing models that evaluate the operational implications of these trends.

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