Improving Clinical Access and Continuity through Physician Panel Redesign

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Improving Clinical Access and Continuity through Physician Panel

Redesign

Running Title: Improving access through panel redesign
ABSTRACT

Word Count: 213

Background:
Population growth combined with the increasing prevalence of chronic disease due to aging is projected to increase the demand for primary care services in the United States.

Objective:
To use systems engineering methods to design physician panels that improve access to and continuity of care.

Design:
We use numerical and simulation techniques to design physician panels based on appointment and capacity data for 2004-2006 from a primary care group practice of 39 physicians with over 20,000 patients at the Mayo Clinic in Rochester, MN.

Measures:
Patient waiting time and patient/clinician continuity, i.e., the number of times patients redirected to see a provider other than their primary care physician (PCP).

Results:
Waiting time decreases by 57% [95% CI: 54.5%-59.5%] and continuity increases by 54% [95% CI: 50.8% - 57.2%] in simulations that use the optimal panel design produced by our numerical technique. The new panel design remains more efficient (less waiting, more continuity) than a standard practice up to adding an additional 3500 more patients to the new system.

Conclusions:
Our simulation results indicate that redesigning primary care physician panels using numerical techniques that trade-off access to and continuity of care has the potential to increase the efficiency of primary care practices and may therefore help mitigate the expected shortage of PCPs.
INTRODUCTION

Recent estimates have suggested that the US faces an impending shortage in the number of primary care physicians (PCPs).(1) These projections are based on forecasts of both the needs of an aging population, and the number of PCPs who are likely to be in practice in the near future.(2) An increasing number of Americans have at least one chronic condition.(3) Current projections estimate that, due to an aging population, 25% of Americans will have multiple chronic conditions by 2020.(4) PCPs, typically the first point of contact between patients and the health system, play a particularly important role in the management of chronic health problems, like back pain, asthma, diabetes, hypertension and heart disease. Older patients, who often have multiple chronic ailments, need careful management by a physician who has broad expertise and can spend the time necessary to understand and manage their care.

Some authors find a strong positive relationship between primary care and greater utilization of preventive services.(5) More effective use of primary care reduces unnecessary and inappropriate specialist care. Moreover, greater access to primary care reduces mortality-rates and is associated with system-wide positive effects, including a more equitable distribution of health within populations.(5) Insufficient primary care access appears to be rising and has perverse consequences 40% of emergency department visits are reported to take place because patients are not able to access their PCP.(6) From 1997 to 2001, the percentage of people reporting an inability to obtain a timely appointment rose from 23% to 33% and in 2001, 43% of adults reporting an urgent condition were unable to receive care when they wanted. (9)

Equally as important as access is continuity of care. Patients who regularly see their own PCPs are 1) more satisfied with their care 2) more likely to take medications
correctly and 3) less likely to be hospitalized. Conversely, not seeing your own PCP can have an impact on efficiency and effectiveness of care provided including increasing the number of follow-up appointments. Patients without a regular health care provider also may be at higher risk of injury or adverse outcome. The use of unnecessary invasive diagnostic tests, or studies with risk, increases with physician unfamiliarity with a patient. Mainous et al. (2001) found that roughly only 65% of US patients in their study reported seeing their own PCP when they needed care.

Several proposals have been advanced to solve the problem of shortage in access to primary care. Chief among these is payment reform which would reward physicians for the quality rather than the quantity of care they provide (pay-for-performance) or payments for care coordination (medical home). Some have proposed incentives for patients to choose primary care providers. The method we explore to increase access and continuity of care is to improve the efficiency of physician panels – the set of patients cared for by a physician. While others have proposed management of patient demand, such as implementation of the advanced access paradigm, we consider an alternative approach that simultaneously optimizes supply and demand through the restructuring of patient panels. For a more technical discussion of related work, see Balasubramanian, Banerjee et al. (32).

How might the design of a physician’s panel affect the “efficiency” of a practice? Size alone is not the only important factor. Together, the number of patients in a panel and their disease burden composition determine the panels aggregate demand for health care services. Optimally choosing a size-composition combination will allow a practice to improve the care existing patients receive by reducing wait times for appointments and increasing the frequency at which these patients see their own provider, as well as, allow
new patients to enroll, since good panel design may open up previously unavailable physician capacity.

**METHODS**

**Baseline data**

We examined the panels of a primary care group practice at the Mayo Clinic in Rochester, Minnesota. The practice consists of 39 physician panels and covers approximately 20,000 patients living in Olmsted and surrounding counties. Since a period in our model corresponds to one week, we collected weekly appointment and capacity data for each physician from 2004 to 2006. An example of the variation in appointment request rates can be seen in Figure 1 where we plot the distribution of weekly visits for three categories of patients. The three distributions illustrate how differences in appointment request rates can be attributed to gender and age.

For our analysis, we divided patients into 14 age categories of five-year increments starting at age 18 and going through age 83. We further divide patients by sex so that we end up with 28 categories in total. We chose this classification for simplicity as suggested by Murray. (20)

The 39 physicians in the Mayo (Primary Care Internal Medicine) PCIM practice cover 20,000 patients in Olmsted County in Rochester, MN. After accounting for part-time and other activities (e.g., education and research), the practice group is equivalent to 17 physicians working full time. The average panel size is approximately 1200 patients per physician panel. To obtain panel sizes more representative of the typical practice (~2000/provider, see (23)), we used the following method. We increased the total empanelled population to 34,000, while keeping the proportion of people in the different
demographic categories the same. The FTE adjusted panel size thus increased from 1200 per physician to about 2000 per physician on average. Note that the composition of patients in the new panels is unchanged relative to the original panels. We also removed physicians who worked less than a day a week on average from our analysis. In summary, our experimental clinic has 33 physicians who cover 34,000 patients. We use this modified data set to compare the baseline design against the optimal and capacity based designs.

Panel outcomes

In order to evaluate whether panel design can increase effective capacity, we have developed a model of patient access to a primary care group practice in which the guiding principle is the trade-off between timely access and continuity of care. Thus our model seeks to choose a panel design that balances these two key, but opposing, forces. On the one hand, timely access to care often necessitates a need to see any available physician. This, however sacrifices continuity of care and brings with it the attendant problems described in previous sections. A prudent choice of panel design – the “optimal panel design” – is one that jointly maximizes timely access and continuity of care.

While we compare designs based on timely access and continuity, we also report on the utilization of the clinic. Specifically, we report two measures: the number of unfilled slots in any week for the entire clinic, and the number of extra slots (additional capacity) that the clinic needed on a weekly basis to meet demand.

Model Description
In essence, the panel design problem is an allocation problem: given a set of health categories, and a number of physician panels in a group practice, how many patients from each category should be assigned to each panel?

Consider a simple example with three patient categories and three physician panels as shown in Figure 2. The three categories have a total of 220, 370 and 450 patients, respectively, while each physician can see a maximum of 35 patients in one week. Demand from each category for the week is assumed to be 10% of category size. The number of patients from each category assigned to each physician’s panel is indicated on the arrows in the figure. The dashed lines indicate redirection of flow for the single-week model. Redirection means that patients have to see another provider since their PCP is unavailable. The panel design in this example is not optimal; however, if the number of patients assigned from category 3 to panels 1, 2 and 3 is changed to 20, 12 and 13, respectively, all patients would see their own PCP.

With an additional week, redirections could either be to the same provider in the next week (implying waiting 1 week for an appointment) or to a different provider in the same week. These are shown using solid arrows in the figure.

The model’s complexity significantly increases when there are multiple weeks, the number of appointment requests for each panel is a random variable, and physicians have a different capacity in each week due to vacations or other commitments. In some panel designs, physicians may have unfilled slots in one week and an over-full calendar in another, which will adversely affect patient waiting time and continuity of care. Physician and staff morale and satisfaction may also suffer. Optimizing the composition and size of panels thus becomes important.

**Model Instantiation**
To find the optimal panel design, we formulate the model as a Stochastic Linear Program,\(^\text{(21)}\) which we solve using numerical techniques. Such methods are an important methodological area within the field of systems engineering, and have been applied to many problems in other service industries including the design of financial portfolios, design of transportation systems, and airline management. \(^\text{(22)}\) The computed optimal panel design is evaluated over 52 weeks using discrete event simulation which allows us to calculate summary statistics like average waiting time and the number of redirections to other providers.

The simulation works in the following manner: physicians start with an empty calendar in the first time period, which in our case is one week. In each week, patients make appointment requests that are satisfied on a first-come-first-served basis; if a request was made in an earlier week, it is filled first, and ties between requests in the same week are broken arbitrarily. When a physician’s calendar in a week is full, patients can either choose to wait for a future week to see their own provider, or they can see another physician in the same week (provided capacity is available). If capacity is not available, extra slots are added to accommodate these patients.

A fraction of patients chooses not to wait additional weeks. In our model, we assume 40% of patients decide to see other physicians in the same period. We base this estimate on the rate observed at the primary care practice at Mayo Clinic. A fraction of patients (50% in this case) who are redirected to other physicians are subsequently asked to follow-up with their own PCP. This feature captures the idea that seeing another physician generates additional follow-up appointments. \(^\text{(23)}\)

In the discrete event simulation model, we sample randomly from historical visit data for each of the demographic categories from 2004-2006. However, in order to factor
in seasonality, for any given week we restrict our sampling within an eight week window around that week (four weeks on either side). Each physician has a weekly schedule that we use to determine weekly capacity. The results we present are averages of 50 replications of the simulation for each design.

**Model Assumptions**

Our model is based on the following assumptions:

1. We divide patients into categories based on age and sex.
2. There are multiple time periods.
3. Physician capacity is fixed in a time period but may vary between time periods.

Assumption 1 is a simple way to categorize patients. We discuss alternative methods below. Assumption 3 says that physician capacity is taken as given and is not a decision variable in our model. This can also be modified to account for additions to staff or changes in how a practice is managed.

**Panel Strategies**

The above information can be used to create panels that generate a relatively stable appointment request rate which would allow practice managers to better plan their staffing needs to optimize continuity while meeting expected demand for appointments. One strategy is to populate each panel with patients from categories that generate appointment request rates which are negatively correlated with each other. In a context where there are two categories of patients, this means that when the request rate from one group is high, the request rate from the other group tends to be low and vice versa. When there are many groups, this is equivalent to choosing the panel composition such that the
total variation in request rates is minimized given an expected level of requests. This principle was first proposed by Markowitz (1952) (24) in the context of designing a diversified portfolio of assets. Our results indicate this concept can be applied to the design of physician panels to maximize timely access to, and continuity of, care.

We compare the results from our optimal panel design arrived at through our numerically solved Stochastic Linear Program with two other designs, also using discrete event simulation. The first, which we call the baseline design, is the design currently used by the PCIM practice. The baseline design allows a comparison of the optimal design with current practice, and helps benchmark the improvements in timely access and continuity that can be expected if the practice were to reallocate its patients optimally.

We also compare the optimal design with a simpler and easier to implement rule of thumb that we call capacity-based panel design. We construct these panels as follows: we tabulate each physician’s average share of the total average weekly capacity of the group practice. So, if physician A sees patients on average for 40 hours a week out of a total of 200 hours of patient-time by the group, her share is 20%. We use this proportion to calculate her share of each category of patients, that is, physician A is assigned 20% of each category. Thus, the capacity-based design is an intuitive allocation that allows us to evaluate the performance of a practice in which panels are balanced based on average physician capacity.

**Case Study: Adding New Patients to the Practice**

Our age-sex categorization reveals that in this particular primary care practice, younger adults of both sexes tend to ask for appointments less often. What would happen to the access metrics if we increased the number of patients from these categories? As the
demand for primary care doctors increases in the United States, practices are routinely faced with decisions regarding whether to empanel new patients. In panels that had young patients, we increased the number of such patients by 25% which corresponded to 3500 more patients in the system. We analyze how the different panel designs perform under this scenario.

RESULTS

Baseline Design

As displayed in Table 1, based on the actual assignment of patients to PCPs, the mean waiting time was 0.81 weeks and there were on average 400 redirections to other physicians per week.

Capacity-based Design

The bottom row in Table 1 shows that the capacity-based design produces an average waiting time of 0.42 weeks and 218 redirections to other physicians per week. Note that this design is 49% better in wait time and 46% better in the number of weekly redirections relative to the baseline.

Optimal Design

Table 1 shows that the optimal design reduces wait time by 57% [95% CI: 54.5%-59.5%] and the number of weekly redirections by 54% [95% CI: 51.8% - 56.2%].

Clinic Utilization
Table 2 shows the average number of unfilled slots (unused capacity) and the additional or extra slots the clinic had to create to meet urgent requests. Note that in any given week, if one of the measures is positive, the other has to be zero. The numbers in the table are averages of the two measures over 52 weeks. The optimal design and capacity-based design require fewer extra slots to be created on average. However, they also have a higher number of unfilled slots on average per week.

**Increasing Panel Size**

Results are shown in Table 3. Waiting times and redirections increase under both the current and optimal designs. In sensitivity analysis the optimal design does better on both metrics with 2000 additional patients than the current design without additional patients. Our simulation suggests that this finding remains valid with up to 2500 additional low-request patients in the system. Moreover, fewer numbers of high-request patients, or some combination of the two, could also be added to the system.

**DISCUSSION**

Optimizing panel structure leads to reductions in wait times and maximizes continuity. A closer look at the model results reveals that the stochastic linear program algorithm better matches physician capacity with historical demand from each category of patients. Thus, physicians who have less patient-time on their schedule are given proportionally fewer patients from categories that tend to request more appointments and vice versa. The capacity-based design also performs quite well relative to the base-case for the same reason: physician capacities under this method are well matched with appointment demand.
The redesigned panels accommodate more patients by increasing the effective capacity of primary care practices: as demand for appointments is better matched to capacity, many patients, who would otherwise wait to see their own provider, no longer need to wait. In addition, fewer follow-up appointments need to be made. Both these factors increase the number of available slots in future periods.

Murray and Tantau (25-26) proposed the Advanced Access paradigm. In this approach, patients choose between an available same-day slot or a future appointment slot at a convenient time. Service providers are expected to flex their capacity to meet all same-day demand which forces the provider to absorb the uncertainty in daily demand. Furthermore, it may result in longer wait times for non-urgent patients. Savin, Green and Murray (27) proposed a method to determine the appropriate panel size to ensure timely access under this paradigm. Their approach applies, however, to a single physician, and does not consider the inevitable cross-coverage of patients by physicians other than the patient’s PCP that commonly occur in group practices. Furthermore, while the approach establishes the relationship between panel sizes with timely access, it does not consider the effect of panel compositions. In contrast, our approach designs primary care panels – considering both size and composition – for a group practice in such a way as to increase effective capacity and reduce the effect of uncertainty and variation in demand from week to week.

Patients could be classified in different ways. A simple addition to the current classification scheme would be to add some marker of patient-health, like chronic disease status. Several disease categorizations exist (e.g., ACGs, DxCGs, and the Medicare HCCs) which could be used to improve predictions of expected visit rates. These data
could be combined with Classification and Regression Tree (CART) Analysis(28) to choose appropriate categories.

Our research has important limitations. We do not consider patient and physician preferences which may play an important role in how panels are formed. In principle, practice managers could take these preferences into account, along with other factors described above, when designing panels. More importantly, panels are dynamic since over time, people age, are diagnosed with new conditions, and enter or leave the system for reasons other than their health. Good panel design should anticipate these changes. Indeed, a useful by-product of this constant state of flux is that opportunities exist to make incremental changes to the current panel design to transition to a more efficient design. In other words, existing panels could be reconstituted as patients enter or leave the practice. Lastly, we do not account for complex operational issues that may occur on a daily basis, including cancellations and no-shows – both of which are an important component of the regular running of an office practice.

CONCLUSION

We have evaluated the impact of improving the allocation design mechanism on access metrics like waiting time and continuity of care. We have also used this model to investigate whether additional patients can be empanelled under an improved design with the same number of providers and found this is possible. Our approach is similar to techniques used for the optimal design of a portfolio of assets.

There is a large set of policies that may help address the problem of primary care access shortage. These include alternative models of care, payments for coordination of
care, computer based care and other tools to facilitate non-visit care and self-directed care for some patients. No one policy or intervention will solve the problem by itself.

We believe that increasing the effective capacity of physicians using systems analytic methods is not only an important part of the solution but also a very cost-effective approach that should contribute to the better health status of patients in the panel.
REFERENCES

### Table 1. Baseline, Optimal and Capacity-based Designs

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<th>Wait Time</th>
<th>Redirections</th>
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<td><strong>Baseline Design</strong></td>
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<tr>
<td>Mean</td>
<td>0.817</td>
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<tr>
<td>95% CI</td>
<td>(0.80, 0.82)</td>
<td>(389.64, 404.84)</td>
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<td><strong>Capacity-Based Design</strong></td>
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<tr>
<td>Mean</td>
<td>0.424</td>
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<tr>
<td>95% CI</td>
<td>(0.409, 0.439)</td>
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<tr>
<td>95% CI</td>
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### Table 2. Utilization under the three designs

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<td>Mean</td>
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<td>95% CI</td>
<td>(90.90, 110.15)</td>
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Table 3. Effects of Increasing Panel Size

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Figure 1. Distributions of Weekly Visits.

Figure 2. Panel Design Example
Physician Panels: Period 1

Panel 1, Physician Capacity = 35

Panel 2, Physician Capacity = 35

Panel 3, Physician Capacity = 35

Patient Categories

Category 1

Category 2

Category 3

Panel 1, Physician Capacity = 35

Panel 2, Physician Capacity = 35

Panel 3, Physician Capacity = 35

Physician Panels: Period 2