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DISCUSSION OF "SPATIAL ACCESSIBILITY OF PEDIATRIC PRIMARY HEALTHCARE: MEASUREMENT AND INFERENCE"

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The Affordable Care Act's Medicaid expansions aim to provide primary care to more Americans by changing eligibility criteria and payments to providers. While these reduce financial barriers, Medicaid patients are still more likely than privately insured to report other barriers, including lack of transportation, lack of timely appointments, long clinic waiting times and limited hours [Cheung et al. (2012)]. And removing financial barriers does not necessarily increase primary care utilization; in fact, following health care reform in Massachusetts, emergency department care actually increased [Smulowitz et al. (2014)]. Other authors document preferences for emergency department care among low-income individuals [Kangovi et al. (2013)]. Most relevant to this discussion is that patients reported that hospitals were more accessible than ambulatory primary care.

In the paper under discussion, Nobels, Serban and Swann (2014) focus on *spatial accessibility* of primary care by developing a sophisticated method for assigning patients to nearby primary care physicians, studying three measures of accessibility given these assignments, and fitting spatially varying coefficient models to understand how accessibility varies with measurable factors. I will begin by describing the strengths of the approach and then discuss a few limitations and extensions.

The authors have gone to considerable trouble to build an assignment model that accounts for realistic features of both demand and supply sides. Their approach minimizes travel time subject to realistic constraints on both sides: physicians require a minimum panel size to stay in business, the proportion of physicians that accept Medicaid and Medicaid caseload vary, patients distribute among nearby physicians to minimize congestion, and patients with (without) cars are willing to travel no more than 10 (25) miles for primary care. Conditional on the assignments generated by this procedure, the authors study variation in three access measures: congestion, coverage (having a physician within the allowed travel maximum), and travel time by census tract and population (Medicaid vs. non-Medicaid). They also study policy interventions that alter three key parameters: the proportion of physicians accepting Medicaid, the proportion of Medicaid patients in physicians' panels, and the mobility of Medicaid patients. Finally, the authors consider how their accessibility measures co-vary across space with factors such as household income, racial diversity, unemployment and education.

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The authors assemble data about physicians (from Centers for Medicaid and Medicare Services) and the Medicaid population (from the Census Bureau) in Georgia and apply their assignment method at the census tract level. Limitations inherent in these data require several simplifications. For example, the distance from the census tract centroid to physicians' offices are used as the travel costs for all patients in a given census tract. Further, the authors lack information on which *particular* physicians accept Medicaid and their Medicaid caseloads, so they do some basic calculations using county-level Medicaid acceptance rates and Medicaid caseload by practice site (public hospital, community health clinic and private offices). Geographic misalignment limits identifying the Medicaid-qualified population with access to vehicles. Although the household income thresholds (by age) can be applied at the census-tract level, these data do not include information about vehicles. For that, the authors turn to the American Community Survey data on a 5% subsample of households in 63 regions of the state. The authors figure the vehicle rates for Medicaid-qualified households and other households. Presumably, they assume that these rates are constant over the census tracts within those regions. This is a reasonable approach and properly incorporates the correlation between low income and vehicle ownership.

The authors emphasize that the model is insensitive to the values of several parameters (Figures 2–5 in Appendix C). Travel cost and congestion were mostly flat across the ranges of the parameters, or could only get worse compared to the status quo. Congestion had some room for improvement with increasing minimum panel size. Moreover, none of the parameters differentially affected Medicaid patients' access. Differentially affecting Medicaid patients (in a positive way) is the policy goal, so clearly these parameters are not fruitful intervention targets. Thus, the authors examined three further parameters more likely to provide targeted impact: the proportion of physicians accepting Medicaid, their Medicaid caseloads, and the mobility of Medicaid patients relative to the rest of the population. Again, they found very little positive impact on Medicaid patients, though they were able to make things worse. For instance, reducing the proportion of physicians that accept Medicaid substantially increased travel times and reduced coverage.

Surprisingly, decreasing the maximum proportion of Medicaid patients in physicians' panels across the board *decreased* the congestion Medicaid patients (who manage to find a physician) face. This is not surprising given the correlation (described below) among the three measures. In general, coverage and travel cost appear to be negatively correlated with one another, while congestion is negatively related to coverage and mostly independent of travel cost. An intervention that increases coverage is likely to be accompanied by increased congestion and vice versa.

These are important and policy-relevant results because on their face, the proportion of physicians accepting Medicaid and Medicaid caseloads seem like reasonable places to look for policy interventions. In particular, raising Medicaid payment rates is meant to affect both. But as these authors demonstrate, there may be unintended consequences.

A second important result of the paper is the close correlation of the three accessibility measures: coverage, congestion, and travel time. In the three-dimensional space defined by coverage, travel time and congestion, only some quadrants are represented in the Georgia data. In particular, they almost never see high travel cost combined with either high coverage or low congestion. That is, where patients must travel long distances to find a physician, many do not have a physician at all and if they do, the congestion is high. Also, they almost never see low travel cost, low congestion and low coverage. That is, where patients have a nearby physician and there is little crowding, nearly everyone *has* a physician.

The maps make it clear that these access issues are strongly associated with urban/rural location. This is especially true for Medicaid patients. Either they live in a city with a robust supply of physicians and where high demand implies many will accept Medicaid, or they live in a rural area where there are simply too few physicians for the population. As the authors point out, "Among the 159 counties in Georgia, approximately $1/3$ have no pediatrician." The remaining approximately 107 counties have some 768 pediatricians; these are highly concentrated in the population centers, as shown by Appendix Figure 10 highlighting census tracts with higher than the statewide average accessibility. The cities stick out prominently.

The paper's Figure 3 highlights tracts where accessibility among Medicaid and other patient populations differ significantly. On coverage and travel costs, the non-Medicaid patients always do better. Counterintuitively, the Medicaid population has significantly lower congestion than others, especially in urban centers that are otherwise more congested than the statewide average. Looking closely, we see a hole in this map in north-central Atlanta. Examining several public data sources, we find that this area corresponds to the wealthiest, most educated section of the city (encompassing the authors' own institution, Georgia Institute of Technology) and where relatively fewer children live [Carnathan (2012)]. I was intrigued to see that the hole fills in and the areas of advantage to Medicaid patients expands when the assignment model assumes that Medicaid-accepting physicians take only *half as large a Medicaid caseload* (Appendix Figure 9). These results are likely driven by inelastic supply and the limitations on capacity for Medicaid patients. In rural areas with limited physician supply, the whole population faces long travel time and low coverage, so reducing Medicaid caseloads frees up coverage (and reduces travel time) for the non-Medicaid population.

In a physician-rich area such as the city center, patients are unconstrained by travel costs and can choose the closest from among a relatively large set of physicians. Very few Medicaid patients are assigned to physicians in the wealthiest area of town and, therefore, we see no statistical evidence in those areas for an advantage to Medicaid patients. When all physicians, including those who practice in poor areas of the city, accept a lower Medicaid caseload, Medicaid patients may need to travel to a physician in these wealthier areas of the city where they then enjoy the same congestion advantages as they do in other areas. In general, where physician supply is abundant, reducing Medicaid caseloads may require Medicaid patients to travel slightly further, but when they do, they experience lower congestion.

The third major contribution of the paper (after the assignment algorithm and the studies of geographic and population variation in the three accessibility measures) is a set of spatially varying coefficient models that attempt to associate accessibility with measurable characteristics: household income, higher education, unemployment, nonwhite population, population density, distance to hospitals, and a diversity ratio. The model fitting is complex, with penalized splines and backfitting, such that it is not entirely clear what models generated the coefficients in the paper's Table 3. Also, the scales of the variables are not comparable, so it is difficult to compare the scale of the effects (or widths of the confidence intervals). Nevertheless, the directions of the effects are mostly intuitive. Travel time is lower in areas with higher education, lower unemployment, more hospital access and more diversity. One exception to the generally sensible coefficients is that of income, which is *positively* associated with travel time. Another exception is the space-varying coefficient for distance to hospitals; the effect actually changes sign from negative in Atlanta to positive in the most rural areas. Neither of these results is explained much by the authors. In the real world, travel cost may be discounted in higher income households, that is, wealthier families can afford to live farther from physicians. However, the authors' assignment model does not allow physician choice to depend on household income, so this cannot explain the results. The authors do suggest that some fit statistics indicated models were better without income.

The sign reversal for the distance to hospitals coefficient in Atlanta versus the rural areas may also be an issue of competition between effects. In dense urban areas where the distance to hospitals is low for nearly everyone, models with several other predictors may have trouble allocating the remaining variation in distance to hospitals in a sensible way.

Population density is the closest covariate to indicating urban/rural and it is varying in space though negative everywhere, as we expect (travel cost increases with decreasing density). The strongest coefficients are in the most rural areas and nearly zero in the urban centers. This mirrors the pattern for racial diversity. Both of these indicate that the effects on travel time are strongest where physician supply is lowest.

There are several interesting extensions and applications of these methods. The results here suggest that most potential improvement in Medicaid patients' access to pediatricians is by re-allocating the supply of physicians to areas where they are needed more. The authors mention interventions along these lines in Section 4.3, such as loan repayment for practicing in rural areas and telemedicine. Rather than conditioning on the locations of physicians and altering their characteristic, these methods can be used to alter the *locations* of the physicians and apply allocation methods conditional on various arrangements to study accessibility.

Another potential application is comparing these optimization approaches to others used by managed care organizations to assign enrollees to providers when they do not choose a primary care physician themselves. In this case, patients' exact locations are known and the supply of physicians is more limited compared to the Georgia example of the paper. Thus, it could be useful to compare the current approaches of managed care plans to assigning new enrollees (those who do not elect a physician) to population-oriented approaches such as the constrained optimization developed in this paper. Another related area of application would be to examine the impacts on access of narrow network policies being implemented by many payers.

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