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Implications for cost and access of site-of-service referrals for ancillary medical services in a US Medicaid population: analysis of claims data from Maryland, USA

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ABSTRACT

Objectives Through analysis of claims and payment data, we quantified several implications of shifting ancillary healthcare services from regulated, more expensive to unregulated, less expensive sites. We also quantified the implications of this shift on access to services, with a focus on differences in access between rural and urban patients for a Medicaid (disadvantaged) population in Maryland, USA.

Design Using a dataset of all Medicaid claims records for 1 year, we identified and extracted all bundles of regulated and unregulated ancillary services. Geospatial computing was used to approximate transportation costs required to access services. Including transportation enabled us to estimate net savings of any added transportation costs. We used location-allocation optimisation models to find the optimal sites to minimise net costs.

Setting Coverage area included Medicaid patients throughout the state of Maryland.

Participants All rural and urban members of this Medicaid cohort.

Primary and secondary outcome measures Change in payer costs and member travel times on shifting ancillary bundles from regulated to unregulated sites.

Results Procedure cost and travel time differentials between regulated and unregulated sites strongly correlated with the percentage of procedures referred to regulated sites. Shifting regulated bundles to unregulated sites, while imposing the constraint of no increase in travel time, reduced expenditures by 15.9%. This figure exceeded 30% if no limit was placed on travel-time increases.

Conclusion With reasonable constraints on allowable travel time increases, shifting ancillary service bundles from regulated to unregulated sites can benefit both patients and payers in terms of cost and access.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study comprehensively evaluated site-of-service referral of medical ancillary services for a large population over 1 year.
⇒ Evaluation took travel costs and times into consideration.
⇒ Analysis considered the differential impact of referrals on cost for urban and rural populations.
⇒ Data were limited to one state and Medicaid population.
⇒ Assumptions were made that quality was not compromised and that capacity was adequate.

INTRODUCTION

Several states in the USA use a regulatory framework that treats some medical service entities differently from others that provide the same care. For example, in Maryland, hospitals are generally subject to oversight from the Health Services Cost Review Commission and thus have limited variance in charged rates. Such facilities primarily use a fee-for-service payment model and are often referred to as 'regulated spaces'. The fees include a relatively high 'technical' fee that significantly raises reimbursement; the technical fee is intended to partially recoup higher costs that are incurred for care of patients who are unable to pay, use of high-cost equipment and educating medical trainees. However, in many instances, the same service can be offered in a facility that is not subject to such regulations. These locations are often referred to as 'unregulated spaces' and may include free-standing offices or laboratories. Unregulated spaces typically have a lower cost structure because they are more specialised. Specialised services in such facilities can range from complex procedures to simpler 'ancillary services', such as radiology and diagnostic imaging, ultrasound, radiation oncology therapy, breast mammography, laboratory services and infusion therapy.

Policies meant to drive patients from regulated space to unregulated space adhere to strict standards intended to ensure adequate quality of care. Evidence to date suggests that free-standing ambulatory surgical centres provide the same or better quality of care than their regulated counterparts.[1 2] Some researchers have investigated potential cost savings that may result from moving selected surgical procedures and services from regulated to unregulated spaces. For instance, Higgins *et al*[3] considered seven procedures/services and found that price differences were significantly lower in private offices and ambulatory surgical centres than in hospital outpatient departments. On the other hand, Kalidindi *et al*[4] found that risk-adjusted chemotherapy drug spending was significantly higher in private offices. In a related study, Shoostari *et al*[5] looked at several outcomes including cancer-related outpatient services other than chemotherapy; in these cases also, risk-adjusted spending was slightly higher in private offices. Interestingly, risk-adjusted in-patient spending was lower for the patients associated with private office care. Resneck[6] considered parallel issues for drug prices. In contrast, Dada *et al*[7] found that by carefully selecting only episodes of care (EOCs) that have potential to yield cost savings, savings per EOC from site-of-service referrals for surgical procedures can be substantial. However, relatively little published work has focused on quantifying cost savings that may be realised from referring patients to unregulated space for ancillary services.

The reduced focus on ancillary services stems in part from the fact that charges and reimbursements per occurrence are typically much lower than those for surgery or other complex services. Given the relatively modest reimbursement rates for medical ancillary services, it is possible that offsetting costs related to travel and coordination would outweigh the potential savings from implementation of a site-of-service referral policy for ancillary services. In this study, we explored this issue by estimating the net travel cost-adjusted savings achieved by shifting movable regulated pure ancillary care episodes (not bundled with inpatient care as in Kalidindi *et al*[4] or Shooshtari *et al*[5]) to unregulated sites. We estimated the net savings under various restrictions on allowable increases in travel time and calculated the net change in travel times for different patient groups and service categories. We found that even after taking travel considerations into account, substantial savings can be realised by directing appropriately chosen patients to unregulated spaces.

METHODS

Data

Our study was based on data provided by Priority Partners Managed Care Organization (PPMCO), which is co-owned by Johns Hopkins HealthCare, part of the Johns Hopkins Medical Institutions. This affiliation facilitated access to the following:

1. Deidentified member data: date of birth, gender, five-digit zip code, county and primary care physician ID for all 404 066 unique members.
2. Healthcare services provider data: national provider identity, name and full address of each healthcare provider covered under the PPMCO plan.
3. Deidentified claims data: claim line number; claim number; claim line status (paid/unpaid); claim status (paid/unpaid); member ID; admission and discharge dates; current procedural terminology (CPT) code and description; CPT code group and range description; diagnosis codes entered by the provider; place of service (hospital outpatient department, physician office, emergency department, etc); amount billed by the provider; amount paid by PPMCO; billing, rendering and referring providers' numbers; and vendor number for each service item procured by a member.

In this work, we focused on claims data for one policy year (1 October 2018 to 30 September 2019). During a policy year, service rates for procedures remain unchanged, ensuring that the estimated savings from a counterfactual (retrospective) shifting of episodes is accurate.

Patient and public involvement

No patients were involved.

Defining pure regulated and unregulated ancillary services

We defined ancillary services as those belonging to one of the following categories: diagnostic radiology (diagnostic imaging) procedures, radiation oncology treatment, diagnostic ultrasound procedures, breast

Table 1 Total pure ancillary claim amounts for different CPT ranges

CPT range	Pure ancillary (US$)	Pure regulated ancillary (US$)	Pure unregulated ancillary (US$)
Breast mammography	~1.6 million	~0.3 million	~1.3 million
Diagnostic radiology (diagnostic imaging) procedures	~3.4 million	~0.8 million	~2.6 million
Diagnostic ultrasound procedures	~3.3 million	~0.8 million	~2.5 million
Other procedures	~1.9 million	~0.9 million	~1 million
Radiation oncology treatment	~3.8 million	~2.5 million	~1.3 million
Total	~14.0 million	~5.3 million	~8.7 million

CPT, current procedural terminology.

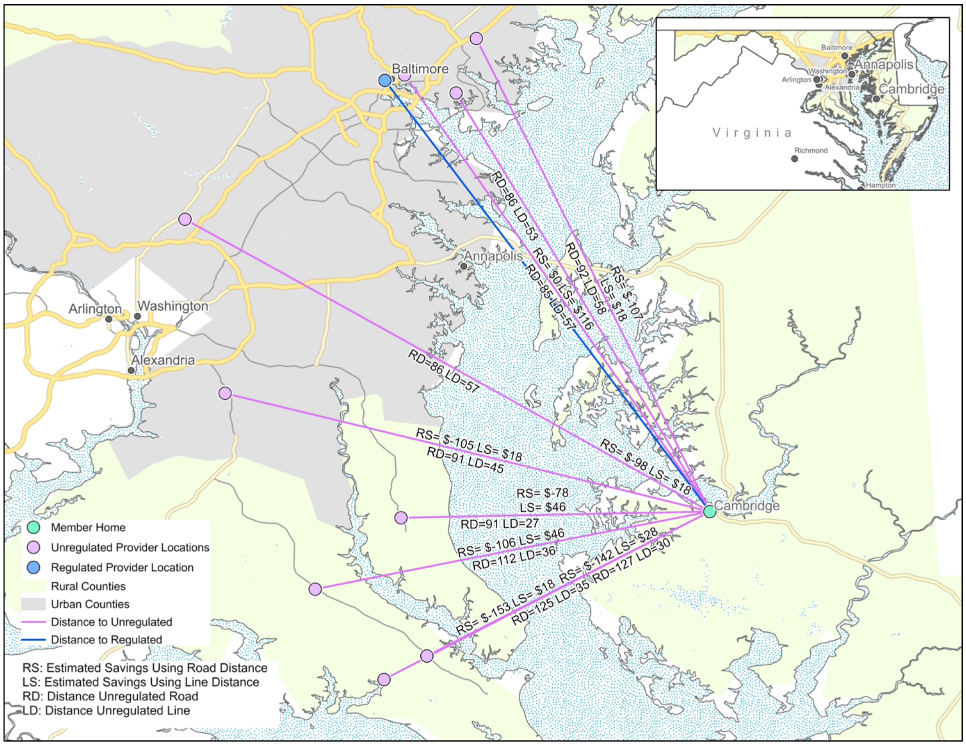

Figure 1 Road network of Maryland. Road distances are significantly longer than straight-line distances.

mammography and other laboratory and pathology procedures. These categories were indicated by ranges of CPT codes. The CPT code of service determines the amount paid by an insurer (or a managed care organisation) to the provider. Online supplemental appendix contains the complete list of CPT codes that qualify as ancillary services.

Claims were omitted from analysis if a charge for an ancillary service coincided with other services whose codes did not qualify as ancillary services (eg, surgery). We refer to the remaining occurrences as pure ancillary services. The total payment for ancillary services over the policy year was roughly US$96.7 million. Of that amount, US$14 million was paid for pure ancillary services (ie, those that did not coincide with non-ancillary services). The pure ancillary service amounts were divided over a range of CPT codes as shown in table 1.

We defined regulated ancillary services as those for which all claim line items listed the place of service as the hospital outpatient department. We defined unregulated ancillary services as those for which all claim line items had the place of service as one of the following: ambulatory surgery centre, mobile unit, telehealth, office visit, walk-in retail health clinic, off-campus outpatient hospital, urgent care facility, birthing centre, independent clinic, federally qualified health centre or independent laboratory.

We defined an EOC as a unique combination of member ID, admission and discharge dates, and provider address. Separating EOCs into 'bundles' for each CPT range (where a bundle was a unique combination of member ID, admission and discharge dates, provider address and CPT range) expanded the number of categories but allowed us to conduct a more nuanced analysis. For example, when defined as unique combinations of member ID, admission and discharge dates, and provider address, pure regulated ancillary episodes numbered 15 614. In contrast, when we split the episodes further by CPT range, the number increased to 16 132.

Estimating road travel times and distances

We used a Geographic Information System (GIS) and network analysis to calculate travel time between home five-digit zip code and provider locations. Because we were given member zip codes, but not home addresses, we used the centroid of the zip code as the virtual home address. Exact addresses for each provider were used. Travel distance was calculated, along with a street network that factored in speed, road type, traffic, stop signs and traffic lights. We used ArcGIS StreetMap Premium, a proprietary street network database, to calculate drive distance and drive time.

The geography of Maryland causes some gaps between straight-line distances and driving distances to be significant. For example, a map of Maryland (figure 1) shows that due to limited transit choices over the Chesapeake Bay, the driving distance between Cambridge and Baltimore is 85 miles, whereas the straight-line distance is approximately 57 miles. Figure 1 also shows the estimated net savings (reduced procedure costs minus incremental costs of travel) from shifting an EOC for a Cambridge resident from a regulated site in Baltimore

City to alternate unregulated sites. In this instance, the estimated savings with line distances would have been positive, whereas the realised savings using drive times would have been negative, suggesting that shifting episodes using straight-line travel estimates may overestimate some benefits.

Optimal unregulated site of ancillary service for a movable regulated bundle

Let 'r' be the address of a regulated facility, and $\boldsymbol{B}_{m,r}$ a bundle of services procured by a member with address 'm' at facility r. Let $\boldsymbol{U}$ be the set of all unregulated provider addresses and $\boldsymbol{S}_u$ be the set of services offered at the provider address $u \in \boldsymbol{U}$. Let $\boldsymbol{C}_{s,u}$ be the cost of service 's' offered at the unregulated address 'u'. For each bundle $\boldsymbol{B}_{m,r}$, we defined the optimal unregulated site of service as one that minimised the sum of the costs of all services in $\boldsymbol{B}_{m,r}$ and the incremental cost of travel $\boldsymbol{C}_\tau\left(u,m,r\right)$ (reimbursed by PPMCO to member for being redirected from the regulated/preferred site). Then, the optimal site is:

$$u^*\left(\boldsymbol{B}_{m,r}\right) = \operatorname{argmin}_{u\in \boldsymbol{U}}\left\{\sum_{s\in B_{m,r}} \boldsymbol{C}_{s,u} + \boldsymbol{C}_\tau\left(u,m,r\right)\right\} \tag{1}$$

Let $\tau_d\left(x,y\right)$, $\tau_t\left(x,y\right)$ denote the travel distance and the travel time, respectively, between addresses x and y. If we constrain the maximum increase in travel distance and travel time to be less than K_d and K_t, respectively, then the optimal constrained site of service is

$$u^*\left(\boldsymbol{B}_{m,r}|K_d,K_t\right) = \operatorname{argmin}_{u\in \boldsymbol{U}}\left\{\sum_{s\in B_{m,r}} \boldsymbol{C}_{s,u} + \boldsymbol{C}_\tau\left(u,m,r\right)\right\}$$

$$\text{subject to: } \tau_\mathrm{d}\left(\mathrm{m,u}\right) - \tau_\mathrm{d}\left(\mathrm{m,r}\right) \le \mathrm{K_d} \text{ and } \tau_\mathrm{t}\left(\mathrm{m,u}\right) - \tau_\mathrm{t}\left(\mathrm{m,r}\right) \le \mathrm{K_t} \tag{2}$$

Estimating the incremental cost of travel

We assumed that the travel cost $\boldsymbol{C}_\tau\left(u,m,r\right)$ is the one-way Uber fare from the member address 'm' to the unregulated site 'u' if and only if the travel distance to the new unregulated address ($\tau_d\left(m,u\right)$) was more than that to the current regulated address ($\tau_d\left(m,r\right)$). (We used a one-way rather than a two-way fare to account for ride sharing or other economies of scale that may be leveraged). An internet search for the Uber fare formula in Maryland showed that Uber charges a fixed base fare for each booking (C_0), a constant cost per minute travel time (C_t) and a constant cost per mile travel distance (C_d). It also charges a minimum fare regardless of the travel time or distance (C_{min}). The cost of travel is given by:

$$\mathrm{C}_\tau\left(u,m,r\right) = \begin{cases} 0, & if\, \tau_d\left(m,u\right) < \tau_d\left(m,r\right) \\ \max\left\{C_{min}, C_0 + C_d * \tau_d\left(m,u\right) + C_t * \tau_t\left(m,u\right)\right\}, & if\, \tau_d\left(m,u\right) \ge \tau_d\left(m,r\right) \end{cases}$$

For this study, we used the parameters C_{min} = US\$6.55, C_0 = US\$1.00, C_d = US\$1.21 and C_t = US\$0.11.

Estimating savings through referrals to unregulated sites for ancillary services

We retrospectively estimated the savings that 'could have been realised' by shifting all movable regulated bundles for the period 1 October 2018 to 30 September 2019 to their optimal unregulated sites of service. Maryland has 462 unique 5-digit zip codes and 7693 unique provider addresses. To make the problem computationally tractable, our approach defers the distance computation to the last step in our five-step algorithm.

Step 1: identify all movable regulated bundles of ancillary services

We retrieved all pure regulated ancillary bundles but excluded the subset in which the member had an emergency visit within 7 days before the admission date or 30 days after the discharge date. There were 16 132 such bundles.

Step 2: find the costs of ancillary services at unregulated sites of service

We constructed a rate card for each pure unregulated service at different provider addresses. For each provider address in pure unregulated claim line items, we found the list of all procedure codes performed at that address. Because it is possible that the claims data can record more than one cost for the same procedure at the same unregulated site, we conducted the entire analysis twice under two separate assumptions:

1. $\boldsymbol{C}_{s,u}$is the minimum cost of service s at site u to get the maximum savings.
2. $\boldsymbol{C}_{s,u}$is the average cost of service s at site u to get the average savings.

Step 3: find all feasible unregulated sites for each movable regulated bundle

For each bundle $\boldsymbol{B}_{m,r}$, we found the set of feasible unregulated sites $\boldsymbol{U}\left(\boldsymbol{B}_{m,r}\right)$ that gave positive savings under zero cost of travel: $\boldsymbol{U}\left(\boldsymbol{B}_{m,r}\right) = \left\{u: \sum_{s\in B_{m,r}} \boldsymbol{C}_{s,u} < \sum_{s\in B_{m,r}} \boldsymbol{C}_{s,r}\right\}$, where $\sum_{s\in B_{m,r}} \boldsymbol{C}_{s,r}$ is the current cost of the bundle at the regulated site r. We made a simplifying assumption that if a service 's' in $\boldsymbol{B}_{m,r}$ is not present for site u (in the dataset), then $\boldsymbol{C}_{s,u} = \boldsymbol{C}_{s,r}$. We found at least one feasible unregulated site for 15 614 of the 16 132 bundles. These had 4234 unique combinations of member zip codes and regulated provider addresses, and 61 722 unique combinations of member zip codes and feasible unregulated provider addresses. We found the travel distances, times and costs for all of the 4234+61 722 address combinations.

Step 4: find the best unregulated site for each movable regulated bundle

For each movable regulated bundle $\boldsymbol{B}_{m,r}$, we solved the optimisation problem (1) to find the best unregulated site with no constraint on travel distance/time. We solved the optimisation problem (2) to find the best unregulated site under the following constraints: (a) increase in travel time less than 15 min ($K_t = 15$); (b) increase in travel time less than 5 min ($K_t = 5$); and (c) no increase in travel time ($K_t = 0$). The

Table 2 Consumption of different ancillary services by rural and urban members

CPT range	Total number of procedures	Percent regulated	Regulated			Unregulated			ΔC (%)	Δ (%)
			Average cost per procedure (US$)	Average travel time (min)	Average bundle size	Average cost per procedure (US$)	Average travel time (min)	Average bundle size		
Breast mammography										
Rural	5787	17	242	27.5	1.4	92	29.7	1.9	62	8
Urban	10 664	3	238	17.3	1.8	84	27.8	1.8	65	61
Diagnostic radiology (imaging) procedures										
Rural	13 318	25	135	38.4	1.3	117	44	1.2	13	15
Urban	14 848	13	163	22.8	1.4	107	27.7	1.2	34	21
Diagnostic ultrasound procedures										
Rural	12 295	14	195	32.9	1.3	99	56.1	1.4	49	71
Urban	18 742	15	165	17.9	1.7	92	24.4	1.3	44	36
Other procedures										
Rural	29 528	56	30	24.6	3.5	23	52.6	2.6	23	114
Urban	47 799	8	107	22.6	2	16	32.9	3.1	85	46
Radiation oncology treatment										
Rural	3925	64	431	26.5	4.5	316	53.7	2.3	27	103
Urban	5146	55	486	24.6	3.1	371	26.2	2	24	7

CPT, current procedural terminology; Δ (%), percentage increase in average travel time at unregulated site (compared with a regulated site); ΔC (%), percentage decrease in average cost at an unregulated site (compared with a regulated site).

net savings from shifting each movable regulated bundle $\boldsymbol{B}_{m,r}$ to the optimal unregulated service site is $[\sum_{s\in B_{m,r}} \boldsymbol{C}_{s,r} - \left(\sum_{s\in B_{m,r}} \boldsymbol{C}_{s,u^*(\boldsymbol{B}_{m,r})} + \boldsymbol{C}_{\mathcal{T}}\left(u^*\left(\boldsymbol{B}_{m,r}\right), m, r\right)\right)]$. Adding the savings over all the movable bundles gave us the maximum total savings.

RESULTS

Current consumption and travel patterns for ancillary services

For each CPT range and member type (urban/rural), table 2 shows the total number of procedures, percentage of regulated procedures, average cost per procedure, travel time and bundle size for regulated and unregulated visits. (Maryland has 24 counties. Members from Baltimore City and the following five counties were classified as urban: Anne Arundel, Baltimore, Howard, Montgomery and Prince George's). Table 2 also shows the cost differential ΔC and the travel time differential $\Delta\tau$ between regulated and unregulated sites for each CPT range and member type:

$$\Delta C = \frac{\text{average cost regulated} - \text{average cost unregulated}}{\text{average cost regulated}} * 100$$

$$\Delta\tau = \frac{\text{average travel time unregulated} - \text{average travel time regulated}}{\text{average travel time regulated}} * 100$$

CPT ranges (procedure types) vary significantly along the dimensions of volume (total number of procedures) and cost (average cost per procedure). The CPT range of 'other procedures' had the greatest volume and the lowest cost per occurrence on average. In contrast, radiation oncology treatment had the lowest volume and the greatest cost on average. The other CPT ranges fell somewhere in between.

We found that even for the same CPT range, the dimensions of cost, access (average travel time) and bundle sizes (number of procedures pooled in one visit) varied substantially across rural and urban members and regulated and unregulated providers. Most notably, rural members travelled significantly more to access unregulated services than did their urban counterparts (except for breast mammography procedures). Rural members also incurred marginally higher costs for unregulated services than did urban members (except for radiation oncology treatment). When the travel time differential across regulated and unregulated providers was extremely high (greater than 100%), rural members had much bigger bundles for regulated visits. These data suggest that poor access to unregulated sites may motivate rural members to pool more procedures into a single visit, and to shift demand from unregulated to regulated space.

Figures 2 and 3 contain heat maps of the total claim amount (total expenses) and average travel times for regulated and unregulated sites, placed geographically over members' addresses. The darker the green, the greater the claim amount, and the darker the orange, the greater the travel time. Figures 4 and 5 contain the heat maps of total regulated and unregulated claim amounts, respectively. The darker the green or the purple, the more is the total regulated or unregulated expense in an area, respectively.

Consider the results for two CPT ranges that differed significantly along volume and cost—breast mammography and radiation oncology treatment. Most breast mammograms are simple—X-ray examinations to

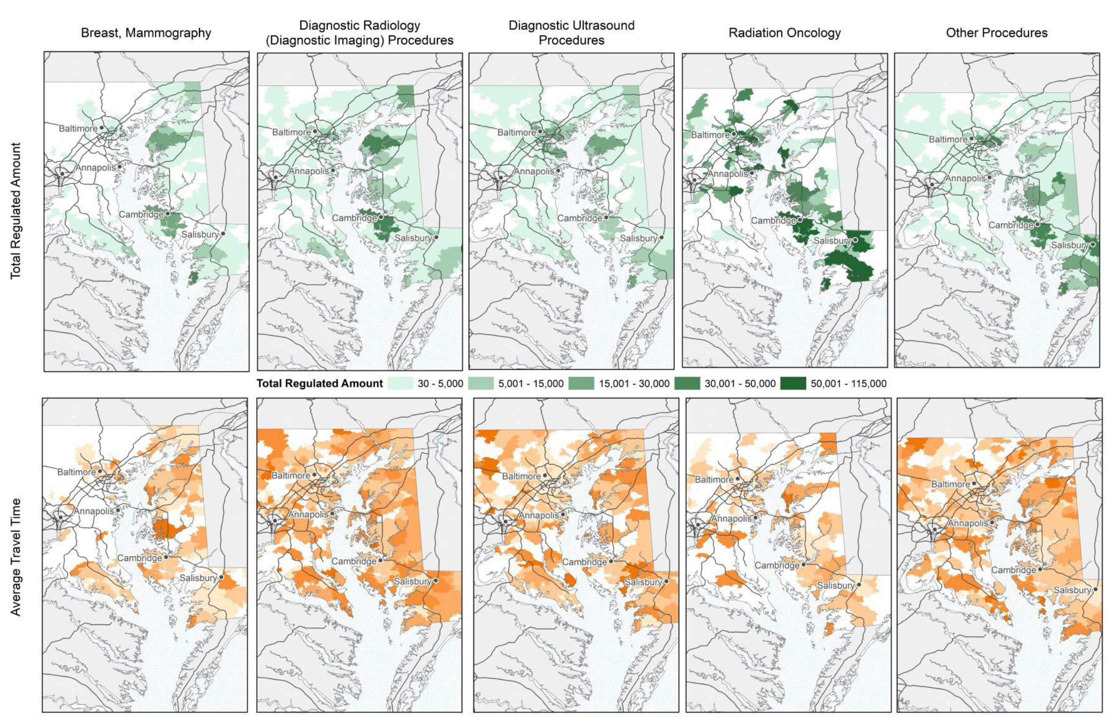

Figure 2 Pure regulated movable amount and travel time (min) mapped over members' addresses.

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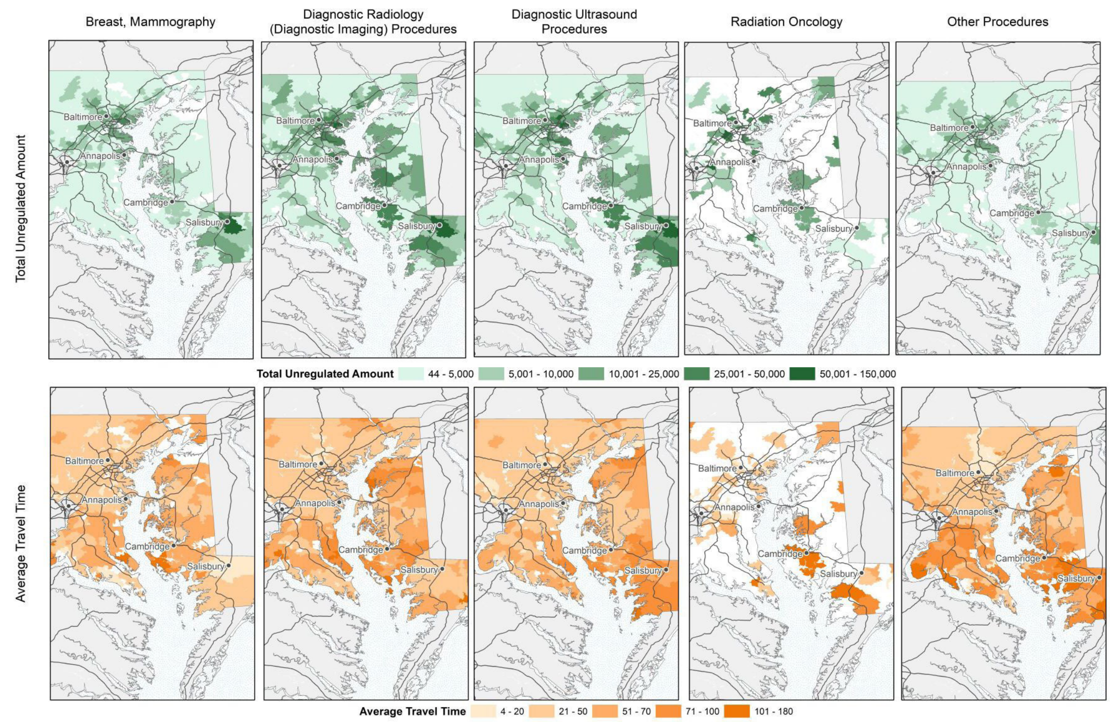

Figure 3 Pure unregulated amount and travel time (min) mapped over members' addresses.

detect breast cancers, benign tumours and cysts—and can be performed at many unregulated sites. In contrast, radiation oncology treatment is often complex and requires specialised skills and equipment, with a limited set of unregulated options.

Breast mammography for urban members has significantly less green in figure 2 and much more green in figure 3. Table 2 shows that less than 3% of breast mammograms for urban members were performed at regulated sites. Figure 3 shows significantly less claim amount for regulated providers in urban areas. For rural areas, the regulated amount was evenly distributed across member and provider geographies, whereas the unregulated amount was concentrated on some provider hotspots, most of which were in urban areas.

The regulated claim amount for radiation oncology treatment was widespread across urban and rural members. The unregulated amount, on the other hand, was more restricted to urban members. Nevertheless, clear hotspots of regulated providers were scattered across both rural and urban areas. The hotspots of unregulated providers, on the other hand, were scattered only in urban areas. Table 2 confirms what one infers visually from the heat maps—rural members travel significantly longer (about twice as much) for unregulated sites than do their urban counterparts.

Net travel-adjusted cost savings and changes in travel times

Tables 3–6 show the maximum possible net travel-adjusted savings and average change in travel times after

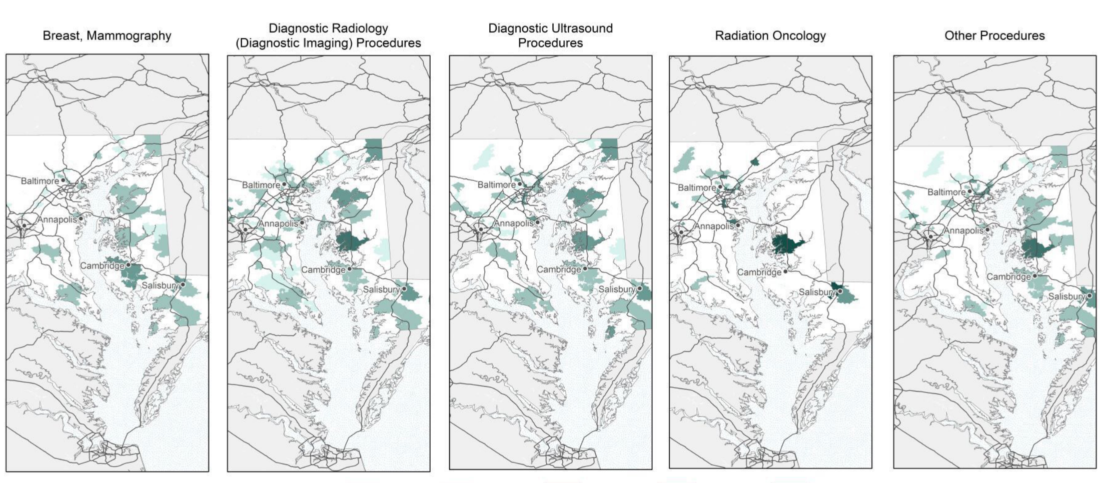

Figure 4 Distribution of pure regulated movable amount mapped over providers' addresses.

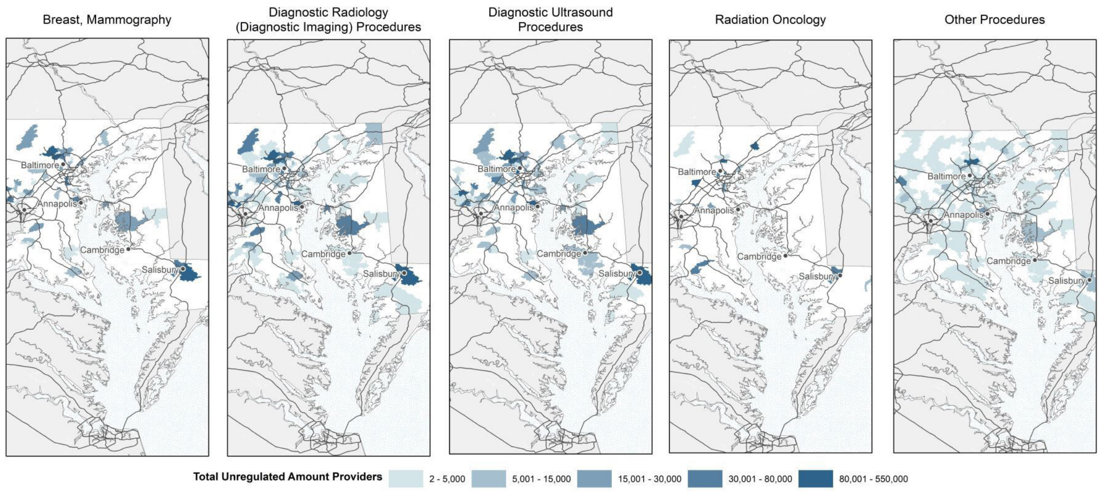

Figure 5 Distribution of pure unregulated amount mapped over providers' addresses.

shifting the pure regulated movable bundles to unregulated sites for assumption 1 that $C_{s,u}$ is the minimum cost for service at unregulated site u, under different constraints. For each constraint, we also determined the number of bundles that were shifted without any increase in travel times. Online supplemental table 1–4 show the maximum possible average savings for assumption 2 that the cost $C_{s,u}$ is the average cost for service s at unregulated site u. The total savings with no constraint on travel time was about US\$5.1 million under assumption 1 and about US\$4.2 million under assumption 2. Interestingly, even without any constraint on travel time increase, about 55% of the shifted bundles (under either assumption) led to a reduction or no change in travel time.

However, shifting episodes to unregulated sites without constraining travel time increased travel time disparity between rural and urban members. For radiation oncology treatment, the average change in travel time for rural members was 33 min and the average increase was 79 min (under assumption 1), compared with 18 and 32 min, respectively, for their urban counterparts. Already, the rural members travel 20–30 min more than urban members. The exacerbation of the disparity in travel times between rural and urban members on shifting the

Table 3 Maximum possible savings under no constraint

CPT range description	Total bundles	Total matched bundles	Total savings (US\$)	Average change in travel time (min)	Average increase in travel time (min)	Bundles with no increase in travel
Breast mammography						
Rural	691	539	248 555	22.2	39.3	226
Urban	196	187	85 680	5.1	15.1	50
Diagnostic radiology (imaging) procedures						
Rural	2632	1671	301 000	13.4	42.2	897
Urban	1384	890	257 422	3	20.8	489
Diagnostic ultrasound procedures						
Rural	1388	981	338 610	7	27.7	524
Urban	1740	1656	480 340	2.9	12.3	775
Other procedures						
Rural	4769	2110	268 243	8.7	36	1577
Urban	1810	1403	337 591	0.1	16.7	908
Radiation oncology treatment						
Rural	550	508	1 157 082	33.1	72.9	248
Urban	913	862	1 649 800	18.3	32.4	298
Overall	16 073	10 807	5 124 323	9.3	29.8	5992

CPT, current procedural terminology.

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Table 4 Maximum possible savings under travel time increase less than or equal to 15 min

CPT range description	Total bundles	Total matched bundles	Total savings (US$)	Average change in travel time (min)	Average increase in travel time (min)	Bundles with no increase in travel
Breast mammography						
Rural	691	324	120 812	–3.4	5.3	237
Urban	196	158	79 470	–2.8	8.7	78
Diagnostic radiology (imaging) procedures						
Rural	2632	1203	169 741	–9.3	5.5	955
Urban	1384	810	196 755	–5.5	6.2	564
Diagnostic ultrasound procedures						
Rural	1388	766	225 063	–6.8	6.1	561
Urban	1740	1611	449 276	–1.1	6.4	854
Other procedures						
Rural	4769	1739	88 056	–6.6	1.5	1606
Urban	1810	941	119 045	–6.9	4.2	715
Radiation oncology treatment						
Rural	550	354	607 908	-6	6.9	324
Urban	913	799	1 242 945	–5.5	4.9	590
Overall	16 073	8705	3 299 071	–5.6	5.6	6484

.CPT, current procedural terminology.

regulated bundles to unregulated sites held for all CPT ranges.

As one would expect, imposing constraints on the allowable increase in travel time reduced the number of matched bundles and, therefore, savings. However, the savings were still substantial and came with the bonus of reducing travel times for both urban and rural members. As we tightened the allowable increase in travel time from unrestricted to 15 min, to 5 min and to 0 min, the savings decreased at a diminishing rate—from US$5.1 million to US$3.3 million, to US$3 million, to US$2.8 million under assumption 1, and from US$4.2 million to US$3 million,

Table 5 Maximum possible savings under travel time increase less than or equal to 5 min

CPT range description	Total bundles	Total matched bundles	Total savings (US$)	Average change in travel time (min)	Average increase in travel time (min)	Bundles with no increase in travel
Breast mammography						
Rural	691	267	82 063	–6.6	1	241
Urban	196	138	71 272	–9.1	1.6	119
Diagnostic radiology (imaging) procedures						
Rural	2632	1092	152 148	–12	1.5	980
Urban	1384	757	172 082	–8.1	2.1	625
Diagnostic ultrasound procedures						
Rural	1388	706	190 971	–9.3	1.9	598
Urban	1740	1488	400 869	–4.6	2.2	1090
Other procedures						
Rural	4769	1704	83 201	–7.1	0.5	1622
Urban	1810	907	101 889	–8.2	2.1	752
Radiation oncology treatment						
Rural	550	347	583 865	–7.3	0.3	346
Urban	913	778	1 133 237	–6.8	2.4	622
Overall	16 073	8184	2 971 597	–7.7	2.0	6995

.CPT, current procedural terminology.

Table 6 Maximum possible average savings with no increase in travel time

CPT range description	Total bundles	Total matched bundles	Total savings (US$)	Average change in travel time (min)	Average increase in travel time (min)	Bundles with no increase in travel
Breast mammography						
Rural	691	253	76 892	−7.3	0.0	253
Urban	196	129	65 333	−10.5	0.0	129
Diagnostic radiology (imaging) procedures						
Rural	2632	1013	141 047	−14.1	0.0	1013
Urban	1384	698	151 446	−10.1	0.0	698
Diagnostic ultrasound procedures						
Rural	1388	659	180 029	−11.4	0.0	659
Urban	1740	1352	361 437	−6.8	0.0	1352
Other procedures						
Rural	4769	1659	78 347	−7.5	0.0	1659
Urban	1810	827	82 531	−10	0.0	827
Radiation oncology treatment						
Rural	550	347	583 865	−7.3	0.0	347
Urban	913	739	1 051 931	−8.3	0.0	739
Overall	16 073	7676	2 772 858	−9.2	0.0	7676

CPT, current procedural terminology.

to US\$2.7 million, to US\$2.5 million under assumption 2. The percentage of matched bundles with reduced or the same travel time increased—from 55% to 64%, to 85% and to 100%, and from 55% to 74%, to 85% and to 100% for assumptions 1 and 2, respectively.

Figure 6 illustrates the distribution of total savings and average change in travel time for members when no restrictions/constraints were placed on travel times. As one would expect, the pattern of savings matched with the pattern of expenses. High regulated claim amount

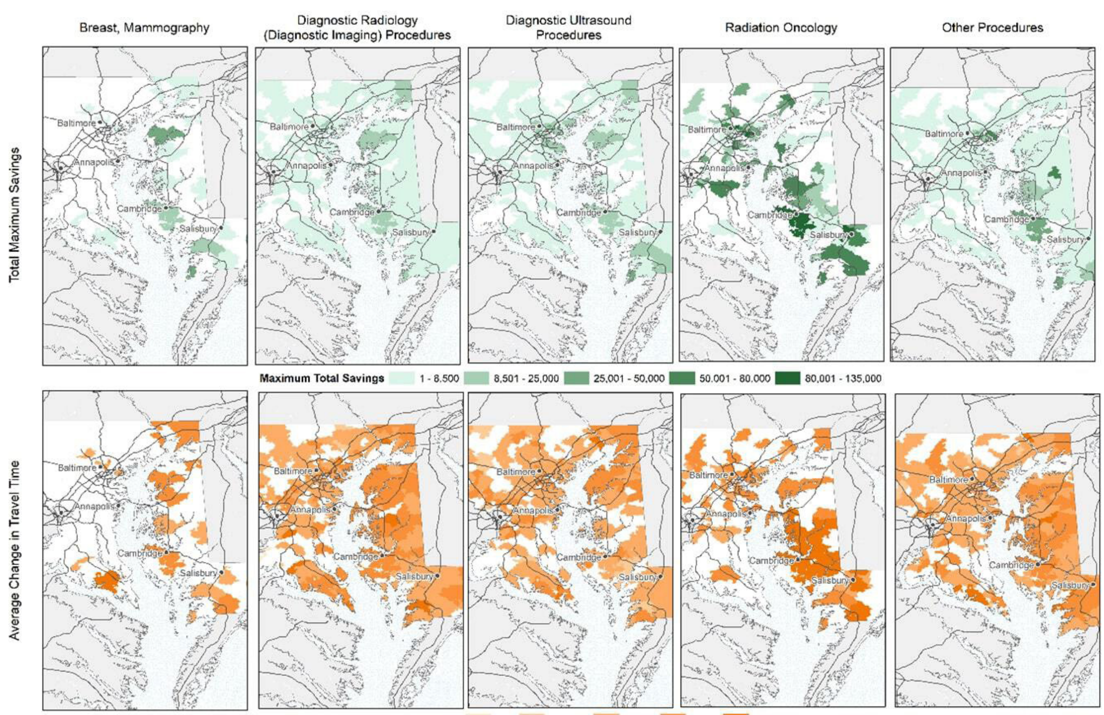

Figure 6 Distribution of savings and change in travel times mapped over members addresses.

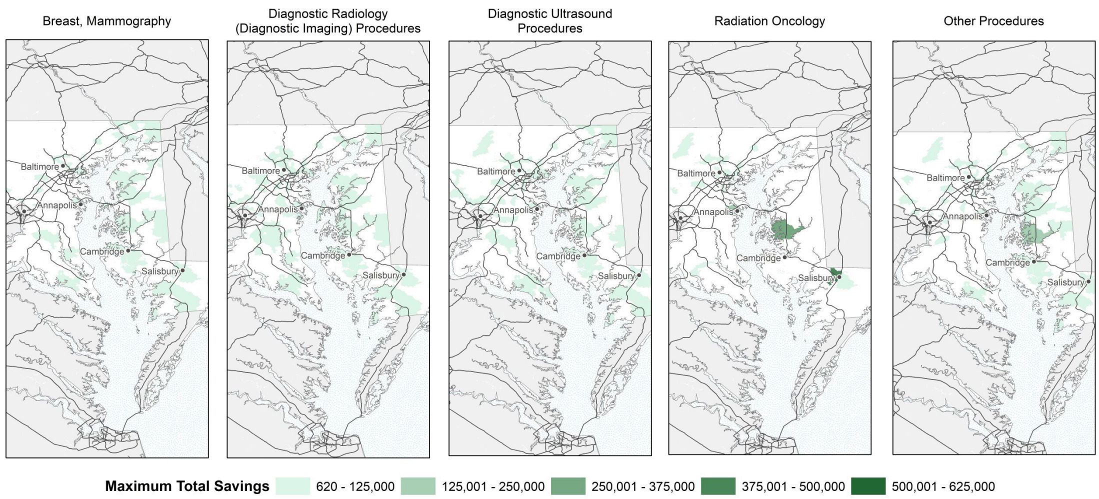

Figure 7 Distribution of savings mapped over regulated providers' addresses.

member areas in figure 3 also corresponded to high savings member areas. Figure 7 shows that the 'transfer out' of money from regulated providers was distributed evenly across the geography of regulated providers' addresses, except for radiation oncology treatment, where the biggest transferor can be isolated.

Figure 8 shows that the 'transfer in' of money into unregulated providers was also evenly distributed over the geography of unregulated providers with a few big gainers scattered relatively evenly. The exception was radiation oncology treatment, where the money flowed into a few specific locations. The biggest unregulated gainers coincided with the biggest unregulated cost centres shown in figure 7, suggesting that shifting of episodes without travel constraints may impose an excessive burden on already burdened unregulated providers.

DISCUSSION

In this work, we present estimates of the potential savings to be drawn from policies that direct patients to use unregulated spaces for pure ancillary services. A complicating factor in the use of such policies is that rural residents typically have greater travel times than urban residents. Consequently, efforts to shift the site of service can impose greater burden on rural members if not applied carefully. Hence, estimates of cost savings that stem from site-of-service selection need to explicitly consider travel-related issues. Our findings also suggest that the long travel times for rural members lead to pooling more procedures into one visit rather than scheduling several shorter visits.

Shifting bundles from regulated to unregulated providers will increase coordination costs. For example, one may need a coordinator to arrange transportation for members with increased travel times. To manage coordination costs, we may selectively restrict the number of members identified for site-of-service referrals by imposing limits on travel times. This plan would still leave substantial savings on the table. Nevertheless, even under the most stringent constraint that imposes no increase in travel time, the savings can be substantial—over 17% in our estimation. Under this strict condition, of the roughly US\$17 million in annual

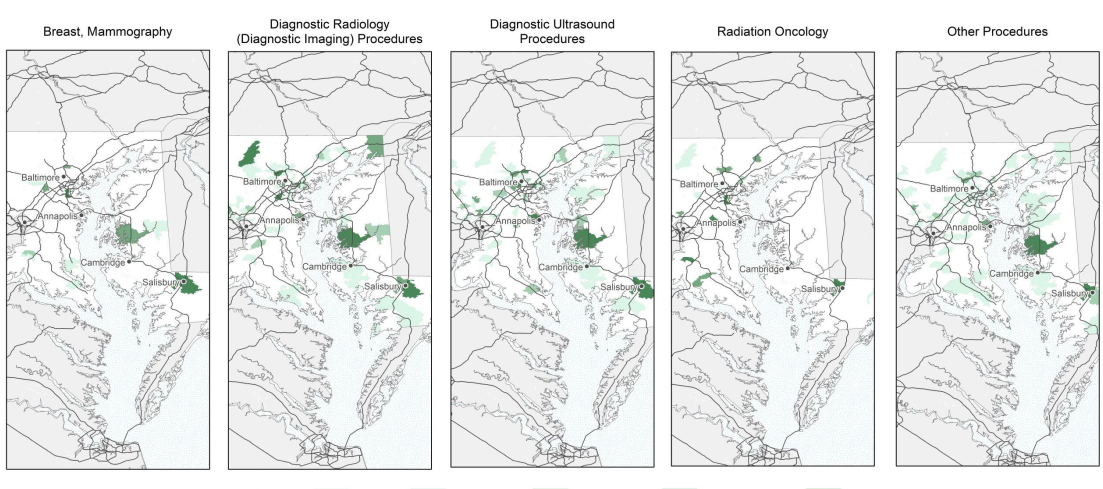

Figure 8 Distribution of savings mapped over unregulated providers' addresses.

expenditures on ancillary diagnostic services, we estimate a potential cost savings of US\$2.8 million and US\$2.5 million from shifting 7616 and 5774 bundles under assumptions 1 and 2, respectively. About 33% and 39% of the shifted procedures under assumptions 1 and 2, respectively, fall under the CPT range of 'other procedures'. These tended to be the lowest cost procedures in our data set. If these were omitted, we would have seen potential cost savings of US\$3.1 million, US\$2.8 million and US\$2.6 million considering our three levels of acceptable travel time increases, under assumption 1, and US\$2.8 million, US\$2.5 million and US\$2.4 million under assumption 2.

A second strategy that can lead to similar savings is to allow an unrestricted increase in travel but focus only on high-saving categories. The biggest bang for the buck would come from shifting radiation oncology bundles. Shifting only 1370 bundles under assumption 1 and 1094 bundles under assumption 2 would lead to about US\$2.8 and US\$2.2 million in savings, respectively. Further, shifting a significant portion of these bundles did not increase travel times and hence would not require coordination. Our analysis confirms the significant variation in costs for ancillary services across regulated and unregulated sites. Additionally, our novel approaches uncovered evident disparities in access (travel times) between rural and urban members for regulated and unregulated services. Perhaps most importantly, our analysis supports the notion that in many cases, shifting ancillary service bundles from regulated to unregulated sites could be a win-win for both the patients and the payers by lowering the cost of care without increasing the travel time. The wide variation in potential referral patterns revealed that customised referral policies have the potential to deliver high savings even after administrative efforts are taken into account. Though our analysis focused on the Medicaid population, our approach used universally available claims data. Our results demonstrate the potential viability of our methodology for other smaller payers to balance access and equity concerns quickly and reliably across different population subgroups. Hence, our approach can be adapted and applied to other populations not just in the USA, but wherever referral policies are being contemplated and reimbursement information from insurance claims data are available.

As discussed by Dada *et al*,[7] insurers affect site-of-service referrals by withholding prior approval for select procedures when the provider and patient wish to have them performed at a regulated facility. In our Medicaid population, the primary care physician makes decisions for patient care. Therefore, in our setting, implementing a site-of-service referral policy can be linked to performance incentives for primary care providers. Fortunately, strict standards are in place for identifying eligible patients for unregulated space; therefore, as discussed in the Introduction, published work has found no differences in quality between regulated and unregulated spaces or facilities. An open question, as referrals to unregulated facilities increase, is whether sufficient capacity will be available to accommodate all requests.

While a key contribution of this study is that it took a patient-centric, microlevel view of potential cost savings that may be realised by moving patients from expensive regulated facilities to less expensive unregulated facilities, it has several limitations. One limitation is that this work focused on 1 year of data only for one state—a longer time period would help infer if savings would have continued to be identified in subsequent periods. The analysis focused on a large but well-identified group of patients for whom delivery and reimbursements are closely regulated by governmental agencies. Since Medicaid populations differ across states in characteristics and reimbursement schemes, future work could determine if savings can be realised in other states. It would have also been insightful to compare these savings against those for patient groups that are covered by commercial insurers. The novel use of travel time and costs had a strong impact on tracing potential savings given the unusual geography of Maryland. It would be useful to compare the differential impact against that of another state that has flatter terrain for which direct distances and travel distance are well aligned.

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Contributors All authors contributed to the writing of the manuscript. SS led the statistical analysis and writing. KJR extracted transportation information from the GIS. CC helped with the writing and analysis. VM managed the datasets. EK and KAW provided overall guidance and interpretation. MD helped with the study, analysis and writing, and is the guarantor.

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REFERENCES

1 Fisher MD, Punekar R, Yim YM, *et al*. Differences in health care use and costs among patients with cancer receiving intravenous chemotherapy in physician offices versus in hospital outpatient settings. *J Oncol Pract* 2017;13:e37–46.
2 Munnich EL, Parente ST. Procedures take less time at ambulatory surgery centers, keeping costs down and ability to meet demand up. *Health Aff* 2014;33:764–9.
3 Higgins A, Veselovskiy G, Schinkel J. National estimates of price variation by site of care. *Am J Manag Care* 2016;22:e116–21.
4 Kalidindi Y, Jung J, Feldman R. Differences in spending on provider-administered chemotherapy by site of care in medicare. *Am J Manag Care* 2018;24:328–33.
5 Shooshtari A, Kalidindi Y, Jung J. Cancer care spending and use by site of provider-administered chemotherapy in medicare. *Am J Manag Care* 2019;25:296–300.
6 Resneck JS, Jr. Refocusing medication prior authorization on its intended purpose. *JAMA* 2020;323:703–4.
7 Dada M, Mundly V, Chambers CG, *et al*. Managing prior approval for site-of-service referrals: an algorithmic approach. *BMC Health Serv Res* 2022;22:201.