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Physician supply, supplier-induced demand and competition: empirical evidence from a single-payer system†

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SUMMARY

We examined the earnings of 8106 office-based (FTE) physicians in 2002 in Taiwan for evidence of supplier-induced demand (SID). We hypothesize that SID, operating in the form of mutual cross-specialty referral, will cause earnings to increase with total physician density (all specialties taken together), but simultaneously, decrease with increasing competition within specialties. We used multiple regression analyses controlling for high-user population, physician demographics and practice type. The evidence supports our hypotheses. Increasing total physician density (all specialties) is positively associated with earnings. Concurrently, within specialties, increased competition is associated with reduced earnings. The medical appropriateness of increasing health care utilization with increasing physician supply cannot be directly determined from the data. However, evidence of a steady earnings increase with increasing total physician density, which precludes a saturation point (of appropriate care levels) at some optimum physician density, substantiates SID in the office-based practice market. Empirically, our data suggest that the average market effect of physicians on one another is synergic when all specialties are considered together, but competitive within each specialty. Copyright © 2006 John Wiley & Sons, Ltd.

KEY WORDS: supplier-induced demand; competition; physician earnings

INTRODUCTION

Supplier-induced demand (SID) in health care has attracted much attention. SID is defined as over-consumption of services, generated by physicians' economic self-interest, enabled by information-asymmetry between physicians and patients (Sorensen and Grytten, 1999). Stano (1987) postulated that, in the absence of uncertainties in patient flows, the potential for SID arises in two situations. First, when there are price rigidities, "a gap may be created between the quantity of service

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the physician would like to provide his patients at the existing service fee without resorting to inducement, and the quantity that would be consumed if his patients were fully informed or if the physician acted as a perfect trustee.'' Second, when the supplier (physician) has monopoly power and not constrained to act as the perfect agent, and consumers are relatively poorly informed and rely on providers for information, it is reasonable to expect that a rational profit-maximizing provider's decisions may be partly driven by demand induction.

Under the above conditions, evidence of a positive relationship between physician density relative to population, and increasing practice earnings would substantiate the existence of SID, if additionally, providers' costs and income are invariant with respect to the distribution between induced and non-induced income. SID can manifest in varied forms, depending on payment incentives and opportunities for inducing demand. Under conditions of fixed, per-patient reimbursement rates, or high transaction costs for procedure-based care imposed in the form of complicated claims processes, providers will avoid increasing their service intensity. This is because the marginal unit cost for such services would exceed the associated revenue. SID may then manifest in the form of co-operative induction of services across specialties, through mutual cross-referral of patients. The scope for increasing cross-referral arises from patients with crosscutting symptoms, or diseases with potential multi-specialty involvement.

With increasing total physician density relative to the population, there is increasing scope for a wider array of specialties and greater availability of specialties within a market, which would result in greater opportunity for mutual cross-specialty referral. All physicians in the area could expect to benefit from this phenomenon, because each outpatient visit would count as a unit for reimbursement purposes, and all specialties could expect to see increased numbers of patients. Under these conditions, SID would manifest as earnings increases with increasing total physician density (all specialties).

Within any given specialty, however, the earnings situation would be impacted by competition. Increasing physician density within a specialty results in competition, as each is a substitute for the others and not complimentary. This situation is particularly likely when providers are unable to induce demand through procedure-driven services due to unfavorable reimbursement policies for care procedures. Therefore, under a fixed-price regime combined with universal access and a single-payer system, increasing supply would cause providers to experience reduced earnings.

STUDY SETTING

Our study setting is Taiwan, with universal, comprehensive health benefit coverage, single payer, and a mix of public, private and not-for-profit hospitals, as well as physician practices competing for patients. Since all claims are logged into the National Health Insurance (NHI) database, population-based data are available to explore SID and competition, based on practice income data. There is no scope for differential rate contracts, and given universal coverage, earnings differences across specialties could be expected to reflect the community's demand for health services relative to physician supply, and SID, if it exists. The study is based on actual reimbursement data rather than a self-administered survey, precluding recall bias and social desirability bias, and causing our earnings measure to be a direct proxy for service volume. The relative purity of this setting from a research perspective facilitates testing for SID, concurrent with the effects of competition.

We test for SID in its generic form, providers with expert knowledge driving increased health service utilization by consumers, who passively consume the recommended service because of information asymmetry. We do not test for SID as defined in the conventional sense in the literature, that is, demand induced by a supplier for his/her own tech-intensive, revenue-generating services. We test for a consensual form of SID among office-based physicians in Taiwan. Discouraged by the reimbursement system from inducing demand for their own tech-intensive services, we postulate that SID takes the form of referral for other specialists' clinical opinions, which increases office visits and the related revenue for all. Being a mutual referral process, all physicians can expect to benefit from increased cross-referral.

RELEVANT CHARACTERISTICS OF OFFICE-BASED PRACTICE IN TAIWAN

Outpatient care is divided almost evenly between hospital outpatient departments and physician practices (55% vs. 45%). Hospital-based physicians are compensated with highly variable combinations of salary, bonus, volume-driven fees, and teaching or research supplements, and their inpatient work is not reimbursed by NHI on itemized basis. Therefore, their earnings do not bear a ratio scale relationship to their clinical effort, as does the practice income of clinic physicians.

Practice markets of office-based physicians and hospital-based physicians are almost mutually exclusive. Office-based physicians do not have admitting privileges in hospitals, and hospital-based physicians see outpatients only in their respective hospital outpatient departments. Within hospitals, cross-specialty referrals are usually in-house, given the intense competition for patients. Office-based physicians make referrals to other office-based specialists, (unless the patient requires inpatient care) to avoid losing patients to large institutions.

Outpatient visits are reimbursed at a fixed rate per visit. Any additional procedure-based reimbursement requires item-wise billing, which involves considerable paperwork. As a result, physicians restrict itemized billing to procedures that are effort-intensive or technology-intensive. Such outpatient procedures are of significant volume only in selected specialties, such as orthopedics, rehabilitation medicine, and ophthalmology. Another factor is that for most other specialties, patients in Taiwan generally prefer interventional or surgical procedures in a hospital setting. As a result, office-based physician earnings represent a proxy for the number of outpatient visits, and the profit per visit is invariant across visits in most specialties.

DATA SOURCES AND METHODS

Outpatient claims data for office-based physicians in 2002 from Taiwan's Department of Health were used. We examine practice earnings of 8106 office-based FTE physicians (all physicians excluding 1203 with no claims for a full month or more, or those who worked part-time, less than 35 h a week). Chen (2005) reported that almost all physicians in Taiwan work full-time (more than 40 h a week, 92%), or almost full-time (35–40 h, 5% of physicians).

The dependent variable of interest is pretax gross earnings, defined as the monetary aggregate of total medical benefit claims and outpatient registration fees (US$3 per visit) collected from patients. The unit of analysis is the physician. The key independent variables are specialty, intra-specialty competition, and variables to capture demand for services. The specialty classification is as follows: primary care (including general practice, family practice, internal medicine, and pediatrics), surgery, ob/gyn, orthopedics, ENT, ophthalmology, dermatology, rehabilitation, and others.

To test for SID and the effects of competition on earnings, we used three variables that either directly represented competition level in each of the 23 administrative districts, physician supply, or proxies for physician supply net of the population determinants of demand for services. Market rivalry or competition level is represented by the Herfindahl–Hirschman index (HHI). This is calculated as $\sum s_i^2$ which is the sum of the squared market share of each office-based physician in the specialty (based on revenues for 2002), and multiplying the resulting fraction by 10 000 (the last step serving the purpose of better functionality in the analysis). Higher HHI values represent lower competition level, and vice versa. Competition levels are defined as, most competitive = $\text{HHI} \leq 1000$, Moderately competitive = $1000 < \text{HHI} \leq 1800$, and Least competitive = $\text{HHI} > 1800$.The remaining supply/demand variables are: number of total physicians per 10 000 residents in each districts (including hospital and clinic-based physicians), and percent population aged over 65 or below 5 years in the health care market (high-user population, surrogate for concentrated demand). The districts have a wide range of populations, mean = 976 221, median = 742 797, range = 3 549 000, minimum = 92 446, maximum = 3 641 446. We also controlled for the districts' total health care reimbursement, representing the net size of the available pie, total demand for all health services in the district.

In the specialty-wise regressions, to account for the population's need for health services, appropriate high-user population was defined for ob/gyn physicians, percent female population aged 15–49. For all other specialties, high user population constituted percent population aged over 65 or under 5 years. For orthopedics and rehabilitation medicine, an additional demand variable was number of accident/trauma cases per 1000 district population was used. Physician availability statistics were obtained from Taiwan Medical Association. In these regressions we do not control for the total district health expenditure, because the specialty-wise share of health expenditure may vary across districts, and therefore cause the direction of association to vary across specialties.

The control variables were practice type (solo, single-specialty group, or multi-specialty group practice), geographic location, and urbanization level of the community (Dedobbeleer *et al.*, 1995; Simon *et al.*, 1998; Sturm, 2002). Urbanization level is determined for the 23 administrative districts by Taiwan's Institute of Occupational Safety and Health. Eight categories are identified (1 = most urbanized, 8 = least urbanized), based on population density, age structure, health care facilities, and socio-economic factors. We also controlled for physician's age and gender.

Earnings data across specialties and within specialties were normal or near normally distributed (unlike the general population earnings which are usually highly skewed). Therefore, linear regression without data transformations was judged to be appropriate.

Multiple regression analysis, with the step-wise option in SAS was used to detect the optimum model predicting physician earnings. (Retaining all independent variables in the models was not a viable option for most specialties because of loss of statistical power. Further a final model retaining only significant variables provides stable estimates enabling robust conclusions.) After identifying the final model, if the competition variable was not retained by the model selection process, it was added back into the model, since it is a key variable of interest. The resulting models are presented and used for comment.

STUDY HYPOTHESES

The study objective was to test for SID and the effects of competition within specialties. We hypothesized that: (1) Increasing total physician density (all specialties) will be positively associated with earnings due to SID through cross specialty referral. (2) Within a given specialty, increasing physician density will be negatively associated with earnings due to competition for patients.

RESULTS

Mean annual physician income was \$NT 8 324 993 (US\$248 507 ± 197 937). Rehabilitation and orthopedic physicians had the highest earnings, and ob/gyn physicians the lowest (Table 1).

EARNINGS VERSUS TOTAL PHYSICIAN DENSITY (ALL SPECIALTIES)

Table 2 shows that a model with age, gender, specialty, practice type, urbanization level, total physicians per 10 000 residents, total district health expenditure, and specialty-specific competition level, explains a fifth of the variation in office-based physician earnings (adjusted $R^2 = 0.206$). To examine specialty-specific earnings, the specialties of general practice, family practice, internal medicine, and pediatrics are combined, because internal medicine and pediatric physicians significantly deal with primary care visits and general practice cases, along with a variable proportion of specialty-specific practice. After adjusting for physician demographics, specialty,

Table 1. Annual earnings and characteristics of office-based physicians (FTEs) in Taiwan, 2002 (Mean exchange rate in 2002: US$1 = NT$33.50)

Variable	*n* (%)	Earnings (NT$)	*p*-value
All physicians	8106 (100%)	8 324 993 (±6 630 899)	
Age (years)			0.000
≤35	282 (3.5)	9 565 496	
36–45	3052 (37.7)	10 911 199	
46–55	2735 (33.7)	8 193 148	
56–65	1132 (14.0)	5 510 633	
≥66	905 (11.1)	3 135 524	
Gender			0.047
Male	7572 (93.4)	8 363 841	
Female	534 (6.6)	7 774 145	
Specialty			0.000
General practice	2300 (28.4)	7 241 755	
Family practice	897 (11.1)	7 572 593	
Internal medicine	1064 (13.1)	9 606 930	
Surgery	304 (3.8)	6 494 397	
Pediatrics	811 (10.0)	8 322 827	
Ob/gyn	655 (8.1)	5 757 139	
Orthopedics	94 (1.2)	12 048 604	
ENT	839 (10.4)	10 145 203	
Ophthalmology	556 (6.9)	10 648 886	
Dermatology	256 (3.2)	10 292 983	
Rehabilitation	73 (0.9)	15 181 717	
Others	257 (3.2)	7 815 130	
Practice type			0.000
Solo practice	5556 (68.6)	7 551 565	
Single-specialty group	1736 (21.4)	10 304 492	
Multi-specialty group	814 (10.0)	9 382 432	
Office-based practice market competition in the district*			0.000
Most competitive	7402 (91.3)	8 149 782	
Moderately competitive	440 (5.4)	9 396 358	
Least competitive	264 (3.3)	11 451 946	
Urbanization level of the healthcare market area			0.000
1 (highest)	1046 (12.9)	7 219 318	
2	2597 (32.0)	8 103 284	
3	1635 (20.2)	8 693 851	
4	730 (9.0)	8 857 441	
5	1112 (13.7)	9 134 042	
6	513 (6.3)	8 108 148	
7	343 (4.2)	8 196 448	
8 (lowest)	130 (1.6)	8 295 890	

*Most competitive = HHI ≤ 1000; Moderately competitive = 1000 < HHI ≤ 1800; Least competitive = HHI > 1800.

practice type, urbanization level, total district health expenditure, and specialty-specific competition within the market, total physician density is positively associated with earnings (an additional physician/10 000 population associated with NT$122 068 higher earnings).

Table 2. Predictors of office-based physician earnings in Taiwan: Physician supply, demographics, population demand, and competition (All specialties; $n = 8106$)

Variable	Yearly earnings ($NT) B	*p*-value
Age (years)		
35	−1 309 523	0.000***
36–45 (ref. group)		
46–55	−2 264 305	0.000***
56–65	−4 770 887	0.000***
≥66	−7 374 228	0.000***
Gender		
Male	2 372 201	0.000***
Female (ref. group)		
Specialty		
Primary practice (ref. group)		
Surgery	−336 280	0.371
Ob/gyn	−2 204 049	0.000***
Orthopedics	2 144 256	0.001**
ENT	1 043 460	0.000***
Ophthalmology	1 681 515	0.000***
Dermatology	1 219 803	0.003**
Rehabilitation	5 563 104	0.000***
Others	−399 794	0.308
Practice type		
Solo practice (ref. group)		
Single-specialty group	2 019 968	0.000***
Multi-specialty group	1 644 490	0.000***
Urbanization level of the healthcare market area		
1 (highest)	−349 717	0.443
2 (ref. group)		
3	126 407	0.536
4	126 645	0.643
5	264 717	0.291
6	−442 391	0.172
7	18 077	0.963
8 (lowest)	998 649	0.084
Total physicians per 10,000 population	122 068	0.021*
Total NHI reimbursement in the district	0.00004	0.000***
Specialty-specific competition level+		
Most competitive	−1 372 784	0.002**
Moderately competitive	−721 686	0.126
Least competitive (ref. group)		
Intercept	7 461 204	0.000***
n		8106
Adjusted R^2		0.206
F		78.77***

*$p < 0.05$;
**$p < 0.01$;
***$p < 0.001$.
Average exchange rate in 2002: US$1 = NT$33.5.
Urbanization level: 1 = Most urbanized; 8 = Least urbanized.
+Most competitive = HHI ≤ 1000; Moderately competitive = 1000 < HHI ≤ 1800; Least competitive = HHI > 1800.

Parameter estimates for the competition variable shows that, a physician's earnings are inversely associated with competition in his/her specific specialty. On average, a physician earns NT$1 372 784 less in the most competitive markets for his/her specialty relative to the least competitive markets. Controlling for within-specialty competition in the all-specialty model addresses the question, "after controlling for within specialty competition, does a physician's earning increase with increasing total physician density (all specialties) within his market?"

Physicians aged 36–45 years have the highest earnings. There is a steady decline in mean earnings in older age groups. Male physicians earn on average NT$ 2 372 201 more than females. Specialty-wise, the adjusted estimates show that ob/gyn physicians have the lowest earnings, and rehabilitation physicians the highest, followed by orthopedics and ophthalmology.

Single specialty group practice physicians have NT$2 019 968 higher income than solo practice physicians (24.2% higher), and multi-specialty group practice physicians have NT$1 644 490 higher mean income than solo practitioners. Urbanization level is not a significant predictor of earnings (once competition level and other factors are adjusted for). Increasing total health expenditure in the district is associated with increasing earnings per physician.

EARNINGS VERSUS TOTAL PHYSICIAN DENSITY AND COMPETITION WITHIN SPECIALTIES

Table 3 presents the predictors of physician earnings within each specialty (except the "others" group, which is too heterogeneous to be treated as a single category). As indicated earlier, these are final models retaining statistically significant variables with the addition of the competition variable in case it did not attain statistical significance. In general, within each specialty, the effects of physician demographics observed in the all-specialty regression analysis hold within each specialty, except for the numerically sparse specialties of orthopedics and rehabilitation medicine. Examining supply and competition issues, we find that number of the respective specialists per 10 000 persons is no longer significant as a positive driver of earnings. Instead, competition, represented by HHI for the respective specialty, is a significant predictor in most specialties. For ENT ($n = 839$) and ob/gyn physicians ($n = 655$), the most competitive markets in the respective specialties are associated with a significant decrease in income relative to the least competitive markets (NT$3 467 264 less for ENT physicians, and NT$2 679 967 less for ob/gyn physicians). For ENT physicians, increasing density of other-specialty physicians further decreases earnings by NT$217 403. For primary care physicians ($n = 5072$), the difference between the most competitive and least competitive primary care markets fails to attain statistical significance ($p = 0.077$), although the magnitude of reduction (NT$2 454 224) is comparable to what is observed for ob/gyn physicians. Among ophthalmologists ($n = 556$), the difference between moderately competitive (ophthalmologic practice) markets and least competitive markets is NT$2 768 503 ($p = 0.048$), while the difference between the most competitive and least competitive markets is not statistically significant. Dermatology ($n = 256$) also shows a

Table 3. Predictors of office-based physician earnings within specialties (Only final models retaining statistically significant variables and the competition variable, are presented for each specialty)

Specialty modeled	Significant predictors of earnings**	Parameter estimate*	R^2	Adjusted R^2
Primary care ($n = 5072$)	Age (years): 35 vs. 36–45	−2 530 767	0.168	0.167
	Age (years): 46–55 vs. 36–45	−2 516 622		
	Age (years): 56–65 vs. 36–45	−4 963 487		
	Age (years): ≥66 vs. 36–45	−7 399 940		
	Male vs. female	2 760 108		
	Percentage population >65 or <5 years	21 492 124		
	Most vs. least competitive	−2 454 224 ($p = 0.077$)		
	Moderately vs. least competitive	−983 486 ($p = 0.524$)		
	Intercept	6 461 187		
ENT ($n = 839$)	Age (years): 46–55 vs. 36–45	−2 499 236	0.271	0.264
	Age (years): 56–65 vs. 36–45	−5 333 380		
	Age (years): ≥66 vs. 36–45	−8 347 768		
	Male vs. female	3 995 579		
	Number of other-specialty physicians per 10 000 population	−217 403		
	Percentage population >65 or <5 years	17 180 917		
	Most competitive vs. least competitive	−3 467 264 ($p = 0.002$)		
	Moderately competitive vs. least competitive	−2 153 134 ($p = 0.084$)		
	Intercept	9 588 457		
Ob/gyn ($n = 655$)	Single-specialty group vs. solo practice	1 116 973	0.264	0.256
	Multi-specialty group vs. solo practice	1 713 510		
	Age (years): 46–55 vs. 36–45	−1 939 124		
	Age (years): 56–65 vs. 36–45	−4 284 569		
	Age (years): ≥66 vs. 36–45	−5 532 169		
	Most competitive vs. least competitive	−2 679 967 ($p = 0.02$)		
	Moderately competitive vs. least competitive	−1 863 476 ($p = 0.036$)		
	Intercept	9 776 324		
Ophthalmology ($n = 556$)	Age (years): 46–55 vs. 36–45	−1 570 503	0.162	0.151
	Age (years): 56–65 vs. 36–45	−5 094 883		
	Age (years): ≥66 vs. 36–45	−9 823 378		
	Male vs. female	3 231 014		
	Percentage population >65 or <5 years	40 114 615		

(Continues)

Table 3. (Continued)

Specialty modeled	Significant predictors of earnings**	Parameter estimate*	R^2	Adjusted R^2
	Most competitive vs. least competitive	−1 746 693 ($p = 0.144$)		
	Moderately competitive vs. least competitive	−2 768 503 ($p = 0.048$)		
	Intercept	4 663 456		
Surgery ($n = 304$)	Single-specialty group vs. solo practice	2 091 229	0.181	0.164
	Multi-specialty group vs. solo practice	1 197 344		
	Age (years): 56–65 vs. 36–45	−2 541 254		
	Age (years): ≥66 vs. 36–45	−4 565 767		
	Most competitive vs. least competitive	604 406 ($p = 0.430$)		
	Moderately competitive vs. least competitive	185 201 (0.824)		
	Intercept	7 556 905		
Dermatology ($n = 256$)	Age (years): 46–55 vs. 36–45	−1 324 630	0.257	0.238
	Age (years): 56–65 vs. 36–45	5 142 878		
	Age (years): ≥66 vs. 36–45	−10 480 638		
	Male vs. female	2 707 142		
	Most competitive vs. least competitive	−3 455 656 ($p = 0.000$)		
	Moderately competitive vs. least competitive	907 382 ($p = 0.412$)		
	Intercept	11 316 076		
Orthopedics ($n = 94$)	Age (years): >66 vs. 36–45	−8 169 031	0.132	0.093
	Multi-specialty group vs. solo practice	−3 001 706		
	Accident/trauma cases per 1000 population	195 913 ($p = 0.053$)		
	Most competitive vs. least competitive	−416 737 ($p = 0.923$)		
	Moderately competitive vs. least competitive	1 901 218 ($p = 0.201$)		
	Intercept	9 798 237		
Rehabilitation ($n = 73$)	Most competitive vs. least competitive	−6 555 276 ($p = 0.005$)	0.109	0.081
	Moderately competitive vs. least competitive	−1 802 705 ($p = 0.339$)		
	Intercept	17 080 951		

*All p values <0.01 unless otherwise mentioned; only variables with $p < 0.05$ were retained in the models, except for competition variables. Accident and trauma incidence in the orthopedics model is close to significance.

**Competition variable is retained in all models regardless of statistical significance, and p-value shown in parentheses. Levels: Most competitive = HHI ≤ 1000; Moderately competitive = 1000 < HHI ≤ 1800; Least competitive = HHI > 1800.

significant decrease in the most competitive markets (by NT$3 455 656) relative to the least competitive market. Orthopedics ($n = 94$) does not show statistically significant difference with competition level. Rehabilitation medicine shows NT$6 555 276 difference between the most competitive and least competitive markets for this specialty ($p = 0.005$).

Examining demand-side variables in the specialty-wise regressions, high user population (aged over 65 or under 5 years) is significantly associated with increasing earnings in case of primary care, ENT and ophthalmology. For primary care physicians, a 1% increase in high user population is associated with NT$21 492 124 increase in mean earnings, for ENT physicians with NT$17 180 917 increase, and for ophthalmologists, NT$40 114 615. For orthopedics, the incidence of accident and trauma cases per 1000 population predicts earnings, each accident/trauma case is associated with $195 913 increase in earnings ($p = 0.053$). This variable is retained and shown due to its clinical significance for this specialty, and potential policy significance of this finding.

DISCUSSION

Our study results show that when all physicians are taken together, increasing physician density is associated with increased physician earnings, after controlling for the impact of rivalry between providers of the same specialty, captured in the form of specialty-specific HHI in the market. Concurrently, in the all-specialty analysis as well as specialty-specific regressions, competition levels are inversely related to earnings. Orthopedics does not show statistically significant relationship estimates for competition, which could be due to small numbers ($n = 94$), or more likely, because their supply is yet to meet the demand for these services. Significantly, accident and trauma case incidence is a key positive predictor (although the difference is at the margin of statistical significance, probably die to small numbers). Surgery also does not show an effect of competition, again possibly due to inadequate sample size ($n = 306$).

A key finding is the concurrent evidence for two distinct supply-related phenomena, increasing outpatient visits with increasing total physician density, and the adverse earnings effect of competition within a given specialty. The latter is a consequence of a fixed price regime that also severely restricts demand induction for procedure-oriented services.

SID is complex and its form varies with the opportunities to provide compensated clinical services. Office-based practitioners in Taiwan are restricted to outpatient services, and are faced with a general population preference for major interventional procedures in hospital settings, as well as discouraged by the reimbursement mechanism to provide procedure-intensive care. As a result, the dominant form of SID is likely to be mutual cross referral between office-based specialists, because inducing demand for procedure-oriented care will cause them to lose patients to hospitals. Our findings support the prevalence of SID, consistent with Stano (1987).

It could be argued that physicians may be preferentially setting up practice in areas with higher earnings. Our explanation may be faulted for assuming that physician density is a relatively fixed feature, and evoking SID as the reason for increasing physician earnings with increasing density. In Taiwan, there is no financial barrier for the population to use care, due to universal health coverage, a generous benefit package, and a single payer. Therefore, there are no ''rich'' or ''poor'' districts with regard to health care utilization potential, except for population density (which may define utilization volumes due to geographic distance issues), and intrinsic care utilization propensities between different regions (e.g., urban vs. rural). From the provider perspective, there is no administrative barrier or facilitation for any physician to set up a practice in a new area. However, the general preference is for setting up in large metropolitan areas which are perceived to offer better quality of life, educational districts for children, etc. For example, Taipei city has 27.02 physicians per 10 000 persons (almost one for every 300 population), compared to Yun-lin district with 7.28 physicians per 10 000 (or one physician for every 1373 persons). Our study shows that physicians in low competition areas relative to their respective specialty have considerably higher earnings. And, low overall physician density is also accompanied by low intra-specialty competition. Yet, low physician density areas continue to remain so. Therefore, the explanation that higher earning areas attract more physicians, causing higher physician density in these areas, is unlikely.

Another potential issue could be raised: while the all-specialty regression analysis accounts for the ''other specialties'' group, (a heterogeneous mixture covering psychiatrists, radiologists, gastroenterologists, etc.), our within-specialty regressions did not examine this ''group.'' Increasing physician density implies the availability of more specialties, together with greater geographic dispersion of specialists, which may cause increased patient-driven rather than physician-driven health care utilization (Tsai *et al*., 2004). This dynamic may have caused physician earnings to increase with increasing total physician density, with the excess earnings accrued to the ''others'' category that was not subjected to within-specialty regression analyses. However, Table 1 shows that ''others'' included only 237 physicians (3.2% of total office-based physicians), and importantly, their mean practice earnings was less than the mean for total physicians, (NT$7 815 130 compared to NT$8 324 993). This finding suggests that the ''others'' group would not significantly affect our conclusions.

Declining patient visits and earnings per physician with increasing physician density among primary care physicians is documented in Norway, which has NHI, similar to Taiwan, fixed reimbursements per visit, itemized reimbursement for procedures (which discourages office-based practitioners from offering procedures), and low, fixed co-payments per visit (Sorensen and Grytten, 1999). Our finding of increasing earnings with increasing physician density when all specialties are combined is similar to Tsai *et al*. (2004) who used time-series data from Taiwan's NHI database on ambulatory care for 1996–1999.

Our inference of SID is reinforced by the concurrent effect of decreasing earnings with increasing market competition within the physician's specialty. Empirically, our data suggest that the average market effect of physicians on one another is synergic when all specialties are considered together, but competitive within each specialty. Synergy increases with total physician density because of the potential for increasing availability of specialists for cross referral as physician numbers increase, and patient visits to multiple specialties substitutes for greater service intensity, given the payer and reimbursement conditions.

Our study also accounts for the extent to which the supply is justified by population demand, that is, earnings increases with increasing demand, represented by the salience of high user population for earnings of primary care, ENT, and ophthalmology. However, when supply reaches competitive levels, earnings of individual physicians decline with rising competition. In the case of orthopedic physicians, trauma cases are the driving factor and competition is not significant, and their mean income is the highest of all physicians (partly also driven by procedure-driven practice). Apart from statistical power issues as an explanation for these observations, orthopedics may be illustrating a situation where supply has not yet satisfied demand, and therefore, not yet ripe for competitive reductions in earnings.

Sorensen and Grytten (1999) explained their finding of decreased primary care physician earnings with increased primary care physician density as evidence against SID. In this study, we find that increasing competition within a given specialty physician is consistently associated with reduced earnings, a finding that is consistent with their finding in one specialty. In addition, we find the opposite direction of association among total physicians compared to same-specialty physicians, which causes us to infer SID, contrary to their conclusions.

Our finding of higher earnings in group practices relative to solo generally reflects an increased ability to attract patients due to more modern facilities and capital investment, better handling of administrative aspects of reimbursement due to hiring of well-paid support staff, and better service quality (Lin et al., 2004).

Our finding of lower earnings in multi-specialty group practice relative to single specialty groups needs some explanation. Logically, SID manifesting as increased cross specialty referral would be empirically substantiated, if physicians in multi-specialty group practice earned significantly more than single specialty practice, because there should be a stronger positive returns for the individual physician's earnings when he/she refers patients to colleagues in the same practice, rather than to physicians in other practices. The practice dynamics are more complex in Taiwan.

Group practices are essentially economic arrangements to share facility and support staff expenses, and to present enhanced facility appearance and sophistication, including tech capability to attract patients. Within each group, however, providers generally strive to keep their patient base, because NHI reimburses individual physicians for each patient visit. Thus, physicians are likely to avoid referrals to those who might be a competitive threat to their patient base, for example, another doctor in the same clinic, who might become the preferred doctor for future primary care consultations by patients referred for a one-time specialist consultation. NHI permits specialists to provide primary care services. Therefore, a physician referring a patient to a specialist within the same multi-specialty clinic risks losing the patient for future primary care consultations. Referrals may be more likely to specialists in other locations, which by definition, are not geographically or otherwise preferred locations for the patient, and therefore less risky for the referring doctor. Referrals to other clinics generate mutual goodwill that translates into ongoing relationships with a low risk of losing patients. (Within single-specialty group practices, the question of referral does not arise.)

Higher earnings in single specialty relative to multi-specialty practice probably reflect the increased tech capability of single specialty groups. Single specialty physicians can pool resources to invest in technology relevant to one specialty, rather than thinly spread resources across multiple specialties, characteristic of a multi-specialty clinic. Higher tech capability (including diagnostic technology) of single specialty groups may make them preferred referral destinations, as well as attract patients coming on their own initiative. (NHI permits patients a full choice of all providers regardless of specialty.) These dynamics may explain why despite the logical expectancy relative to SID, multi-specialty group practice is not associated with superior earnings relative to single specialty group.

CONCLUSION AND POLICY IMPLICATIONS

This study contributes to the literature from both theoretical and policy perspectives. From a health services theory perspective, the relative purity of the research setting facilitates examination of SID, net of other confounders. It supports the theory of SID, while concurrently demonstrating the negative effects of within-specialty competition on physician earnings.

From a policy perspective, the findings validate the assertions of some health policy makers and analysts that, allowing the free run of market forces in medical school intake and residency slots, unambiguously adds to health care cost escalation through SID, net of technology and population factors. To the extent that earning potential determines career choices, young people will continue to seek medical careers, resulting in increased medical manpower across the spectrum of specialties, which may be fueling SID, and sustaining physician earnings beyond the level necessitated by medical need. Although the associated increases in supply within specialties generate competitive pressures on individual physician earnings, the overall national health expenditure trend will be upwards, plausibly due to mutual cross-specialty referrals, exceeding the population's need level.

Governments may consider regulation of specialist manpower production when significant earnings reduction is observed with increasing supply within a specialty. This may indicate that the community's "carrying capacity" for this category has been exceeded. This point may be determined by a combination of data sources. Our findings on orthopedics suggests one method, to determine the supply level at which specialist numbers turn competitive, that is, the point at which the positive earnings trend turns negative with increasing supply. This can be substantiated by surveys to determine the appropriateness of service utilization in competitive specialties.

STUDY LIMITATIONS

A potential criticism of this study is that we did not use sub-region as the market area, which may be considered a more appropriate "market area" for outpatient care clientele (Tsai *et al*., 2004), compared to the administrative district. However, with too small an area and associated population, statistical power is lost when using supply variables such as physicians per 10 000 persons, especially for specialty-wise analyses. The maximum diameter of a district in Taiwan is about 20 miles, implying less than a 10-mile travel radius in dispersed-population districts, which is quite reasonable with the transportation options available in Taiwan.

A second limitation is that we are unable to directly examine whether, increased outpatient utilization with increasing physician supply is indeed due to inappropriate use induced by physicians for pecuniary reasons. An alternative explanation is that it represents higher appropriate service utilization due to better information flows to patients, and better opportunity for referring patients for needed services, as the supply and dispersal of physicians improves. Our study shows evidence of a steady increase in services with increasing supply of office-based practice physicians. If there were to be a reversal of association after a saturation point for needed services at some optimum physician density, linear regression analysis would show statistically insignificant results for the physician density variable. Areas like Taipei have a very high physician density, about 1 per 300 population, yet the linear earnings increase with supply holds. Given our finding, we believe it most likely our findings represent evidence of SID. Primary data from specially designed surveys are needed to settle this issue.

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