Journal of Health Economics 43 (2015) 56–73

Contents lists available at ScienceDirect

Journal of Health Economics

journal homepage: www.elsevier.com/locate/econbase

# Old boys' network in general practitioners' referral behavior?☆

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ARTICLE INFO

*Article history:*
Received 3 July 2013
Received in revised form 16 June 2015
Accepted 22 June 2015
Available online 2 July 2015

*JEL classification:*
I1
I11

*Keywords:*
Referral behavior
General practitioner
Information asymmetry
Personal networks
Affinity-based networks

ABSTRACT

We analyzed the impact of social networks on general practitioners' (GPs) referral behavior based on administrative panel data from 2,684,273 referrals to specialists made between 1998 and 2007. For the definition of social networks, we used information on the doctors' place and time of study and their hospital work history. We found that GPs referred more patients to specialists within their personal networks and that patients referred within a social network had fewer follow-up consultations and less inpatient days thereafter. The effects on patient outcomes (e.g. waiting periods, days in hospital) of referrals within personal networks and affinity-based networks differed. Specifically, whereas empirical evidence showed a concentration on high-quality specialists for referrals within the personal network, suggesting that referrals within personal networks overcome information asymmetry with respect to specialists' abilities, the empirical evidence for affinity-based networks was different and less clear. Same-gender networks tended to refer patients to low-quality specialists.



## 1. Introduction

In most health-care systems, general practitioners (GPs) serve as gatekeepers who coordinate access to health-care services provided by resident medical specialists, outpatient departments, and hospitals. Though institutional settings differ between countries and health-care systems, primary care providers can either diagnose and treat patients themselves or refer the patients to medical specialists. Patient referrals from GPs to specialist care (resident doctors or hospitals) are of particular importance in health policy. (i) Quantitative evidence has shown that follow-up health-care costs vary substantially depending on GPs' referral behavior.[1] (ii) A quality-cost tradeoff for patients' health may exist depending on whether they are being referred on to further specialists or receive treatment from the GP. (iii) Finally, the introduction of managed care in national health systems has changed the responsibility and flexibility of GPs in their referring behavior by limiting the number of consultants (e.g., resident specialists, hospital doctors) to whom patients are allowed to be referred, and by shifting control over health-care delivery from doctors' judgment toward predetermined bureaucratic mechanisms such as referral guidelines. Regardless of whether referral rates are high or low, the policy-relevant question is whether referrals are medically and economically appropriate or not. Obviously, from a medical point of view, the referral behavior of GPs should be based on medical criteria. Apart from that, economic considerations influence the referral behavior of GPs due to scarcity of resources in health-care systems.

Under the traditional view of microeconomics, interactions between economic agents take place via markets and their signals (Manski, 2000; Soetevent, 2006). However, in a regulated health-care sector where costs for medical services are covered by social insurance, the price mechanism does not function as it otherwise would. This is particularly true in Bismarckian fee-for-service (FFS)

☆ We would like to thank Alexander Ahammer, René Böheim, Josef Falkinger, Martin Halla, Rupert Sausgruber, Josef Zweimüller, the participants of the Spring Meeting of Young Economists in Aarhus, the Cesifo/JKU Workshop Applied Labor Economics in Bischofswiesen, and the participants of the research seminars at the Universities of Linz and Innsbruck for their helpful discussions and comments. We would also like to thank two anonymous referees for their helpful suggestions as well as the Upper Austrian Sickness Fund and the Upper Austrian Chamber of Medicine for providing data. Financial support from the Austrian Science Fund (FWF) under the National Research Network "The Austrian Center for Labor Economics and the Analysis of the Welfare State," project no. S10306-G16, is gratefully acknowledged.

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http://dx.doi.org/10.1016/j.jhealeco.2015.06.005
0167-6296/

[1] For example, Crombie and Fleming (1988) found that a 10-fold difference in hospital expenditures for GP practice populations is associated with the lowest and highest rates of referrals to hospitals.

health-care systems. As a result, we propose that social interaction plays an important role in doctors' referral behavior.

In this paper, we analyzed the referral behavior of GPs who refer patients to resident specialists for further diagnosis and treatment. Based on comprehensive administrative panel data from the Austrian province of Upper Austria for the period of 1998–2007, we studied the quantitative relationship between doctors' referral behavior and their affiliation with a social network. A GP and a specialist form a social network if they (i) studied at the same university, (ii) studied at the same university at the same time, (iii) worked in the same teaching hospital, (iv) worked in the same teaching hospital at the same time, (v) were in the same age cohort, or (vi) were the same sex. The influence of the GP's social network on his/her referral behavior might be detrimental in the case of "old boys networks," in which referral decisions are mainly driven by doctors' rent-seeking motives. This would be the case if referral decisions do not reflect medical necessities but rather preferential treatment of befriended specialists, who increase their income by additional health care services provided for patients referred within the social network. Social networks could also be of benefit for patients if GPs take inside information into account when they select a specialist, using all the relevant information that he or she has gained from past referrals, such as the ability of a specialist, his or her strengths, and wait times, to increase the quality of the referral.

First, we identified the determinants of GPs' referral rates and analyzed the role played by social networks. Second, by observing patient flow between all pairs of GPs and medical specialists, we examined (i) whether GPs preferred specialists belonging to their social network to outsiders for given referral rates, and (ii) the appropriateness of within-network referrals. The appropriateness of a referral was measured by waiting time, follow-up consultations, the referral's effect on patient health, and outpatient expenditures of the referred patient. (iii) Finally, we offer empirical strategies that allow for discrimination between two competing mechanisms that could explain network effects in doctors' referral behavior. We tested whether social networks reduce information asymmetries with respect to specialist quality (statistical discrimination) or simply reflect the selection of particular groups of patients who were referred from GPs to medical specialists.

We found that doctors' networks formed at the teaching hospital played an important role in their referral behavior. The number of referrals from a GP to a medical specialist increased, ceteris paribus, if both doctors had worked in the same teaching hospital, and increased further if they had worked there at the same time. Moreover, patients referred within a social network had fewer follow-up consultations with another specialist in the same medical field, and compared to patients referred outside the social network, spent fewer subsequent days in the hospital; they also lost less work time due to illness. A network referral increased the waiting time of patients slightly, though we did not find any differences in outpatient expenditures or subsequent re-referrals to specialists from other medical fields. From this, we conclude that referrals within doctors' social networks are more appropriate, as they neither adversely affect patients' health nor increase health-care costs. Further empirical evidence showed that within hospital and co-worker networks, higher-quality doctors received more referrals than lower-quality doctors compared to referrals outside of the network. We conclude that social networks help to reduce information asymmetry with respect to specialists' abilities.

### 1.1. Networks and referral rate

Previous studies have focused on the following determinants of referral behavior: (i) patient characteristics, (ii) GP characteristics, (iii) practice characteristics, and (iv) the availability of specialist care. O'Donnell (2000) reported in her comprehensive literature survey that age and gender may explain approximately 10% of the variation observed in referral rates. Similarly, Salam-Schaatz et al. (1994) showed that controlling for patient characteristics decreased the variation in primary care doctors' referral profiles by more than 50%. The empirical evidence on the most important GP characteristics, namely, age and years of experience, is inconclusive. Whereas several UK studies did not identify any significant impact of age or experience on a GP's referral rate (Cummins et al., 1981; Wilkin and Smith, 1987), one Finnish study (Vehvilainen et al., 1996) and another UK study (Rashid and Jagger, 1990) reported higher referral rates for younger and relatively inexperienced primary care providers. Conflicting evidence was reported on the impact of practice characteristics. Whereas several authors found a positive association between high referral rates and single-handed practices (Hippisley-Cox et al., 1997a), others reported no relationship between referral rates and the number of doctors in a practice (Christensen et al., 1989). Conversely, Verhaak (1993) found an increase in referral rates with the number of GPs in the practice. Finally, a series of empirical studies stressed the importance of the availability of specialist care in explaining referral rates (Jones, 1987; Noone et al., 1989; Roland and Morris, 1988). Madeley et al. (1990) found that urban GP's have higher referral rates than do their rural counterparts.

O'Donnell (2000) concluded that patient characteristics together with practice and GP characteristics cannot explain more than 50% of the variation in referral rates. Qualitative empirical evidence suggests that "having a personal relationship with the consultant" is one of the most important determinants of referral decisions in a fee-for-service (FSS) environment (Shortell, 1973) and that GPs rely on consultants' professional reputations in their referral decision-making (Ludke, 1982). Similarly, Whynes et al. (1998) suggested that GPs' choice of referral destination is dominated by their knowledge of and confidence in the hospital consultants and by their physical proximity. Anthony (2003) argued that, in addition to personal and professional relationships, FFS referrals rely on direct communication between the providers and on the opportunities to monitor one another in the referral process.

### 1.2. Networks and referral appropriateness

The main contribution of this paper is the positive and normative analysis of the impact of the doctors' membership in social networks on the GPs' referral behavior. Even if network effects can be identified, social and professional relationships in referral processes do not guarantee, *per se*, high-quality health-care. "Referral relationships based in social ties may be stuck in old-boy networks, or based on friendship or inertia, resulting in referrals to known, but not necessarily high-quality providers" (Anthony, 2003, p. 2035). Schaffer and Holloman (1985) found that GPs selected their consultants from a group of colleagues with whom they shared a background, interests, or training. However, the authors did not offer a strategy for normative statements about the patients' welfare or the health-care system. Neither the magnitude of referral rates nor their determinants allow a clear judgment on whether referrals are appropriate or not.

Coulter (1998) specifies a referral as appropriate if it is necessary for the patient, effective in achieving its objectives, timely in the course of the disease, and cost effective.[2] Similarly, Foot et al. (2010)

[2] An extended welfare economic perspective might focus on the net benefits of referrals; this would, however, require the economic (monetary) evaluation of health benefits.

argued that there is no commonly agreed-upon definition of "high-quality" referrals. Based on their literature review, they evaluated the quality of a referral along the following dimensions: necessity, timeliness, destination, and process.[3] Most available qualitative studies on the appropriateness of referrals have included joint reviews of the sending and receiving doctors for a series of referrals. The available evidence is mixed, with some hospital consultants being critical of GPs' referrals, and other studies suggesting that GPs generally do refer appropriately.[4]

### 1.3. Statistical discrimination and selection

Referral processes based on social networks may work well as they facilitate the flow of information and control (Grembowski et al., 1998). For example, network participants may gain information on others' reliability and reputation, either through past experience or via third-party connections. This corresponds with economists' notion of statistical discrimination, under which rational agents may favor or disadvantage different social groups (Arrow, 1973; Phelps, 1972). The term "statistical discrimination" means that a group affiliation is used as a decision criterion if the productivity signals of the agents (the medical ability of specialists) are differently informative within and outside of the network.[5] Consequently, GPs may refer patients to specialists within their network because it is easier to assess the strength and ability of these specialists. Another important argument is that social relationships allow social control and increase conformity to rules and norms (Horne, 2001).

Alternatively, a positive association between network membership and the appropriateness of a referral may indicate selection of patients. One might hypothesize that GPs do their network specialists a favor by sending them more profitable patients[6] whereas it is a priori unclear whether these patients are the healthier or the sicker ones. Selection might also occur if GPs do not refer certain patients to reduce their own risk of embarrassment in cases where the referral might be considered inappropriate by the specialist. In such situations the allocation of patients within the health system might not be optimal (e.g. cost efficient). We offer empirical strategies that may help to distinguish between statistical discrimination and selection as two possible driving forces behind the network effects.

### 1.4. Innovative aspects and organization of the paper

This paper extends the literature in several ways: (i) we use a unique comprehensive panel dataset that allows the estimation of gravity models for pairs of sending and receiving doctors by including GP and specialist fixed effects, (ii) the match of this panel dataset with doctor characteristics provided by the Medical Chamber allows for a good representation of doctors' personal networks, (iii) we provide evidence for the determinants of referrals with particular emphasis on the role of social networks, and (iv) we estimate the appropriateness of referrals within social networks using various patient outcomes. (v) Finally, we provide evidence suggesting that social networks are suitable to overcome information asymmetries between GPs and specialists. The role of social networks in patient referrals in particular (including an analysis of patient outcomes) has not, to our knowledge, been quantitatively analyzed before now.

The rest of the paper is organized as follows: Section 2 presents the institutional setting in the Austrian outpatient health-care sector. Section 3 describes the data and provides descriptive statistics. Section 4 presents the empirical strategy, the results of which are presented in Section 5. Section 6 concludes the paper.

## 2. Institutional setting

In Austria, every resident is covered by mandatory health insurance administered through 25 "sickness funds." Residents cannot freely choose among these funds; they are assigned to a fund depending on their occupation and place of residence. Private employees and their dependents are insured with one of nine regional sickness funds representing the nine Austrian provinces and 75% of the Austrian population.[7] The remaining 16 social security institutions provide mandatory health insurance for particular occupational groups such as farmers, civil servants, self-employed persons, employees of the Austrian Railway Company (OEBB), and employees in several other large companies.

The sickness funds cover all costs associated with maternity and illness. As deductibles and co-payments are small in general, access to the health-care system is not limited by financial constraints. The majority of ambulatory care is provided by resident doctors, including GPs and medical specialists.[8] Although patients can freely select among all available GPs, they usually consult a GP located close to their primary residence. In fact, we observed that 73.7% of patients' home zip codes were the same as the zip code of their GPs' practice.[9] Note that for a substantial number of patients, the nearest doctor might reside in a neighboring community with a different zip code. The GP is expected to coordinate patient care and serves as the recommended first point of contact in non-emergency cases. This gatekeeping function is justified by the fact that doctors can better decide on appropriate treatment than patients. Based on their diagnoses, GPs have to decide whether further services of medical specialists are necessary. However, in the Austrian health-care system, the GP does not receive any fee for referring patients and is not responsible for the costs of specialist care.[10] If the GP decides that specialist care is necessary, s/he refers the patient to a specialist in that particular field. The patient is then eligible to consult one doctor in this field per calendar quarter. GPs are free in their decision to select a suitable specialist.

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[3] See also Blundell and Clarke (2010).

[4] See O'Donnell (2000, p. 467) for a brief review of this literature.

[5] Note that the literature on statistical discrimination distinguishes two cases (for a broader survey, see, for instance, Fang and Moro (2011)). Let us assume that GPs are interested in the specialists' quality $q$. In the first case, group identity is used as the signal for different group averages of the quality. The second case assumes identical distributions of $q$ for the two groups, but the signals on $q$ for the two groups are differently informative. In this second case, a rational agent decides in favor of the group in which quality can be better assessed. Throughout the paper, we refer to the second case when discussing statistical discrimination.
For illustration purposes, we would like to mention an example for the network of doctors who used to work in the same teaching hospital at the same time. These doctors have experienced the quality of their colleagues either by personal contact or by word of mouth. The signal quality about the doctors' performance is undoubtedly better as compared to the information about the quality of doctors who used to work in a different hospital.

[6] Profitability of patients refers here to the specialists' rent representing the difference between the doctor's fee and the actual cost of treatment.

[7] Our data refer to the Upper Austrian Sickness Fund, which is one of these regional sickness funds.

[8] These two groups of providers account for 78.9% of total ambulatory expenditures or 5.8 bn Euro in 2010. Source: OECD System of Health Accounts: http://www.statistik.at/web_de/statistiken/gesundheit/gesundheitsausgaben/index.html, Accessed May 5, 2012.

[9] Based on survey results, Salisbury (1989) showed that most people chose the nearest doctor, and that patients, in general, did not have much information on the doctor's practice. Therefore, a patient's selection of his/her GP can be expected to be exogenous. Patients do not know the GP's network, and as a consequence, we do not expect any influence of the network on patients' selection of GPs.

[10] Resident doctors in Austria (GPs and medical specialists) work under a fee-for-service remuneration framework. Hence, there is no variation in remuneration schemes in our data.

**Table 1**
Average referral rate, 1998–2007.

| Year | Average number of patients per GP | Average number of referrals per GP | Referral rate |
|---|---|---|---|
| 1998 | 3145 | 483 | 15.10 |
| 1999 | 3482 | 545 | 15.29 |
| 2000 | 3564 | 549 | 15.10 |
| 2001 | 3660 | 587 | 15.91 |
| 2002 | 3801 | 639 | 16.46 |
| 2003 | 3907 | 644 | 16.11 |
| 2004 | 3997 | 682 | 16.60 |
| 2005 | 4195 | 597 | 14.01 |
| 2006 | 4292 | 379 | 8.69 |
| 2007 | 4345 | 396 | 9.01 |

*Note*: This table provides the number of patients, referrals, and the resulting referral rate in percentages for the average GP per year.

## 3. Data and descriptives

For our empirical analysis, we used administrative data from the *Upper Austrian Sickness Fund*. This database includes detailed information on the health-care service utilization of approximately 1.1 million private employees and their dependents; this represents 75% of the provincial population. The data comprise health-care services provided by 957 doctors, including information on medical appointments, drug prescriptions, approvals for sick leave, and referrals from GPs to medical specialists. The referral data-set includes 2,684,273 referrals from 575 GPs to 382 medical specialists between 1998 and 2007.[11]

For each referral, we recorded the referring GP, the receiving medical specialist, the referred patient, and the specialist's revenues generated by this consultation during the quarter of the referral.[12] From these data, we compiled a yearly panel data-set for each potential GP–specialist pair. On average, 95% of a GP's referrals were made to only 35 different specialists. Consequently, 85.3% of all GP–specialist pairs did not include any referrals. For each year and pair, we identified the number of referrals and the specialist's revenues as outcomes. We matched this file with data from the Upper-Austrian Medical Chamber to obtain the doctors' socio-economic characteristics such as gender, age, medical field (for specialists), place and time of study, job history, and the zip code of their medical practice. The information on the zip code of their practice allows us to compute the geographic distance between GPs and medical specialists.

Table 1 illustrates the development of the average GP referral rate over the observation period, and demonstrates that the percentage of referred patients increased slightly from 15.1% in 1998 to 16.6% in 2004. However, the referral rate decreased sharply in 2005, and referral rates dropped close to 9% in 2006 and 2007. This drop can be explained by the introduction of the electronic insurance card in 2005. This card, used for electronic invoicing of medical services, allows patients to see certain medical specialists without a referral slip issued by the primary care provider, as was necessary before 2005. As a result, an increasing number of patients consulted resident specialists without being referred by their GP.[13]

Table 2 shows the number of GPs and specialists per medical field available in our data.[14] The average number of patients treated per year lies between 1015 (neurology and psychiatry) and 6795 (radiology). On average, a GP refers 14.7% of his or her patients to medical specialists. Column 4 displays the proportions of specialists' patients referred by GPs. Whereas only 3.11% of patients treated by pediatricians were referred by GPs, the rate of referred patients was highest for neurologists and psychiatrists (65.12%), followed by radiologists (43.84%) and surgeons (42.88%). This pattern is mirrored by the percentages of revenue generated by referred patients. Neurologists and psychiatrists earn more than 63% of their revenue from referred patients, followed by radiologists and surgeons. The revenue per referred patient was highest for internists, followed by pulmonary specialists, surgeons, and orthopedists, with internists earning nearly 100 Euro per referred patient per year. Moreover, Table 2 shows that the proportion of female resident doctors is below 10% in the fields of urology, surgery, internal medicine, and orthopedics, whereas they represent 32% in neurology and psychiatry, 33% in dermatology, and 43% in pediatrics. The last column indicates that the variation in mean age of doctors is low across medical specialties.

## 4. Estimation strategy

This section presents our empirical strategy to identify the impact of social networks on GPs' specialist referrals.

### 4.1. Determinants of referral rates: the standard approach

Quantitative research into referral behavior argues that the variation in referral rates of GP *i* is basically explained by GP, practice, and patient characteristics. In accordance with this literature (see Section 1), we present regressions for referral rates of Upper Austrian GPs to resident specialists that controlled for these groups of determinants. In contrast to previous studies, we also tested whether social networks influenced referral rates. GP referral rate is estimated by this equation:

$$rate_{it} = \theta\, GP_{it} + \lambda\, practice_{it} + \nu\, patient_{it} + \pi\, network_{it} + \rho_t + \xi_{it} \quad (1)$$

The dependent variable $rate_{it}$ denotes the referral rate of a GP in period *t*, and is defined as the fraction of patients per year who are referred to specialist care (referred patients divided by all patients who consulted the GP per year). $GP_{it}$ denotes GP characteristics including experience (the doctor's current age minus his or her age when s/he graduated from university), experience squared, gender, dummies for marital status, dummies for the university of graduation, and the teaching hospital. Characteristics of a GP's practice were captured by $practice_{it}$ including a city dummy,[15] practice size (measured in cases treated per year), the number of GPs, and the number of specialists in the same zip code area. Moreover, we included patient characteristics ($patient_{it}$), which included the proportion of female patients, the average age of the patient group, and patients' labor market status. The vector $network_{it}$ denotes the network variables measured as the share of specialists who belonged to

[11] We included all doctors who held a contract with the sickness fund for at least one year. The majority of these doctors (75%) can be observed in each year.

[12] Revenues paid to specialists in a subsequent quarter were not considered, as it was unclear whether these follow-up treatments were initiated by the GP. This approach might underestimate the true volume of revenue; however, the short time period examined guarantees a conservative approach that does not over-emphasize the GPs' importance.

[13] In the subsequent regression analysis of referral rates, we use period dummies to control for time effects. Moreover, we have no reason to assume that this structural break due to changes in the accounting system correlates with the research question in this paper (the determinants of referral behavior and the role of social networks).

[14] Specialists not included in the analysis are surgeons and anesthesiologists. They are typically employed in hospitals, and GPs do not refer patients directly to them. Furthermore, dentists are not included because patients contact dentists directly. All medical disciplines that are not explicitly listed are subsumed under one of the mentioned categories (cardiology, endocrinology, hematology, and rheumatology can, for instance, be found in the internist category).

[15] The *City* dummy is equal to one for the cities of Linz, Wels, and Steyr, which have 191,107, 58,717, and 38,248 inhabitants, respectively. These are the three largest cities, comprising about 20.33% of the Upper Austrian population in 2012.

**Table 2**
Sample composition.

| | # of doctors | Average # of patients | Average # of referrals | Share of referred patients (in %) | Total revenues | Total revenues from referred patients per specialist (absolute) | Total revenues from referred patients per specialist (in %) | Revenues per referred patient and specialist (absolute) | Revenues per referred patient and specialist (in %) | Female share | Mean age of specialists |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| GP | 575 | 3249 | 477 | 14.68 | 120,644 | – | – | – | 36.90 | 11 | 53.94 |
| Eye specialist | 45 | 4156 | 682 | 16.41 | 176,227 | 27,612 | 15.67 | 35.24 | 35.97 | 33 | 53.93 |
| Surgery | 16 | 1110 | 476 | 42.88 | 134,768 | 56,523 | 41.94 | 58.78 | 66.97 | 1 | 56.24 |
| Dermatologist | 32 | 4855 | 959 | 19.75 | 185,874 | 38,187 | 20.54 | 34.72 | 32.17 | 33 | 53.62 |
| Gynecologist | 69 | 3218 | 474 | 14.73 | 164,329 | 23,840 | 14.51 | 42.40 | 41.67 | 9 | 56.10 |
| Internists | 44 | 1426 | 422 | 29.59 | 168,012 | 55,129 | 32.81 | 99.55 | 84.93 | 3 | 55.77 |
| Pediatricians | 36 | 2253 | 70 | 3.11 | 175,535 | 5480 | 3.12 | 55.02 | 52.78 | 43 | 54.71 |
| ENT specialist | 29 | 2852 | 742 | 26.02 | 177,484 | 47,593 | 26.82 | 49.52 | 46.22 | 13 | 52.34 |
| Pulmonary specialist | 22 | 2530 | 931 | 36.80 | 185,727 | 68,156 | 36.70 | 64.93 | 64.17 | 10 | 55.75 |
| Neurology and psychiatry | 29 | 1015 | 661 | 65.12 | 134,363 | 84,948 | 63.22 | 54.81 | 61.79 | 32 | 55.79 |
| Orthopedics | 27 | 3050 | 869 | 28.49 | 207,553 | 55,026 | 26.51 | 59.01 | 63.91 | 4 | 54.09 |
| Radiology | 18 | 6795 | 2979 | 43.84 | 493,937 | 207,495 | 42.01 | 50.48 | 55.31 | 14 | 56.50 |
| Urology | 15 | 2658 | 867 | 32.62 | 159,103 | 41,869 | 26.32 | 39.93 | 53.15 | 1 | 57.31 |

*Note*: This table provides summary statistics for the doctors included in the estimation sample covering the period from 1998 to 2007. Column (1) shows the number of doctors per medical field. In total, we observed 382 medical specialists. The annual average number of patients and referrals are shown in columns (2) and (3). Column (4) shows the share of specialists' patients referred by GPs. The first entry in this column represents referrals by the GP; for the specialists, these numbers denote the referrals received. The total annual average revenues from medical consultations are shown in column (5). Column (6) shows the specialists' revenues from referred patients; the corresponding percentage is shown in column (7). The revenues per referred and non-referred patient are shown in columns (8) and (9). Finally, columns (10) and (11) depict the percentage of female doctors and the average age per medical field. All monetary values are expressed in 2007 Euros. ENT: ear, nose, and throat.

the GP's network divided by the total number of specialists within a 50-km radius of the GP's practice. We constructed the following networks: (i) the share of specialists who graduated from the same *university* as the GP at different points in time, (ii) the share of specialists who were *fellow students* of the GP, (iii) the share of specialists who were educated in the same *teaching hospital*[16] as the GP at different points in time, (iv) the share of specialists who were educated in the same teaching hospital as the GP in the same time period (*co-workers*), (v) the share of specialists of the same gender as the GP, and (vi) the share of specialists in the same age group as the GP. $\rho_t$ are period dummies, and $\xi_{it}$ denotes the error term. We used repeated cross-section ordinary least squares (OLS) estimations.

### 4.2. The impact of social networks on referral behavior

The aforementioned model, however, only measures the impact of the size of social networks on the GP's overall referral rate; it does not analyze whether GPs prefer specialists within their social network to outsiders for a given referral rate. To examine the distribution of referrals, we observed annual patient flows between each GP–specialist pair and estimated the following gravity model.[17]

$$y_{ijt} = \alpha \cdot x_{ijt} + \beta \cdot z_{it} + \mu \cdot r_{jt} + \gamma_i + \eta_j + \delta_t + \epsilon_{ijt} \qquad (2)$$

The major difference between Eqs. (2) and (1) is that the unit of observation is no longer the GP, but the GP–specialist pair.[18] In this equation, $y_{ijt}$ denotes either the number of patients referred from GP $i$ to specialist $j$ in year $t$ (referred to as referrals) or the resulting *revenues* of specialist $j$ from the referrals of GP $i$. Summary statistics for these and the other variables are presented in Table 3.

Our network effects are covered by the vector of pair variables $x_{ijt}$, defined as dummy variables equal to one if the respective attribute of GP $i$ and specialist $j$ corresponds, and zero otherwise. For the identification of social networks, we used information on the doctors' place and time of study and their work history.[19] We constructed (i) a dummy equal to one if GP $i$ and specialist $j$ graduated from the same *university* at different points in time, (ii) a dummy equal to one if both were *fellow students*, (iii) a dummy equal to one if both did their medical internship at the same teaching *hospital* at different points in time, and (iv) a dummy equal to one if both were *co-workers* at the same teaching *hospital*. For (i) and (iii), we expected that both doctors might know each other indirectly via third-party connections. For (ii) and (iv), however, it is reasonable to assume that the doctors know each other directly. Note that an affiliation with the same social network does not ensure that two doctors know each other; the pair variables rather serve as proxies to capture a higher probability of being acquainted with one another. Thus, we expected stronger effects for the networks of *co-workers* and *fellow students* than for *hospital* and *university*.

The variables discussed thus far test whether GPs referred more or fewer patients to specialists with whom they had a personal connection. We refer to these networks as "personal networks." In their comprehensive literature review, McPherson et al. (2001) showed

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[16] After graduation from university, Austrian medical doctors must undergo a three-year medical internship in a teaching hospital before they are allowed to work as resident doctors under their own responsibility. The teaching hospitals need to be officially recognized by the Austrian Medical Chamber.

[17] This model is called a "gravity model" due to its resemblance to models of the economics of trade. In this gravity model, the exporting country is represented by the GP and the importing country is represented by the medical specialist. The trade flows are typified by the number of referred patients and the resulting revenues of the specialist.

[18] Each GP is paired with all specialists.

[19] Similar strategies for the construction of networks are used in Cohen et al. (2008) and Gompers et al. (2012).

**Table 3**
Summary statistics of variables used in the gravity model.

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| Referrals | 1.82 | 11.66 | 0 | 1086 |
| Revenues | 93.64 | 623.85 | 0 | 90496.43 |
| University | 0.39 | | 0 | 1 |
| Fellow students | 0.11 | | 0 | 1 |
| Hospital | 0.08 | | 0 | 1 |
| Co-workers | 0.02 | | 0 | 1 |
| Same age group | 0.51 | | 0 | 1 |
| Same gender | 0.76 | | 0 | 1 |
| Distance[a] | 65.08 | 30.30 | 0 | 205.75 |
| GP's experience | 22.17 | 5.62 | 5 | 43 |
| Specialist's experience | 23.41 | 5.82 | 10 | 48 |
| GP's patients[b] | 3.907 | 1.409 | 0.276 | 10.7 |
| Specialist's patients[b] | 3.826 | 2.413 | 0.001 | 25.001 |
| Number of GPs | | | 575 | |
| Number of specialists | | | 382 | |
| Observations | | | 1,502,333 | |
| Non-zero observations | | | 220,698 | |

*Note*: This table provides summary statistics for the variables used in the subsequent regressions. The number of GPs and specialists represents all doctors included in the estimation sample. The sample comprises 1,502,333 observations; however, referrals between a doctor pair were only present in 220,698 observations. The figures of the summary statistics are based on all observations, including the zeros.
[a] Measured in minutes.
[b] Measured in thousands of patients.

that similar individuals are more likely to interact than dissimilar ones. This phenomenon has been demonstrated in a wide range of social settings, e.g., friendship, school, marriage, or work. Therefore, we tested whether similarities in doctors also enhanced collaboration, although they did not reflect a potential personal connection. For this purpose, we constructed (v) another dummy equal to one if the GP and the specialist were of the *same gender*. Similarly, (vi) the dummy for *same age group* was one if the GP and the specialist belonged to the same age group (below/above median age). We used these two variables because this information is rather easily accessible for GPs. We called these social interactions "affinity-based networks."[20] As additional pair variables, we included the traveling distance between GP $i$ and specialist $j$ measured in minutes.

It is important to note that the attributes used to construct the pair variables were time-invariant at the doctor level, but varied over doctor pairs. This is because GP $i$ was paired with different specialists $j$, and vice versa. Thus, it was possible to include both GP and specialist fixed effects denoted by $\gamma_i$ and $\eta_j$, although we used time-invariant information of the individual doctors. The doctor fixed effects account for time-invariant heterogeneity such as education effects influenced by universities or hospitals, and time-invariant ability. Consequently, the pair variables captured the network effects but no idiosyncratic effects based on doctor-specific attributes.[21]

We also included time-variant characteristics of GP ($z_{it}$) and specialist ($r_{jt}$), such as experience (current age minus age in year of graduation from university) and each doctor's total annual number of patients. In order to prevent reverse causality, we subtracted from this right-hand side variable all patients referred between the GP–specialist pair. To control for changes in referral behavior over time, we included period dummies $\delta_t$. Finally, $\epsilon_{ijt}$ denotes the error term.

[20] Obviously, we cannot exclude the possibility that doctors within affinity-based networks know each other personally; this will certainly be true for some of the doctor pairs within those networks. Nevertheless, we presume that there is a lower probability that doctors know each other within affinity-based networks as compared to personal networks.

[21] For analogous empirical work in trade see Egger and Pfaffermayr (2003) or Silva and Tenreyro (2006).

Based on this positive analysis, we also present evidence on normative aspects of referrals within personal and affinity-based networks. By using indicator variables for the appropriateness of referrals (e.g., quality indicators for destination, process and competency, timeliness of the referral, or subsequent outpatient expenditures) as dependent variables ($y_{ijt}$) in Eq. (2), we present evidence on whether referrals within social networks are advantageous or detrimental for patients. A detailed description of the employed quality indicators is given in Section 5.2.2.

### 4.3. Network effects: statistical discrimination or selection?

Various motives can be provided for GPs' preference to select specialists within their own network. These motives range from explicit or statistical discrimination to rent-seeking motives in which GPs might shift rents to doctors within their social network (also referred to as the "old boys network") instead of searching for an objectively ideal specialist for the patient. Although we cannot empirically test the full breadth of motives for referrals within networks, we exploited the typical characteristics of personal networks to validate the importance of positive statistical discrimination within them. In personal networks, doctors are acquainted personally at a substantially higher probability compared to affinity-based networks constructed solely based on the doctors' similarity. Hence, the two types of networks differ, as in the affinity-based networks, GPs do not refer patients to specialists because they know them, but because they share similar characteristics. Based on acquaintance via personal networks, GPs are better informed regarding the specialists' particular skills and can make better decisions because it is easier to assess the ability and strength of the specialists. According to statistical discrimination, specialists from the GP's personal network are chosen because their quality is more precisely known (see also Footnote 5). One would therefore expect that high-quality specialists within the network would receive more referrals than low-quality specialists. This concentration on high-quality doctors should be more pronounced in personal networks compared to affinity-based networks, as we assume doctors are personally acquainted with specialists at a substantially higher probability in personal networks compared to affinity-based networks, which are constructed solely on the basis of the doctors' similarity.

Consequently, we tested whether the referrals within a network were more concentrated on high-quality specialists. We provided two measures of specialist quality: (i) the percentage of a specialist's patients who worked in a hospital and had not been referred by a GP, and (ii) the percentage of a specialist's patients who hold an academic degree and who had not been referred by a GP. For this purpose, we computed the number of specialists' hospital staff patients divided by their total number of patients, and the number of the specialists' university graduate patients divided by their total number of patients in each year and for each specialist. It is reasonable to assume that both patient groups possess more information on the quality of a specialist than the average referred patient. Individuals working in a hospital can be expected to gather information on doctors through their occupational experience and networks, and university graduates are more likely to form networks with doctors during their shared time at the university. Moreover, following the Grossman model, university graduates are more efficient in health production and, in particular, in processing information in health-care markets. Therefore, these patient proportions should be positively correlated with specialist quality.

We constructed three dummy variables for each of these cardinally measured factors indicating low-quality, mid-quality, and high-quality specialists by dividing the observations into tertiles. We used the identical econometric framework as in Section 4.2, but added the dummy variables for mid- and high-quality specialists and generated interaction terms between these dummies and each network variable. Significant positive coefficients for the interaction terms would imply that high- and mid-quality specialists within a network received more referrals, and that social networks reduced information asymmetry.[22]

An important counter-argument against positive statistical discrimination is the existence of selection effects. More profitable patients may be referred within the doctor's social network and thus influence the results. GPs may do their network specialists a favor by sending them a selection of healthier or sicker patients. Depending on the mark-ups for different treatments, specialists may profit from the particular selection of referred healthier or sicker patients. Another form of selection might arise if the preferred specialist from the network has particularly long wait lists – in such cases, the GP may be forced to refer urgent cases (and, therefore, less healthy patients) to another specialist outside his or her network. Such an approach is good medical practice and is compatible with a GP looking out for the best interest of his or her patients.

To empirically address potential selection effects, we performed falsification tests that analyzed whether patients referred in social networks were sicker or healthier before the referral. In doing so, we compared the health status of individuals approximated by their number of days spent in the hospital and days of sick leave in the quarters prior to the referral.

## 5. Empirical results

This section presents the main empirical results. Section 5.1 starts with a discussion of the determinants of GP referral rates. Section 5.2 shows the results for the gravity model including a normative assessment of the impact of social networks on patient outcomes. Section 5.3 provides test results for the hypotheses of statistical discrimination and selection. Section 5.4 summarizes the estimation results for personal versus affinity-based networks.

### *5.1. The determinants of GP referral rates*

The regression results for the determinants of referral rate are depicted in Table 4. In specification (1), we present the impacts of controls that were analyzed in previous studies, including GP, practice, and patient characteristics. In columns (2) and (3) we present separate results for male and female GPs, respectively. Supplementing the existing literature, in specifications (4) and (5) we additionally analyze whether network characteristics influence referral rate.

As can be seen in column (1), the GP's experience was a positive regression coefficient. As compared to their older colleagues, younger GPs tend to treat patients themselves rather than referring them to specialists. The family status of a GP does not play a major role in her referral behavior. Single and divorced primary care providers were not significantly different from married doctors (the base category). Similarly, the location of the university from which the GP graduated did not have an effect. The referral pattern of GPs who studied at the medical schools in Graz and Vienna was similar to that of those who studied in Innsbruck (the base category).[23]

The dummy variable for city showed a strong and significant impact on GP referral rates. The percentage of referred patients increased by 3.80 points if the GP's practice was located in an urban versus a rural area. Another positive influence was observed for practice size, representing the number of patients who consulted the GP per year. Two further supply-side impacts showed the expected signs: the number of specialists in a GP's zip code was an indicator of the availability of complementary good specialist care. As can be seen, an additional specialist in the GP's zip code area increased the referral rate by 0.17 percentage points. Obviously, GPs were more inclined to refer their patients if the specialists were located in proximity to the GP's ordination. This result is in line with empirical evidence that both a shorter distance between a GP's practice and specialist care and the availability of consultants increased referral rates, as presented in the literature review. Finally, we found a significant negative influence of the number of GPs in the same zip code area: another GP practice decreased the referral rate of a GP in a zip code area by 0.19 percentage points. This is evidence for substitution.

The GPs' referral rates depended significantly on their patients' age and labor market status. One additional year of mean age increased the referral rate by 0.22 percentage points. This can be explained by the fact that patients' health status deteriorates with age, and that a worsened state of health increases the need for referrals. Moreover, the GPs' referral rate decreased significantly with the share of unemployed, retired, and other patients.[24] A one percentage point higher unemployment rate among a GP's patients reduced the referral rate by 0.52 percentage points. The same increase in the share of retired or other patients decreased the referral rate by 0.36 and 0.12 percentage points, respectively. These results support the findings of Sorensen et al. (2009), who showed that persons with low socio-economic status are referred less to practicing specialists and more to hospitals. The influence of the *female share* of patients remained non-significant.

The separate analysis for male and female GPs indicates that the effects depicted in column (1) were mainly driven by male doctors.

[22] Because of the quality indicators, we could not simultaneously control for specialist fixed effects. However, as doctors' observable and unobservable heterogeneity might be correlated with regional characteristics (e.g., high-quality specialists might be concentrated around hospitals), we additionally controlled for either a city dummy or zip code fixed effects.

[23] The regressions also controlled for hospital fixed effects (the teaching hospital where the GP did his or her medical internship after graduation from university) and for period fixed effects.

[24] The category "other patients" included mothers on maternity leave, conscripts, individuals on rehabilitation, and co-insured children.

**Table 4**
Determinants of referral rate.

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| **GP characteristics** | | | | | |
| Experience | 0.426** | 0.480** | −0.446 | 0.597*** | −0.205 |
| | (0.154) | (0.155) | (0.472) | (0.179) | (0.655) |
| Experience squared | −0.008 | −0.009* | 0.011 | −0.011** | 0.006 |
| | (0.004) | (0.004) | (0.011) | (0.004) | (0.015) |
| Single | 2.586 | 3.382 | −0.236 | 3.324 | −0.459 |
| | (1.525) | (2.715) | (1.711) | (2.696) | (1.721) |
| Divorced | −0.423 | −0.137 | −7.534** | −0.163 | −8.109** |
| | (0.821) | (0.855) | (2.265) | (0.846) | (2.785) |
| Widowed | 1.454 | 1.890 | −3.964 | 2.710 | −5.328 |
| | (1.674) | (1.862) | (3.411) | (1.805) | (3.538) |
| Graz[a] | 0.520 | 0.519 | 0.708 | 1.134 | −0.827 |
| | (0.670) | (0.702) | (2.406) | (0.959) | (5.180) |
| Vienna[a] | 0.241 | 0.388 | 0.316 | 0.533 | 1.262 |
| | (0.472) | (0.479) | (1.868) | (0.491) | (2.219) |
| **Practice characteristics** | | | | | |
| City | 3.830*** | 3.842*** | 4.197 | 3.907*** | 4.058 |
| | (0.800) | (0.848) | (2.443) | (0.833) | (2.350) |
| Practice size[b] | 0.496** | 0.502** | 0.698 | 0.457* | 0.610 |
| | (0.167) | (0.183) | (0.584) | (0.179) | (0.579) |
| Number of GPs | −0.184* | −0.209* | 0.201 | −0.205* | 0.178 |
| | (0.079) | (0.085) | (0.147) | (0.083) | (0.142) |
| Number of specialists | 0.166** | 0.181** | −0.063 | 0.176** | −0.048 |
| | (0.058) | (0.062) | (0.115) | (0.061) | (0.111) |
| **Patient characteristics** | | | | | |
| Share of females | 0.038 | 0.029 | −0.088 | 0.014 | −0.106 |
| | (0.062) | (0.069) | (0.173) | (0.065) | (0.166) |
| Mean age of patients | 0.223** | 0.233** | −0.114 | 0.217** | −0.072 |
| | (0.077) | (0.079) | (0.201) | (0.077) | (0.201) |
| Share of unemployed patients | −0.520** | −0.660*** | 0.234 | −0.586*** | 0.279 |
| | (0.166) | (0.178) | (0.427) | (0.174) | (0.439) |
| Share of retired patients | −0.356*** | −0.373*** | −0.034 | −0.359*** | −0.032 |
| | (0.063) | (0.067) | (0.143) | (0.065) | (0.143) |
| Share of other patients[c] | −0.117* | −0.117* | 0.004 | −0.109* | 0.026 |
| | (0.049) | (0.055) | (0.103) | (0.053) | (0.118) |
| **Shares of network specialists** | | | | | |
| Same gender | | | | 0.170*** | −0.099 |
| | | | | (0.027) | (0.138) |
| Same age group | | | | −0.024 | −0.044 |
| | | | | (0.018) | (0.063) |
| University | | | | 0.015 | −0.078 |
| | | | | (0.021) | (0.131) |
| Fellow students | | | | 0.029 | −0.049 |
| | | | | (0.028) | (0.137) |
| Hospital | | | | −0.030 | 0.001 |
| | | | | (0.023) | (0.058) |
| Co-workers | | | | 0.108** | −0.133 |
| | | | | (0.042) | (0.130) |
| Observations | 4823 | 4329 | 494 | 4329 | 494 |
| $R^2$ | 0.383 | 0.369 | 0.640 | 0.400 | 0.643 |
| Mean of dependent variable | 14.12 | 13.88 | 16.15 | 13.88 | 16.15 |

*Note*: This table summarizes estimation results of GP, practice, and patient characteristics and the share of network specialists on the referral rate (annual number of referrals divided by annual number of patients expressed as a percentage) in a repeated cross-section with GPs as observation units. The results are based on OLS estimations; standard errors (in parentheses) are robust to clustering at the GP level and to heteroscedasticity of unknown form. Each estimation also controlled for hospital and period fixed effects.

[a] In comparison to GPs who studied at the medical university of Innsbruck.
[b] Measured in thousands of patients.
[c] Mothers on maternity leave, conscripts, persons on rehabilitation, and co-insured children.
* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

Almost all quantitative and qualitative results in column (2) correspond with those in column (1). On the contrary, as can be seen in column (3), the control variables remain consistently insignificant for female GPs. The one exception is the doctor's family status. Female GPs who were divorced had a ceteris paribus 7.5 percentage points lower referral rate than their married colleagues. However, the small sample size for female GPs does not permit an unambiguous assessment of structural differences between males and females in referral behavior.

A comparison of columns (2) and (3) with columns (4) and (5) reveals that the coefficients remained almost unchanged qualitatively and quantitatively if we additionally control for network characteristics. Among these characteristics, we found statistically significant effects for the *same-gender* and *co-worker* networks in the male sample, but these effects were of minor quantitative importance. This evidence would suggest that the size of social networks did not substantially influence overall GP referral rates. A separate analysis for different medical fields (estimation of

**Table 5**
Mean comparison tests for referrals and referral revenues.

| | Referrals | | | Revenues | | |
|---|---|---|---|---|---|---|
| | No (1) | Yes (2) | *p*-Value (3) | No (4) | Yes (5) | *p*-Value (6) |
| University | 1.536 | 1.916 | 0.000 | 73.380 | 100.121 | 0.000 |
| Fellow students | 1.761 | 1.923 | 0.000 | 89.146 | 100.711 | 0.000 |
| Hospital | 1.802 | 1.994 | 0.000 | 92.409 | 103.265 | 0.000 |
| Co-workers | 1.577 | 4.518 | 0.000 | 80.715 | 234.599 | 0.000 |
| Same age group | 1.735 | 6.269 | 0.000 | 88.749 | 338.471 | 0.000 |
| Same gender | 1.782 | 1.865 | 0.000 | 91.321 | 95.907 | 0.000 |
| Mean[a] | | 1.820 | | | 93.640 | |
| Observations | | 1,502,333 | | | 1,502,333 | |

*Note*: This table shows mean comparison tests of referrals and revenues for each network variable. Columns (2) and (5) show the means within the network and (1) and (4) show the means outside the network. The *p*-values indicate whether the differences in means are statistically significant.
[a] The unconditional sample mean.

field-specific referral rates) confirmed this result.[25] Nothing is said, however, about the preferential treatment of doctors within the social network. In the next section, we analyze whether increased referrals and revenues to doctors within the GPs' social networks can be observed.

### 5.2. A gravity model of referral behavior

Table 5 provides an initial descriptive picture of mean comparison tests for the number of referred patients (referrals) and revenues based on referred patients measured in 2007 Euro (revenues). The social groups according to different network criteria are listed in the rows. Columns (2) and (5) show the means for referrals within the network; columns (1) and (4) list the respective means for referrals outside the networks. The *p*-values in columns (3) and (6) indicate that the differences in means for all social groups were statistically significant. We found that, on average, more patients were referred within a social network as compared to outside the network, and that revenues were higher for referrals to specialists in the network.

#### 5.2.1. Preferences for social networks

The descriptive results are supported by the data in Table 6, which presents the OLS regression results on the determinants of this referral behavior for gravity model (2). The dependent variables are the annual number of referrals (left panel) and annual revenue from these referrals (right panel). The four different columns (no fixed effects, GP fixed effects, specialist fixed effects, both fixed effects) indicate different model specifications with respect to the inclusion of fixed effects.

We found some evidence that GPs refer more patients to specialists who graduated from the *same university* at different points in time. However, when we controlled for GP and specialist fixed effects simultaneously, the significant effects disappeared for both referrals and revenues. For the *fellow-students* network, we found significant (at the 10% level) negative effects only in the specifications that controlled for GP fixed effects. In the most comprehensive models with fixed effects for GPs and specialists, the *same-gender* variable remained statistically significant at the 10% level in explaining the number of referrals (left panel). The network variable *same age group* was not significant in any specification.[26]

Our results revealed that having worked in the same *hospital* and having worked there at the same time contrasted with our other network variables over all specifications as stable indicators for higher patient referrals and higher revenue. Given the unconditional sample mean of 1.82 referred patients and 93.64 Euro revenue, the increase of 1.21 patients (or 60.60 Euro) for having worked in the same hospital and additional 1.08 patients (72.82 Euro) for having been *co-workers* is substantial.

Therefore, networks formed at the teaching hospital seemed to be more influential than university networks. Obviously, we cannot directly measure whether two doctors knew each other personally; rather, our variables indicate the probability that they might have interacted. Given the structure of Austrian medical schools and hospitals, this probability is likely lower in a university setting compared to the normal operations of a hospital. Other controls showed the expected signs: specialists with a medical practice closer to the GP and with a larger number of patients (higher reputation) received more referrals.[27] Whereas the experience of a GP had no influence on referral behavior, younger specialists received on average more patients and higher revenues. GPs with a high number of patients also referred more patients.

#### 5.2.2. Social networks and patient outcomes

The identification of significant social network effects on the doctors' referral behavior *per se* did not allow an appraisal of the welfare implications of the referral practice. Unfortunately, data on patients' benefits were not available, so we cannot offer a rigorous welfare analysis. However, we present empirical evidence on the appropriateness of referrals based on indicators that clearly corresponded with patients' well-being. Although the literature lacks a commonly agreed-upon definition of high-quality referrals, different multi-dimensional criteria for the appropriateness of referrals exist. Blundell and Clarke (2010) and Foot et al. (2010) list the following criteria: (i) "necessity" asks whether the referral of a patient is necessary from a medical point of view; (ii) "timeliness" identifies whether the referral takes place without avoidable delay. (iii) According to "destination," the question is whether the patients

[25] The estimation results also remained unchanged when we substituted the shares of network specialists for shares of network referrals or shares of referred network volumes and when we changed the radius from 50 to 30 or 60 km for the computation of the network variables.

[26] This result was confirmed in a robustness check where we substituted the *same age group* with dummy variables indicating the different tertiles of the age difference distribution for all GP–specialist pairs.

[27] Our results are robust with regard to the chosen functional form of distance. Both a quadratic functional form and an estimation with deciles of the distribution of GP–specialist distances (in minutes) as categorical variables did not change our network coefficients. Referrals decrease with distance in a convex functional form.

**Table 6**
Gravity model: determinants of referral behavior.

| | Referrals | | | | Revenues | | | |
|---|---|---|---|---|---|---|---|---|
| | No FE | GP FE | Specialist FE | Both FE | No FE | GP FE | Specialist FE | Both FE |
| University | 0.120** | 0.056 | 0.127** | 0.021 | 9.876*** | 6.559** | 9.161*** | 3.737 |
| | (0.056) | (0.051) | (0.062) | (0.054) | (3.130) | (2.905) | (3.459) | (3.028) |
| Fellow students | −0.168 | −0.189* | −0.052 | −0.029 | −8.949 | −10.264* | −2.495 | −1.489 |
| | (0.103) | (0.096) | (0.106) | (0.092) | (5.648) | (5.374) | (5.749) | (5.103) |
| Hospital | 1.615*** | 1.498*** | 1.572*** | 1.207*** | 80.121*** | 75.445*** | 77.826*** | 60.599*** |
| | (0.209) | (0.202) | (0.224) | (0.201) | (10.692) | (10.370) | (11.446) | (10.353) |
| Co-workers | 1.533*** | 1.455*** | 1.341*** | 1.081*** | 99.202*** | 94.475*** | 86.928*** | 72.820*** |
| | (0.353) | (0.346) | (0.350) | (0.334) | (19.548) | (19.232) | (19.253) | (18.587) |
| Same age group | 0.044 | 0.052 | 0.029 | 0.036 | 2.453 | 2.714 | 1.702 | 1.914 |
| | (0.044) | (0.045) | (0.043) | (0.043) | (2.466) | (2.492) | (2.406) | (2.380) |
| Same gender | 0.458*** | 0.541*** | 0.259 | 0.104* | 30.327*** | 36.739*** | 11.680 | 3.767 |
| | (0.077) | (0.052) | (0.168) | (0.062) | (4.043) | (2.700) | (8.538) | (3.071) |
| GP experience | 0.046*** | 0.132 | 0.050*** | 0.209 | 2.435*** | 6.079 | 2.666*** | 9.884 |
| | (0.012) | (0.160) | (0.015) | (0.189) | (0.602) | (5.770) | (0.765) | (17.577) |
| Specialist experience | 0.001 | −0.009 | −0.074** | −0.153*** | −0.094 | −0.619** | −5.980*** | −10.037*** |
| | (0.005) | (0.006) | (0.035) | (0.030) | (0.281) | (0.288) | (1.799) | (1.609) |
| Distance | −0.074*** | −0.116*** | −0.098*** | −0.191*** | −3.846*** | −6.067*** | −5.038*** | −9.895*** |
| | (0.003) | (0.003) | (0.005) | (0.007) | (0.148) | (0.185) | (0.240) | (0.363) |
| GP patients | 0.245*** | 0.236*** | 0.162*** | 0.227*** | 11.744*** | 10.861*** | 7.858*** | 10.382*** |
| | (0.045) | (0.036) | (0.054) | (0.035) | (2.375) | (2.246) | (1.489) | (1.492) |
| Specialist patients | 0.611*** | 0.574*** | 0.426*** | 0.427*** | 24.791*** | 22.857*** | 17.676*** | 17.704*** |
| | (0.043) | (0.043) | (0.028) | (0.029) | (2.261) | (2.246) | (1.489) | (1.492) |
| Mean of dependent variable | 1.82 | 1.82 | 1.82 | 1.82 | 93.64 | 93.64 | 93.64 | 93.64 |
| Observations | 1,502,333 | 1,502,333 | 1,502,333 | 1,502,333 | 1,502,333 | 1,502,333 | 1,502,333 | 1,502,333 |

*Note*: This table summarizes the results on the determinants of referral behavior based on ordinary least squares (OLS) in pooled cross-section data. Referral behavior was either measured as the annual number of referrals for each doctor pair (left panel) or as the annual referral revenues for specialists (measured in 2007 Euro) for each doctor pair (right panel). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. The estimations also control for period fixed effects. The model specifications vary with respect to the inclusion of doctor fixed effects. FE: fixed effects.

* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

are referred to the most appropriate destination. (iv) The criterion "process" focuses on the quality of the referral process per se (e.g., Is there a referral letter? Are the patients' preferences considered in the selection process?). We offer two further criteria in addition to these criteria discussed in the literature: (v) the "competency" of the specialist in solving the patient's medical problem, and (vi) an assessment of the effects on "outpatient expenditures" within the health system.

In the following section, we analyze the appropriateness of referrals based on indicator variables for criteria (ii)–(vi).[28] To estimate the effects of social networks on these indicators, we used the exact econometric framework presented in Eq. (2). In this section, however, we changed the dependent variable and used the respective indicators as discussed below. With the exception of "timeliness," we measured the indicators $q$ quarters – with $q \subseteq \{1, 2, 3, 4\}$ – after the initial referral from GP $i$ to specialist $j$, and presented the results including fixed effects for both doctor types. As the effects of referrals within social networks on patient outcomes can only be estimated for doctor pairs with referrals greater than zero, the number of observations decreased from 1,502,333 to 220,698 annual GP–specialist pairs.[29]

### 5.2.3. Destination

We used two different variables for the destination criterion: (i) "Follow-up consultations" measured how many patients consulted another specialist in the same medical field after the initial referral from GP $i$ to specialist $j$. A follow-up consultation may indicate that the initial referral was inappropriate, and that the patient and/or GP was not satisfied with the specialist's treatment. Consequently, the patient consults a new specialist. Apart from the potential harm to patients, follow-up consultations result in additional expenditures for the health-care system. (ii) "Subsequent referrals" measured how many patients have been re-referred to a specialist in another medical field by the original specialist to whom the patient was referred. A subsequent referral may indicate that the GP made an error and selected the wrong medical field. Obviously, both events might regularly occur in daily medical practice without any negative connotations (for example, if a patient moves to another area and therefore has to consult another specialist, or when specialists refer their patients to radiologists for further tests).[30] In both cases, however, we should not expect differences for referrals within and outside of social networks. Hence, a statistically significant difference for the number of follow-up consultations and subsequent referrals for referrals within and outside of social networks allows an assessment of the appropriateness of referral behavior.

Our results on the determinants of follow-up consultations and subsequent referrals within one, two, three, and four quarters after the initial referral based on OLS estimations are presented in Tables 7 and 8. A significant negative sign for our pair variables $x_{ijt}$ would indicate fewer follow-up consultations for specialists in the same field, and fewer subsequent referrals to specialists in a different field for referrals within the social network. Table 7 shows statistically significant negative signs for follow-up

[28] We cannot deliver evidence on the criteria (i) necessity. The data used did not include any information on this.

[29] We also estimated the determinants of referral behavior (Table 6) with the restricted sample. The results (not shown in this paper) depicted qualitatively identical results, however, with somewhat reduced statistical significance.

[30] We presume that subsequent referrals happen more often in daily medical practice, whereas follow-up consultations would be more typical for dissatisfied patients or GPs and are therefore a better predictor of patients' well-being. Thus, we interpreted follow-up consultations compared to subsequent referrals as a stronger indicator of the inappropriateness of referrals.

**Table 7**
Determinants of follow-up consultations.

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| University | 0.003 | 0.006 | 0.033 | 0.003 |
| | (0.037) | (0.044) | (0.049) | (0.052) |
| Fellow students | −0.059 | −0.071 | −0.107* | −0.119* |
| | (0.049) | (0.056) | (0.064) | (0.067) |
| Hospital | −0.094 | −0.116 | −0.151* | −0.176** |
| | (0.060) | (0.072) | (0.081) | (0.083) |
| Co-workers | −0.134* | −0.177** | −0.257*** | −0.266*** |
| | (0.071) | (0.080) | (0.088) | (0.093) |
| Identical age group | 0.044 | 0.028 | 0.062 | 0.062 |
| | (0.032) | (0.037) | (0.040) | (0.042) |
| Same gender | −0.140** | −0.145* | −0.121 | −0.127 |
| | (0.067) | (0.081) | (0.085) | (0.089) |
| GP experience | 0.018*** | 0.024*** | 0.024*** | 0.011* |
| | (0.005) | (0.005) | (0.006) | (0.006) |
| Specialist experience | −0.020 | −0.043 | −0.034 | −0.026 |
| | (0.028) | (0.035) | (0.038) | (0.040) |
| Distance | 0.014*** | 0.020*** | 0.025*** | 0.028*** |
| | (0.002) | (0.002) | (0.002) | (0.003) |
| GP patients | 0.070 | 0.042 | 0.052 | 0.043 |
| | (0.047) | (0.054) | (0.064) | (0.066) |
| Specialist patients | 0.042* | 0.087*** | 0.124*** | 0.138*** |
| | (0.025) | (0.032) | (0.035) | (0.037) |
| Mean of dependent variable | 0.857 | 1.237 | 1.511 | 1.694 |
| Observations | 220,698 | 220,698 | 220,698 | 220,698 |

*Note*: This table summarizes the results on the determinants of follow-up consultations conducted at a different specialist in the same medical field 1, 2, 3, and 4 quarters after the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the follow-up consultations could only be determined for doctor pairs with positive referrals, these figures are based on 220,698 observations.
* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

**Table 8**
Determinants of subsequent referrals.

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| University | 0.030 | −0.023 | 0.018 | 0.005 |
| | (0.043) | (0.032) | (0.030) | (0.032) |
| Fellow students | −0.104 | 0.092* | 0.054 | 0.029 |
| | (0.065) | (0.048) | (0.046) | (0.048) |
| Hospital | 0.010 | 0.052 | 0.017 | 0.040 |
| | (0.068) | (0.050) | (0.049) | (0.052) |
| Co-workers | −0.166* | −0.123* | −0.092 | −0.026 |
| | (0.099) | (0.071) | (0.071) | (0.071) |
| Identical age group | 0.060 | −0.022 | −0.037 | −0.028 |
| | (0.037) | (0.026) | (0.024) | (0.027) |
| Same gender | −0.025 | −0.059 | −0.022 | 0.061 |
| | (0.070) | (0.051) | (0.043) | (0.061) |
| GP experience | 0.028*** | −0.033*** | −0.016*** | 0.037*** |
| | (0.006) | (0.004) | (0.004) | (0.005) |
| Specialist experience | −0.009 | −0.066*** | −0.058*** | −0.062*** |
| | (0.041) | (0.023) | (0.021) | (0.017) |
| Distance | −0.004*** | −0.003** | −0.002** | −0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| GP patients | 0.121** | −0.043 | 0.042 | 0.067* |
| | (0.047) | (0.037) | (0.032) | (0.037) |
| Specialist patients | −0.030* | −0.023* | 0.007 | −0.004 |
| | (0.018) | (0.013) | (0.012) | (0.013) |
| Mean of dependent variable | 1.238 | 0.673 | 0.633 | 0.778 |
| Observations | 220,698 | 220,698 | 220,698 | 220,698 |

*Note*: This table summarizes the results on the determinants of subsequent referrals to a specialist in another medical field 1, 2, 3, and 4 quarters after the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the subsequent referrals could only be determined for doctor pairs with positive referrals, these figures are based on 220,698 observations.
* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

consultations in quarters 3 and 4 for the *fellow students* and *hospital* social networks. Moreover, we observed highly significant negative coefficients for *co-workers* at the same hospital for all quarters. These figures are also economically significant as, for example, the coefficient of −0.266 in quarter 4 corresponded to a decrease in follow-up consultations by 15% (see the mean of 1.694 follow-up consultations in Table 7). In contrast, the coefficients of social networks explaining the number of subsequent referrals to

**Table 9**
Determinants of subsequent hospital days.

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| University | 0.007 | 0.008 | 0.011 | 0.016 |
| | (0.017) | (0.021) | (0.025) | (0.026) |
| Fellow students | −0.023 | −0.045* | −0.059* | −0.072** |
| | (0.020) | (0.026) | (0.030) | (0.033) |
| Hospital | 0.008 | −0.008 | −0.034 | −0.040 |
| | (0.023) | (0.031) | (0.035) | (0.036) |
| Co-workers | −0.030 | 0.028 | 0.031 | 0.018 |
| | (0.032) | (0.055) | (0.057) | (0.059) |
| Same age group | −0.003 | 0.012 | 0.017 | 0.013 |
| | (0.013) | (0.017) | (0.019) | (0.020) |
| Same gender | 0.048 | 0.004 | −0.010 | −0.012 |
| | (0.037) | (0.041) | (0.045) | (0.047) |
| GP experience | 0.034*** | 0.029*** | 0.027*** | 0.026*** |
| | (0.002) | (0.002) | (0.003) | (0.003) |
| Specialist experience | −0.011 | −0.013 | −0.019* | −0.024** |
| | (0.008) | (0.010) | (0.011) | (0.012) |
| Distance | −0.001 | −0.001 | −0.000 | −0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| GP patients | 0.017 | 0.024 | 0.041 | 0.047* |
| | (0.019) | (0.022) | (0.025) | (0.028) |
| Specialist patients | −0.008 | −0.001 | −0.003 | −0.003 |
| | (0.008) | (0.010) | (0.012) | (0.013) |
| Mean of dependent variable | 0.457 | 0.659 | 0.792 | 0.894 |
| Observations | 215,174 | 215,174 | 215,174 | 215,174 |

*Note*: This table summarizes the results on the determinants of subsequent hospital days within 1, 2, 3, and 4 quarters after the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the subsequent hospital days could only be determined for doctor pairs with positive referrals, these figures are based on 215,174 observations.
* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

specialists in other medical fields (see Table 8) are lower in value and statistical confidence. Only in quarters 1 and 2 did we observe a lower number of subsequent referrals within the *co-workers* social group.[31] Hence, we did not find detrimental effects for patients referred within the social network with regard to destination. On the contrary, the results supported the view that patients were more satisfied with referrals within the GPs' social network, and the number of follow-up consultations with other specialists decreased.

### 5.2.4. *Process and competency*

With regard to the criteria "process" and "competency," we offer two different variables targeting the quality of the referral and the specialist's medical performance. A first best approach would compare the patient's health status before and after a referral within and outside of social networks. As we could not observe the patient's health status directly, we used the days of hospitalization and the days of sick leave (only for employed persons) as proxies for health status. We utilized the econometric framework of Eq. (2) with the number of hospital days and the number of days of sick leave as the dependent variables; Tables 9 and 10 list the empirical results. For the subsequent hospital days, we found significant negative effects for the *fellow students* network in the quarters 2, 3, and 4. This suggests improvement in the patients' health. For the subsequent days of sick leave, no significant network effects were identified. In summary, neither hospital days nor days of sick leave increased after a referral within a network, implying that increased referrals within a doctor's social networks had no beneficial or detrimental effects on patients' health status.

[31] Given the volatile results for the coefficient of *fellow students* over time, we did not want to over-interpret the statistical artifact of a positive coefficient for *fellow students* in the second quarter at the 90% confidence level.

### 5.2.5. *Timeliness*

According to the criterion "timeliness," the period between the referral and the consultation with the specialist should be as short as possible. Unfortunately, the exact dates of patients' consultations were not included in our data. We were only provided data for the quarter during which the doctors balanced their accounts with the sickness fund for the medical services provided. Hence, for each referral, we counted the number of quarters between the billing for the GP visit and the specialist consultation.[32] Subsequently, we computed the mean waiting period for each GP–specialist pair per year and used this mean as the dependent variable. The empirical results are presented in Table 11. The only significant effect was for *hospital* network, indicating that patients referred between doctors who worked at the same hospital had a longer period to wait for the appointment with a specialist.[33] This suggests a fundamental trade-off involved in doctors' referral behavior: within the *hospital* social network, patients may be referred to better specialists (see the results on indicators for "destination" and "process and competency"), but they have to accept longer waiting periods. Although we had no data on the welfare implications of this trade-off, we interpreted the result in favor of the quality of referrals within networks. As the additional waiting period is relatively small, we believe that the quality aspects of the referral decision prevail.

[32] Doctors are required to settle their accounts with the sickness fund as soon as possible.

[33] We observed a 7.96% increase in wait time for the *hospital* network. Note that we underestimated the true waiting periods because we could only observe the quarter during which the referral and the actual consultation took place. For short waiting periods, the queue time for many of the patients fell within the same quarter and was thus unobservable for us. Hence, our proxy for timeliness represents only a lower limit of the true waiting period.

**Table 10**
Determinants of subsequent days of sick leave.

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| University | 0.020 | 0.037 | 0.059 | 0.054 |
| | (0.035) | (0.043) | (0.048) | (0.051) |
| Fellow students | 0.015 | −0.036 | −0.034 | −0.023 |
| | (0.044) | (0.054) | (0.058) | (0.064) |
| Hospital | −0.008 | −0.031 | 0.018 | 0.021 |
| | (0.065) | (0.072) | (0.079) | (0.083) |
| Co-workers | 0.001 | 0.010 | 0.044 | 0.077 |
| | (0.072) | (0.090) | (0.096) | (0.111) |
| Same age group | 0.051* | 0.033 | 0.028 | 0.016 |
| | (0.028) | (0.036) | (0.038) | (0.041) |
| Same gender | −0.043 | 0.022 | −0.007 | 0.001 |
| | (0.067) | (0.093) | (0.103) | (0.108) |
| GP experience | −0.006 | 0.006 | 0.003 | 0.003 |
| | (0.012) | (0.015) | (0.016) | (0.018) |
| Specialist experience | −0.103*** | −0.131*** | −0.148*** | −0.166*** |
| | (0.029) | (0.032) | (0.040) | (0.040) |
| Distance | −0.002 | −0.002 | −0.003 | −0.004* |
| | (0.001) | (0.002) | (0.002) | (0.002) |
| GP patients | −0.013 | 0.033 | 0.022 | 0.026 |
| | (0.045) | (0.057) | (0.066) | (0.071) |
| Specialist patients | −0.015 | 0.004 | 0.010 | 0.019 |
| | (0.020) | (0.025) | (0.028) | (0.030) |
| Mean of dependent variable | 0.910 | 1.315 | 1.594 | 1.815 |
| Observations | 171,788 | 171,788 | 171,788 | 171,788 |

*Note*: This table summarizes the results on the determinants of subsequent days of sick leave within 1, 2, 3, and 4 quarters after the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the subsequent days of sick leave could only be determined for doctor pairs with positive referrals and for employed patients, these figures are based on 171,788 observations.

* Statistical significance at 10% level.

*** Statistical significance at 1% level.

### 5.2.6. Outpatient expenditures

Finally, we present results concerning the cost implications for the outpatient health-care system. For each referred patient, we calculated the total outpatient expenditures for each of the four quarters following the consultation with the specialist. To estimate the effects of social networks on the subsequent outpatient expenditures, we used Eq. 2 and calculated the annual mean expenditures over all patients for each doctor pair as the dependent variable. The empirical results in Table 12 demonstrate that statistical significance was not observed for our social network variables. Apparently, referrals within personal networks did not increase outpatient expenditures. We found only cost-reducing effects for the *same- gender* network in the first quarter after the referral. In general, however, savings from a reduced number of follow-up consultations were too small to significantly affect outpatient expenditures. As far as other controls are concerned, we found lower outpatient expenditures with increases in GP and specialist experience, suggesting that more practiced GPs and specialists incurred lower outpatient expenditures in treating their patients (note that the effect was larger for specialists). The significant negative sign of distance may be the result of lower health-care utilization by patients in rural areas, which typically exhibit lower densities of doctors.

**Table 11**
Determinants of referral duration.

| | in % |
|---|---|
| University | 0.398 |
| | (2.593) |
| Fellow students | 3.847 |
| | (3.590) |
| Hospital | 7.966** |
| | (3.861) |
| Co-workers | −2.976 |
| | (4.836) |
| Same age group | −1.477 |
| | (2.205) |
| Same gender | 3.825 |
| | (4.918) |
| GP experience | −12.036*** |
| | (2.149) |
| Specialist experience | 2.333 |
| | (3.986) |
| Distance | 0.496*** |
| | (0.118) |
| GP patients | −55.213*** |
| | (10.920) |
| Specialist patients | 3.417** |
| | (1.408) |
| Mean of dependent variable [in quarters] | 0.04 |
| Observations | 211,140 |

*Note*: This table summarizes the results on the determinants of referral duration based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the referral duration could only be determined for doctor pairs with positive referrals, these figures are based on 211,140 observations.

** Statistical significance at 5% level.

*** Statistical significance at 1% level.

### 5.2.7. Normative assessment

Our results on personal networks can be summarized as follows: GPs referred more patients to specialists if both had previously worked at the same hospital. The effect intensified for those doctors who had worked in the hospital at the same time. Fewer follow-up consultations, fewer subsequent referrals, and fewer subsequent days in hospital suggest that referrals within this type of network are more appropriate. For affinity-based networks, we also observed improved patient outcomes, but the effects were substantially weaker compared to personal networks.

## 5.3. Statistical discrimination or selection

The results on patient outcomes support the hypothesis of statistical discrimination. We observed better health outcomes for

**Table 12**
Determinants of subsequent outpatient expenditures.

| | Q1 | Q2 | Q3 | Q4 |
|---|---|---|---|---|
| University | 2.327 | 1.980 | 2.399 | 2.577 |
| | (3.178) | (3.402) | (3.466) | (3.501) |
| Fellow students | −5.908 | −6.155 | −6.737 | −7.011 |
| | (4.498) | (4.721) | (4.795) | (4.866) |
| Hospital | 2.799 | 3.872 | 3.820 | 3.813 |
| | (4.974) | (5.228) | (5.303) | (5.316) |
| Co-workers | −0.505 | −1.488 | −1.406 | −1.306 |
| | (7.149) | (7.688) | (7.810) | (7.854) |
| Same age group | −2.606 | −2.597 | −2.645 | −2.462 |
| | (2.628) | (2.754) | (2.786) | (2.809) |
| Same gender | −8.980* | −8.772 | −8.611 | −8.674 |
| | (5.335) | (5.905) | (6.030) | (6.119) |
| GP experience | −4.132*** | −4.300*** | −4.249*** | −4.403*** |
| | (0.364) | (0.373) | (0.381) | (0.383) |
| Specialist experience | −8.846*** | −10.257*** | −10.998*** | −11.408*** |
| | (1.599) | (2.070) | (2.101) | (2.121) |
| Distance | −0.517*** | −0.589*** | −0.579*** | −0.576*** |
| | (0.163) | (0.169) | (0.171) | (0.172) |
| GP patients | 2.562 | 2.352 | 1.687 | 1.290 |
| | (3.435) | (3.642) | (3.687) | (3.716) |
| Specialist patients | 1.877 | 1.606 | 1.463 | 1.348 |
| | (1.633) | (1.753) | (1.796) | (1.803) |
| Mean of dependent variable | 173.38 | 199.62 | 208.90 | 213.66 |
| Observations | 215,174 | 215,174 | 215,174 | 215,174 |

*Note*: This table summarizes the results on the determinants of subsequent outpatient expenditures within 1, 2, 3, and 4 quarters after the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the subsequent outpatient expenditures could only be determined for doctor pairs with positive referrals, these figures are based on 215,174 observations.

* Statistical significance at 10% level.
*** Statistical significance at 1% level.

patients referred within personal networks as compared to referrals outside of networks, and the health outcomes for referrals within personal networks were better than for referrals within affinity-based networks.

Since we cannot perfectly monitor the individual treatment of referred patients at the level of specialists, another form of discriminatory behavior of specialists could drive the results. Specialists may take extra care of patients referred within social networks and treat them more thoroughly than patients referred outside of social networks. Apart from the fact that this behavior of doctors is morally reprehensible, the Austrian social security system does not provide any incentive for such a discriminatory conduct. This argument is supported by the results of Table 12 where we show that the referrals within networks by no means increase treatment costs. Even if we cannot rule out anecdotal discriminatory behavior of specialists, the empirical evidence does not support this objection. Obviously, specialists do not charge better (and more expensive) treatments of referred network patients.

To provide further evidence of the existence of statistical discrimination in personal networks, we tested whether the referrals within a network were more concentrated on high-quality specialists (see Tables 13 and 14). Finally, Table 15 includes estimation results on whether the improvements in patient outcomes were influenced by the selection of healthier or sicker patients.

To test the concentration on high-quality specialists for referrals within social networks, we have included dummy variables for specialist quality together with the respective interaction terms for the different social networks in the gravity model of Eq. (2).[34] Table 13 shows the results for the quality indicator based on the specialists' share of hospital staff.[35] High-quality specialists receive 1.557 fewer referrals in the base specification, 1.346 fewer referrals in the city specification, and 0.908 fewer referrals in the zip code fixed effect specification. A similar pattern was observed for mid-quality specialists, but the effect was not statistically significant in the zip code fixed effect specification; they received between 0.311 and 0.217 fewer referrals. Although these level effects seem contradictory, it is important to note that these coefficients showed the effects of high-quality compared to low-quality specialists, irrespective whether patients had been referred within or outside of social networks. High-quality specialists have limited patient capacity and thus accept significantly fewer patients referred by GPs. These specialists may be hospital employees themselves who work part-time in the outpatient sector or who have a large number of private patients. This was confirmed in our data, where we found that mid- and high-quality doctors had fewer consulting days per week, worked fewer days over the year, and had higher workloads in terms of patients seen per work day.

For mid-quality specialists in the *same-gender* network, we observed negative effects across all specifications, ranging from −0.324 to −0.169. We discerned an identical pattern for the high-quality doctors of the same network, but the effects were larger in magnitude, falling between −0.471 in the zip code fixed effects specification and −0.446 in the base specification. The only significant effect among the *university* and *fellow students* networks was observed for mid-quality doctors in the city specification. We observed stronger effects in terms of quantitative and statistical significance for the *hospital* and *co-worker* networks for both quality measures. Mid-quality doctors of the *hospital* network received 1.617 more patients in the base specification, 1.574 more patients

[34] For the employed quality indicators and the construction of dummy variables, see Section 4.3.

[35] The tables only present the coefficients for the quality indicators and the interaction terms. The remaining coefficients are almost identical to the estimation results presented in Table 6.

**Table 13**
Test of information asymmetry (share of hospital staff).

| | Base | City | Zip FE |
|---|---|---|---|
| Mid-quality | −0.311*** | −0.217** | −0.039 |
| | (0.111) | (0.108) | (0.107) |
| High-quality | −1.557*** | −1.346*** | −0.908*** |
| | (0.173) | (0.173) | (0.171) |
| Same age group × mid-quality | 0.007 | 0.017 | 0.028 |
| | (0.080) | (0.081) | (0.080) |
| Same age group × high-quality | −0.062 | −0.063 | −0.043 |
| | (0.078) | (0.078) | (0.079) |
| Same gender × mid-quality | −0.324*** | −0.169* | −0.197** |
| | (0.101) | (0.099) | (0.091) |
| Same gender × high-quality | −0.446*** | −0.451*** | −0.471*** |
| | (0.101) | (0.101) | (0.099) |
| University × mid-quality | 0.123 | 0.104 | 0.068 |
| | (0.111) | (0.111) | (0.113) |
| University × high-quality | 0.048 | 0.059 | 0.069 |
| | (0.096) | (0.096) | (0.098) |
| Fellow students × mid-quality | 0.225 | 0.240* | 0.144 |
| | (0.139) | (0.139) | (0.138) |
| Fellow students × high-quality | 0.077 | 0.133 | 0.112 |
| | (0.146) | (0.146) | (0.144) |
| Hospital × mid-quality | 1.617*** | 1.574*** | 1.410*** |
| | (0.278) | (0.278) | (0.273) |
| Hospital × high-quality | 0.691*** | 0.754*** | 0.479* |
| | (0.266) | (0.261) | (0.258) |
| Co-workers × mid-quality | 4.313*** | 4.260*** | 4.011*** |
| | (0.678) | (0.677) | (0.675) |
| Co-workers × high-quality | 1.809*** | 1.691*** | 1.514*** |
| | (0.479) | (0.477) | (0.467) |
| Other controls included | Yes | Yes | Yes |
| Mean of dependent variable | 1.82 | 1.82 | 1.82 |
| Observations | 1,502,333 | 1,502,333 | 1,502,333 |

*Note*: This table summarizes the ordinary least squares (OLS) results for the test of information asymmetry based on specialists' share of hospital staff in all patients. The dependent variable is the annual number of referrals. The table only shows the effects of the quality indicators and their interaction terms with social network variables. Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. In the base specification, we did not include regional controls. We controlled for a city dummy and for zip code fixed effects in the city and zip code fixed effects specification, respectively. FE: fixed effects.

* Statistical significance at 10% level.

** Statistical significance at 5% level.

*** Statistical significance at 1% level.

**Table 14**
Test of information asymmetry (share of university graduates).

| | Base | City | Zip FE |
|---|---|---|---|
| Mid-quality | 0.023 | 0.327*** | 0.435*** |
| | (0.086) | (0.083) | (0.080) |
| High-quality | −0.358** | 0.308* | 0.728*** |
| | (0.170) | (0.170) | (0.153) |
| Same age group × mid-quality | 0.029 | 0.014 | 0.017 |
| | (0.108) | (0.108) | (0.105) |
| Same age group × high-quality | 0.023 | 0.003 | 0.018 |
| | (0.119) | (0.116) | (0.112) |
| Same gender × mid-quality | −0.045 | −0.120 | −0.137* |
| | (0.076) | (0.076) | (0.077) |
| Same gender × high-quality | 0.086 | 0.110 | −0.000 |
| | (0.153) | (0.152) | (0.141) |
| University × mid-quality | 0.095 | 0.074 | 0.129 |
| | (0.117) | (0.117) | (0.118) |
| University × high-quality | −0.102 | −0.102 | 0.004 |
| | (0.131) | (0.131) | (0.130) |
| Fellow students × mid-quality | 0.124 | 0.156 | 0.037 |
| | (0.182) | (0.182) | (0.186) |
| Fellow students × high-quality | 0.126 | 0.154 | 0.078 |
| | (0.200) | (0.199) | (0.198) |
| Hospital × mid-quality | 1.355*** | 1.359*** | 1.321*** |
| | (0.298) | (0.297) | (0.291) |
| Hospital × high-quality | 0.463 | 0.467 | 0.379 |
| | (0.396) | (0.395) | (0.377) |
| Co-workers × mid-quality | 2.417*** | 2.475*** | 2.492*** |
| | (0.624) | (0.623) | (0.616) |
| Co-workers × high-quality | 1.050 | 1.119 | 0.863 |
| | (0.776) | (0.776) | (0.760) |
| Other controls included | Yes | Yes | Yes |
| Mean of dependent variable | 1.82 | 1.82 | 1.82 |
| Observations | 1,502,333 | 1,502,333 | 1,502,333 |

*Note*: This table summarizes the ordinary least squares (OLS) results for the test of information asymmetry based on specialists' share of university graduates in all patients. The dependent variable is the annual number of referrals. The table only shows the effects of the quality indicators and their interaction terms with social network variables. Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. In the base specification, we did not include regional controls. We controlled for a city dummy and for zip code fixed effects in the city and zip code fixed effects specification, respectively. FE: fixed effects.

* Statistical significance at 10% level.

** Statistical significance at 5% level.

*** Statistical significance at 1% level.

in the city dummy specification, and 1.410 more patients in the zip code fixed effects specification. For the high-quality category, the effects decreased but were still significant. In the *co-worker* network, the effect for the mid-quality category was more than twice as large as compared to the *hospital* network: the effects ranged from 4.011 in the zip code fixed effects specification to 4.313 in the base specification. For the high-quality category, we again observed a decrease in magnitude. Doctors from this category received between 1.514 and 1.809 more referrals than did low-quality doctors in the same network.

Table 14 presents the results for the quality indicator share of university graduates among the specialists' patients. The first column shows that the high-quality specialists received 0.358 fewer referrals than did the low-quality specialists. However, the sign changed if regional controls were included. High-quality specialists received 0.308 more referrals in the city specification and 0.728 more referrals in the zip code fixed effects specification. In the last specification, we observed that mid-quality specialists from the *same-gender* network received on average 0.137 fewer referrals. Mid-quality specialists belonging to the *hospital* network received more referrals (1.321–1.359). The effect for mid-quality specialists from the *co-workers* network was even stronger, ranging from 2.417 to 2.492 additional referrals.

The combination of findings from both quality indicators reveals that higher-quality doctors within the *hospital* and *co-workers* networks received more referrals than did lower-quality doctors in the same networks.[36] These results support the hypothesis that statistical discrimination can explain the quality-improved referrals within personal networks. In this way, GPs can better acquire information regarding specialists' skills within the personal social network compared to doctors outside the network, thus enabling the GP to refer patients more appropriately. We would not expect such a concentration of referrals to high-quality doctors within social networks under pure rent-seeking motivation toward increasing revenue.

Estimation results for the falsification test to analyze whether patients who were referred in social networks were healthier or sicker before the referral can be seen in Table 15. In these regressions, we used health status before the referral as the dependent

[36] In another robustness check, we split the sample of GPs in the gravity model by their median age. The results reveal that both the statistical significance and the size of the coefficients are higher in the sample for the younger GPs. This might indicate support for the hypothesis that the motive of statistical discrimination is more important for newly minted medical doctors as compared to older GPs who have enough experience to choose high-quality doctors without the insider knowledge of social networks.

**Table 15**
Falsification test: outcomes measured one quarter and one year before the referral.

| | Hospital days | | Days of sick leave | |
|---|---|---|---|---|
| | Quarter before referral | Year before referral | Quarter before referral | Year before referral |
| University | −0.002 | −0.024 | 0.011 | −0.023 |
| | (0.015) | (0.024) | (0.030) | (0.045) |
| Fellow students | 0.012 | −0.008 | 0.001 | 0.028 |
| | (0.021) | (0.032) | (0.035) | (0.058) |
| Hospital | 0.025 | −0.005 | −0.001 | 0.037 |
| | (0.027) | (0.039) | (0.045) | (0.072) |
| Co-worker | 0.011 | −0.025 | 0.047 | 0.044 |
| | (0.028) | (0.043) | (0.061) | (0.087) |
| Same age group | −0.016 | −0.020 | −0.032 | −0.046 |
| | (0.013) | (0.021) | (0.024) | (0.036) |
| Same gender | −0.013 | −0.049 | −0.059 | 0.004 |
| | (0.024) | (0.045) | (0.053) | (0.079) |
| GP experience | 0.002 | 0.010*** | 0.015*** | 0.055*** |
| | (0.002) | (0.003) | (0.004) | (0.006) |
| Specialist experience | −0.012* | −0.029** | −0.060*** | −0.140*** |
| | (0.006) | (0.013) | (0.012) | (0.023) |
| Distance | −0.000 | −0.001 | −0.009*** | −0.018*** |
| | (0.001) | (0.001) | (0.001) | (0.002) |
| GP patients | 0.030 | 0.031 | 0.045 | 0.099 |
| | (0.023) | (0.029) | (0.038) | (0.062) |
| Specialist patients | 0.005 | 0.021* | 0.011 | 0.048* |
| | (0.007) | (0.011) | (0.014) | (0.025) |
| Mean of dependent variable | 0.418 | 0.418 | 0.345 | 0.345 |
| Observations | 215,174 | 215,174 | 215,174 | 215,174 |

*Note*: This table summarizes the results on the determinants of hospitalized days and days of sick leave one quarter and one year prior to the initial referral based on ordinary least squares (OLS). Standard errors are robust to clustering at the GP level and to heteroscedasticity of unknown form. As the outcomes could only be determined for doctor pairs with positive referrals, these figures are based on 215,174 observations.
* Statistical significance at 10% level.
** Statistical significance at 5% level.
*** Statistical significance at 1% level.

variable in the gravity approach of Eq. (2). Neither the pre-referral number of days of hospitalization nor days of sick leave were significantly affected by the network variables. This holds true for a period of one quarter before the referral and also for an extension of this period up to one year. The table demonstrates that patients referred within social networks were neither healthier nor sicker than patients referred outside the network. This is a clear indication against selection of healthy patients as an explanation for the positive association between within-network referrals and beneficial patient outcomes.

### 5.4. *Personal versus affinity-based networks: a synthesis of results*

According to our results, the *co-worker* and *hospital* personal networks were apparently used to reduce information asymmetries concerning specialist quality, which in turn improved the appropriateness of referrals (see Tables 7 and 12 as well as Section 5.3). However, the test for information asymmetry (see Tables 13 and 14) showed opposite effects for the *same gender* network. This confirms that the strategy of GPs to choose specialists within this affinity-based network was indeed different. GPs did not use this network to acquire information on the specialists' quality, but they did choose specialists based on their affinity toward the specialist. This hypothesis was supported by our empirical findings: (i) an increase in the share of surrounding specialists of the same gender increased the referral rate (Table 4), suggesting that GPs refer more patients. This might imply that some patients were referred even if no specialist care was absolutely necessary, which stands in contrast to the results of the other network variables. (ii) The gravity model (Table 6) showed that the number of referrals to doctors with the same gender increased. (iii) We found evidence that the number of follow-up consultations (Table 7) and amount of outpatient expenditures (Table 12) tended to be slightly lower. (iv) However, we observed a higher concentration of referrals to low-quality specialists, and fewer referrals to mid- and high-quality doctors (see Tables 13 and 14) in this network.

To summarize this evidence, we conclude that other motives (e.g., rent-seeking, . . .), as opposed to positive statistical discrimination, seemed to be the driving force behind the additional referrals within the *same-gender* affinity-based network.[37] This result is in line with Gompers et al. (2012), who showed that affinity-based networks perform worse than ability-based networks for the venture capital market. Note, however, that our results on the *same-gender* affinity-based network are based on weaker statistical evidence compared to the statistical discrimination phenomenon within the *hospital* or *co-workers* networks. As we observed neither statistically significant detrimental effects for patients nor cost increases for the health-care system, it is important not to overvalue this result.

## 6. Conclusions

Based on comprehensive health-care service utilization data from Austria, we examined the determinants of GPs' referral

[37] Regarding gender differences, we observed more (fewer) re-referrals and higher (lower) outpatient expenditures for male (female) pairs. We also found evidence of increased (decreased) referrals to low-quality doctors for male (female) GP–specialist pairs. Thus, if there exists a rent-seeking motive in referral behavior such that a specialist profits financially from the preferential treatment of the GP, it is a male phenomenon ("old boys' network"). It must be noted, however, that the number of observed female GP–specialist pairs was substantially lower than the number of male GP–specialist pairs.

behavior with a particular focus on social networks. We analyzed the effects of social networks on referral rates – the decision of a GP to refer patients to specialist care – and on the distribution of the referred patients among different specialists. Moreover, we tested the appropriateness of within-network referrals using various indicators correlated with patients' well-being, such as the timeliness of the referral, the destination, proxies for the health status of patients, and outpatient expenditures. Finally we analyzed whether the observed network effects were the result of information asymmetries concerning the quality and ability of specialists. To our knowledge, this paper is the first to use rich administrative data to assess the role of social networks in referral behavior and the appropriateness of referrals within these networks.

Our results on the determinants of referral rate are in line with previous studies. We found that referral rates varied substantially across GPs, and that rates were influenced by GP, practice, and patient characteristics. Extending upon previous quantitative studies, we analyzed the role of social networks and differentiated between personal and affinity-based networks. In general, we found that GPs did not refer more patients if the surrounding specialists belonged to their social network.

However, the evidence from a gravity model for the GPs' referral behavior demonstrated that social networks changed the distribution of referrals. GPs who had worked in the same hospital at different times (third-party links) and at the same time (direct links) as the specialists referred more patients to these specialists. Moreover, we provide empirical evidence that this type of personal network reduced information asymmetry on the specialists' abilities as GPs selected specialists from higher-quality categories within these networks. This evidence supports statistical discrimination: GPs used their personal networks in order to acquire information on the quality of specialists and therefore improve the appropriateness of their referrals.

For the affinity-based *same-gender* network, a different empirical pattern emerges. Now, we observed increasing referral rates if more specialists of the same gender practiced in the vicinity of GPs. In contrast to all other networks, there was a notably higher concentration on lower-quality doctors for referrals within this type of network. Rent-seeking motives might be a possible explanation – our paper, however, did not provide statistical support for this hypothesis. We could only eliminate positive statistical discrimination and some forms of selection effects as possible causes. We found some statistical evidence that affinity-based networks performed worse in comparison to personal networks. Based on this, we conclude that affinity-based networks, as opposed to personal networks, decreased the appropriateness of referrals. Social networks that reduced information asymmetry, however, improved the appropriateness of referrals.

The empirical evidence presented in this paper has two potential implications for the organization of referrals between health-care providers: (i) health-care organizations should not only collect information on the referrals themselves, but also on variables that allow for assessment of the quality and the necessity of referrals. A combination of a variety of indicators of the quality of referral behavior would facilitate better identification of important patterns. Such an evaluation might also enable more effective control of health-care resources. A systematic and comprehensive compilation of information on quality aspects of referrals would provide the basis for better guidelines for GPs' referring behavior. Moreover, making quality indicators of referrals available to patients may contribute to an increase in efficiency even for patients who self-refer without having seen a GP beforehand. (ii) The central finding of the paper (that GPs use their personal networks in order to gather information on specialists' abilities) demonstrates the consequences of information asymmetry in this health-care market. Different mechanisms, such as an information system, that could reduce these information asymmetries increase the appropriateness of referrals and could in turn improve patient outcomes and decrease health-care costs.

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