Old Boys Networks in GPs' Referral Behavior*

Franz Hackl Michael Hummer Gerald J. Pruckner

University of Linz

Draft paper

December 8, 2012

Abstract

We estimate the impact of social networks on general practitioners (GPs) referral behavior. Our analysis uses administrative panel data from 1998 through 2007 on 2,684,273 referrals to resident specialists. To approximate social networks we use information on the doctors' place and time of study and their working history in hospitals. We find that GPs refer more patients to specialists within their social networks. Using follow-up consultations we assess the effects of networks on the appropriateness of referrals and find that referrals within social networks have lower follow-up consultations. Consequently, referrals within social networks tend to decrease health care costs by overcoming the information asymmetry with respect to specialists' abilities.

Keywords: Referral behavior, general practitioners, information asymmetry, social networks

JEL Classification Numbers: I1, I11

*Corresponding author: Michael Hummer, Johannes Kepler University of Linz, Department of Economics, Altenberger Strae 69, 4040 Linz, ph.: +43 70 2468 5425, fax: +43 70 2468 25425, email: michael.hummer@jku.at.
For helpful discussion and comments we would like to thank Martin Halla, Josef Zweimller and the participants of the Cesifo/JKU Workshop Applied Labour Economics, Bischofswiesen (Germany). The usual disclaimer applies. Moreover, we thank the Upper Austrian Sickness Fund and the Upper Austrian Chamber of Medicine for providing us with 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-G14, is gratefully acknowledged.

1 Introduction

In most health systems, general practitioners serve as gatekeepers who coordinate access to health care provided by resident medical specialists, outpatient departments, and hospitals. Though institutional settings differ between countries and health care systems, the providers of primary health care can either diagnose and treat patients themselves or refer the patients to medical specialists.[1] Referrals of patients from general practitioners (GPs) to specialist care (resident doctors or hospitals) are of particular importance in health policy (i): There is quantitative evidence that follow-up health care cost vary substantially depending on GPs' referral behavior.[2] (ii) A quality-cost tradeoff for the patients' health may exist depending on whether a patient is being referred on to further specialists or alternatively treated by 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 that patients are allowed to be referred to, and by transforming the control over health care delivery from physicians' perception towards 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 healthcare sector where prices for medical services are covered by social insurance, the price mechanism cannot develop its effects. This is particularly true in Bismarckian fee-for-service (FFS) health care systems. As a consequence, we expect that-apart from price mechanisms-social interaction may play another important role in doctors' referral behavior. In this paper we analyze the referral behavior of GPs who refer patients to resident specialists for further diagnosis and treatment. Based on comprehensive, administrative panel data for the Austrian province of Upper Austria in the period of 1998 to 2007, we identify the determinants of GPs' referral rates, analyze the role that social networks play, and finally assess the appropriateness of referrals by estimating the effects of social networks on follow-up consultations with other specialists in the same medical field.

We find that GPs refer patients more frequently to specialists within their social network compared to specialists outside of the network. Patients who are referred within a social network have less follow-up consultations indicating that these referrals are more appropriate. Consequently, referrals within social networks tend to decrease health care costs as they overcome information asymmetry with respect to specialists' abilities.

What are the determinants of individual referral behavior? Besides the dependency from indi-

[1] In a strict gatekeeping system GP referrals are compulsory for patients to utilize medical specialists.

[2] For example, Crombie and Fleming (1988) found a 10-fold difference in hospital expenditures for GP practice populations of 2000 patients associated with the lowest and highest rate of referrals to hospitals.

vidual health characteristics existing medical and economic literature show that referral patterns are also determined by factors other than patient medical needs. The most important reported categories of factors that explain variation in referral rates are (i) patient characteristics, (ii) GP characteristics, (iii) practice characteristics, and (iv) the availability of specialist care.

Patient characteristics: O'Donnell (2000) reports in her comprehensive literature survey that the standardization of referral rates for age and sex of consulting patients reduces the observed variation by less than 10 percent. An adjustment of the referral rate for the social class of the patients does not have much effect on referral rates. However, if the socio-economic status of the whole practice population is used-rather than from those who consult-several authors find positive association between referral rates and area social deprivation (see e.g, Hippisley-Cox et al. 1997a and Hippisley-Cox et al. 1997b). In their more recent cross section analysis of Danish GP referral rates to specialist care, Sorensen et al. (2009) find that persons with high socio-economic status are referred more often to practicing specialists and less often to hospitals as compared to low socio-economic counterparts. Salam-Schaatz et. al. (1994) show that the control for patient characteristics (age, sex, and case-mix) decreases the variation in referral profiles of primary care physicians by more than 50 percent based on a cohort of patients within 52 physician practices in a large health maintenance organization. The authors conclude from this that a failure to adjust for the case-mix in a practice may lead to overestimation of variation in referral rates and also to misdirection of scarce resources.

GP characteristics: The empirical evidence on the most important GP characteristics age of GP and years of experience is inconclusive. Whereas several UK studies do not identify a significant impact of a GP's age or her experience on the referral rate (Cummings et al. 1981 and Wilkin et al. 1987), a Finnish study (Vehvilainen et al. 1996) and another UK study (Rashid and Jagger 1990) demonstrate higher referral rates for younger and relatively inexperienced primary care providers.

Practice characteristics: Similar conflicting evidence on the impact of practice characteristics on variation in referral rates is reported in O'Donnell (2000). Whereas several authors find a positive association between high referral rates and single-handed practices (Hippisley-Cox et al. 1997a), others report no relationship between referral rates and the number of physicians in a practice (Christensen et al. 1989). Conversely, Verhaak (1993) finds an increase in referral rates with the number of GPs in the practice. Availability of specialist care: A series of empirical studies stresses the importance of the availability of specialist care in explaining referral rates. The distance of a GP's practice to specialist care can be expected to have an influence on the access to secondary care. In their study based on referrals from GPs to hospitals in Wales, Jones (1987) finds significantly higher referral rates to outpatient clinic services with shorter distances between the practice and the hospital. Other studies analyze the effects of opening a hospital (Noone et al. 1989) or of the availability of consultants per population (Roland and Morris 1988) and find that the referral rates strongly depend on the availability of hospitals or outpatient consultants. The supply of local hospitals and resident specialists reduces the association between socio-economic

status and referral rates of Danish GPs (see Sorensen et al. 2009). Other authors find that urban GP's have higher referral rates than their rural counterparts (Madeley et al. 1990).

In her above-mentioned literature survey, O'Donnell (2000) concludes that patient characteristics together with practice and GP characteristics cannot explain more than 50 percent of the variation in referral rates. Qualitative empirical evidence suggests that psychological factors are equally important to explain individual referral behavior. The literature in this field focuses on the importance of the GP's cognitive processes in connection with referrals including the decision to whom to refer. These studies consequently analyze psychological variables such as a GP's tolerance of uncertainty, her confidence in the clinical judgment, or her awareness of life-threatening events (Dowie 1983).[3] Other papers identify "having a personal relationship with the consultant" as one of the most important determinants of referral decisions in a fee-for-service (FSS) environment (Shortell 1973) and stress that GPs also rely on the professional reputation of consultants (Ludke 1982) in their referral decision-making. Similarly, Whynes et al. (1996) suggest that GPs' choice of referral destination is dominated by knowledge of, and confidence in hospital consultants and also by their physical proximity. Anthony (2003) argues that in addition to personal and professional relationships, FFS referrals rely on direct communication between the providers and also on the opportunities to monitor one another in the referral process.

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 the 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 decision criterion if the productivity of agents (the medical ability of specialists) cannot be observed. As a consequence GPs refer patients to specialists within their network, because it is easier to assess the ability and strength of these specialists. Another important argument is that social relationships allow social control and increase the conformity to rules and norms (Horne 2001). Social and professional relationships in referral processes do, however, not guarantee per se high quality of 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) find that GP's select their consultants from a group of colleagues with whom they share background, interests or training. However, the authors do not offer a strategy for normative statements about the welfare of patients or the health system.

Neither the size of referral rates nor their determinants allow a clear judgment whether referrals are appropriate or not. Coulter (1998) specifies a referral as appropriate if it is necessary for the

[3] In their experimental setting Earwicker and Whynes (1998) support the so-called referral threshold hypothesis that when confronted with the same set of nominal patients some GPs refer more cases than others, based on own subjective criteria.

patient, effective in achieving its objectives, timely in the course of the disease, and if it is cost effective.[4] Most available qualitative studies on the appropriateness of referrals have included joint reviews of the sending and receiving doctor 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 in general do refer appropriately.[5]

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 and also to include a series of fixed-effects, (ii) the match with doctor characteristics provided by the medical chamber allows for a good representation of personal doctor networks, (iii) we provide evidence for the determinants of referrals with particular emphasis on the role of social networks, and (iv) we interpret the number of follow-up consultations to a different specialist in the same medical field as a measure for the appropriateness of a referral. Both the rich administrative dataset and the appropriate econometric specifications may overcome deficiencies in previous work. Especially the role of social networks including an analysis of patients' welfare implications has-at least to our knowledge-not been quantitatively studied before.

The remainder of the paper is organized as follows. Section 2 presents the institutional setting in the Austrian outpatient healthcare sector. Section 3 describes the data. Section 4 reports regression results on the correlations between referral rates and GP-, practice- and patient characteristics. In Section 5 we specify a gravity model for pairs of sending and receiving doctors and analyze the role of social networks in GPs' referral behavior. Moreover, in Section 6 we provide results on whether and how network effects may have an influence on the appropriateness of referrals. Section 6 concludes the paper.

2 Institutional setting

In Austria every resident is covered by mandatory health insurance that is operated through 25 (regional) sickness funds. Insurants cannot freely choose among these funds, they are assigned to a fund depending on their occupation and place of residence. The sickness funds cover all costs associated with maternity and sickness. Since deductibles and copayments 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.[6] Although patients can freely select among all available GPs, they usually choose their GP (family doctor) next to their place of living. In fact, we observe that for 73.7 percent of patients the zip code of their place of

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

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

[6] These two groups of providers account for 78.9 percent of total ambulatory expenditures in Austria 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.

living coincides with the zip code of the GPs' practice.[7] Note that for a substantial part of patients the nearest doctor might reside in the neighboring commune with a different zip code. The GP is the recommended first point of contact in non-emergency cases and is expected to coordinate the care of patients. This gatekeeping function is justified by the fact that the physician can better decide on the appropriate treatment than the patient. Based on their diagnoses GPs have to decide whether further services of medical specialists are necessary. However, in the Austrian healthcare system, the GP does not receive any fee for referring patients and is not responsible for the costs of specialist care. If the GP decides that specialist care is necessary she writes a letter of referral, including the specialist field. The patient is then eligible to consult one doctor of this field per quarter.[8] GPs are free in their decision to select a suitable specialist. They are, however, recommended to choose a specialist who provides the best medical treatment for the patients under cost benefit considerations.

3 Data

For our empirical analysis we use administrative data from the *Upper Austrian Sickness Fund*. This database includes detailed information on the health service utilization of about 1.1 million private employees and their dependents who are representative for about 75 percent of the provincial population. These data comprise health services provided by 957 physicians including information on medical attendance, prescription of medical drugs, approvals of sick leave, and referrals from GPs to medical specialists. Our referral data set finally covers 2,684,273 referrals from 575 GPs to 382 medical specialists from 1998 to 2007.[9]

For each referral we observe information on the referring GP, the medical specialist, the referred patient and the specialist's revenues generated by this consultation during the quarter of the referral.[10] From these data we compile a yearly panel data set for each potential GP-specialist pair. On average GPs refer 95 percent of their referrals to only 35 different specialists. As a consequence, 85.3 percent of all GP-specialist pairs do not include any referral. For each year and pair, we determine the number of referrals and the associated specialists' revenues as outcomes. We match this file with data from the *Upper-Austrian Medical Chamber* to obtain socio-economic characteristics of doctors such as sex, age, medical field of the specialist, place and time of study, job history, and the zip code of the medical practice. The information on the zip code of the medical practice allows us to compute the geographic distance between GPs and medical specialists.

[7] Based on survey results, Salisbury (1989) shows that most people choose the nearest doctor and they do not have any information on the practice. We have any reason to assume that patients do not have enough information to select their GPs according to the GPs' social networks.

[8] A patient can also consult a specialist directly after 2004.

[9] We include all doctors who hold a contract with the sickness fund for at least one year. The majority of these physicians (75 percent) can be observed in each year.

[10] Revenues that were initially caused by the referral, but occur in a subsequent quarter, cannot be determined.

4 Variation in referral rates

It was mentioned in the introductory review of quantitative research that the variation in GP referral rates is basically explained by GP-, practice- and patient characteristics. In accordance with this literature, we present regressions for referral rates of Upper Austrian GPs to resident specialists that control for these groups of determinants. Before doing so, we discuss the sample composition of our data and present descriptive statistics.

Table 1 illustrates the development of the average GP referral rate over the observation period. It can be seen that the percentage of referred patients increased slightly from 15.1 percent in 1998 to 16.6 percent in 2004. However, in 2005 the referral rate started to sharply decrease with referral rates close to 9 percent in the years 2006 and 2007. This drop can be explained by the introduction of the electronic insurance card in 2005. This card that is being used for electronic invoicing of medical services allows patients to see certain medical specialists without the requirement of a referral slip issued by the primary care provider as this was necessary before 2005. As a consequence more and more patients attended resident specialists without being referred by their GP.[11]

Table 2 shows the number of GPs and specialists per medical field available in our data. The average number of treated patients per year lies between 1,015 (neurology and psychiatry) and 4,855 (dermatology). On average, a GP refers 14.7 percent of her patients to medical specialists. Whereas only 3.11 percent of patients treated at pediatricians are referred by GPs, the rate of referred patients is highest for neurologists and psychiatrists (65.12 percent) followed by radiologists (43.84 percent) and surgeons (42.88 percent) as can be seen in column 4. This pattern is mirrored by the percentages of revenues due to referred patients. Neurologists and psychiatrists earn more than 63 percent of their revenues with referred patients followed by radiologists and surgeons. The revenues per patient are highest for internists followed by pulmonary specialists, surgeons, and orthopedists with an internist earning almost 100 Euro per referred patient per year. Moreover, Table 2 shows that the female share of resident doctors is below 10 percent in urology, surgery, internal medicine, and orthopedics whereas these percentages increase to 32 percent in neurology and psychiatry, 33 percent in dermatology, and 43 percent in pediatrics. The last column indicates that the variation in mean age of doctors is low across medical specialties.

Table 3 (Panel a) includes information on how many different specialists the average GP refers her patients to and on how many GPs receive the average medical specialist her patients from. The average GP refers 21.4 percent of all referred patients to one single specialist and another 11.12 percent to a second one. The column of cumulative percentages illustrates that on average a GP refers almost 50 percent of all referred patients to only 4 specialists. Similarly, as can be seen in Panel b, the average specialist receives 10.05 percent of patients referred to her from one single GP. Another 7 percent of all referred patients are received from a second GP. The cumulative

[11] In the subsequent regression analysis of referral rates we use year 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 questions of interest in this paper (the determinants of referral behavior and the role of social networks).

percentages indicate that 50 percent of a specialist's received patients are referred to by 10 different GPs.

To analyze the referral behavior of GPs, we start with regressions of referral rates on GP-, patient- and practice characteristics. The dependent variable referral rate is a GP's fraction of patients per year who are referred to specialist care irrespective of a specialist's medical field (referred patients divided by all patients who consult the GP per year). We use repeated cross section ordinary least squares (OLS) estimations and do not include GP fixed-effects since the variables of interest are time-invariant, so that they cannot be identified in a fixed-effects model. Therefore, we cannot draw causal inferences from the results, but rather provide associations between referral rates and major determinants as they are discussed in the literature. The regression results of three different specifications are depicted in Table 4. In the first specification we only include GP characteristics, in the second we add practice characteristics, and finally we simultaneously control for patient characteristics.

GP characteristics

As can be seen in column (1) a GP's *experience* – the doctor's current age minus her age in the year of graduation from university-enters the regression inverse U-shaped with positive impacts of experience on the referral rate for a professional experience lower than 30 years, and negative impacts thereafter. This result corresponds in its tendency with evidence demonstrating higher referral rates for younger primary care providers (Vehvilainen et al. 1996, Rashid and Jagger 1990). The *female dummy* indicates that the referral rate of female GP's is 2.15 percentage points higher than that of male counterparts. It seems reasonable to assume that male and female doctors differ in psychological variables such as tolerance of uncertainty, or – to put it in economic terms – that female GPs are more risk-averse than their male colleagues. Obviously, the family status of a GP does not play a major role in her referral behavior. Single and divorced primary care providers are not significantly different from married doctors (the base category). Likewise the location of the medical study does not make any difference. The referral pattern of GPs who studied at the Medical Universities of Graz and Vienna is not different from those who did their studies in Innsbruck (the base category).[12]

Practice characteristics

The inclusion of practice characteristics increases the percentage of variation that can be explained by the regressors from 0.27 to 0.37 (see column 2). The dummy variable *city* indicates a strong and significant impact on a GP's referral rate. The percentage of referred patients increases by 3.7 points if the GP's practice is located in an urban versus a rural area.[13] Another positive influence

[12]The regressions also control for hospital fixed-effects (the hospital where the GP did her medical internship after university graduation) and for period fixed-effects.

[13]The *City* dummy is equal to 1 for the cities of Linz, Wels, and Steyr that have 191,107, 58,717, and 38,248

can be observed for Practice size, representing the number of patients who consult the GP per year. The highly significant coefficient indicates that an increase in the practice size by 300 patients per year (approximately a 10 percent increase at the mean) increases the referral rate by 0.3 percentage points. Two further supply side impacts show the expected signs. The *number of specialists* in a GP's zip code is an indicator for the availability of the complement good specialist care. As can be seen, an additional specialist in the zip code area of the GP increases the referral rate by 0.13 percentage points. GP's will be more inclined to refer their patients if the specialists are located in the vicinity of patients' residences, and patients can be expected to rather agree to a referral if they have 'just to cross the street'. This result is in line with empirical evidence that both a shorter distance between a GP practice and specialist care and also the availability of consultants increase referral rates as it was presented in the literature review. Finally, we find a significantly negative influence of the *number of GPs* in the same zip code area. Another GP practice decreases the referral rate of a GP in a zip code area by 0.14 percentage points. We interpret this finding as evidence for substitution. The higher the number of GPs in a given area among whom patients can choose, the lower is the expected referral rate per GP. In other words, patients have more opportunities to be treated by GPs rather than being referred to medical specialists who do not only offer complements to GP service but may also supply substitutive treatment.

Patient characteristics

The impacts of patient characteristics are depicted in column 3 of Table 4. The referral rate of a GP depends significantly on the patients' age and on their labor market status. One additional year of patients' average age increases the referral rate by 0.24 percentage points. This can be explained by the fact that the health status of patients deteriorates with age, and that a worse state of patients' mean health makes more referrals necessary. Moreover, the referral rate of a GP decreases significantly with the *share of unemployed, retired, and other patients*.[14] A one percentage point higher unemployment rate among the patients of a GP reduces the referral rate by 0.52 percentage points. The same increase in the share of retired or other patients decreases the referral rate by 0.35 and 0.12 percentage points, respectively. These results support the findings of Sorensen et al. (2009) who find 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 remains insignificant. Column (3) and column (2) show that the coefficients remain qualitatively and quantitatively almost unchanged if we expand the model step by step by practice- and patient characteristics. Solely the significant and positive dummy variable for a female GP gets insignificant if we also control for practice characteristics which implies a correlation between the practice characteristics and the sex of a GP.

inhabitants, respectively. These are the three largest cities that comprise about 20.33 percent of the Upper Austrian population in 2012.

[14]The category 'other patients' include mothers on maternal leave, conscripts, persons on rehabilitation and co-insured children.

5 Social networks and referral practice - a gravity model approach

To analyze the role of social networks in GPs' referral behavior we estimate the following equation:[15]

$$y_{ijt} = \alpha \times x_{ijt} + \beta \times z_{it} + \mu \times r_{jt} + \gamma_i + \eta_j + \delta_t + \epsilon_{ijt} \tag{1}$$

In this equation y_{ijt} denotes either the count of patients referred from GP i to specialist j in year t (referred to as *referrals*) or the resulting *revenues* of the specialist from these referrals. Summary statistics for these and the other used variables can be seen in Table 5.

Our network effects are depicted as a vector of so-called pair-variables x_{ijt}, which are defined as dummy variables equal to one if the attribute of GP i and specialist j corresponds and is zero otherwise. For the identification of social networks we use information on the physicians' place and time of study, and their working history. We then construct (i) a dummy that is equal to one if GP i and specialist j visited the same *university* at different points in time and zero otherwise, (ii) a dummy that is equal to one if both were *fellow students* and zero otherwise, (iii) a dummy that is equal to one if both worked at the same *hospital* at different points in time and zero otherwise, and (iv) a dummy that is equal to one if both were *co-workers* at the same *hospital* and zero otherwise. For (i) and (iii) we expect that both physicians may know each other indirectly via third party connections. For (ii) and (iv), however, it is reasonable to assume that physicians have known each other directly. Moreover, we expect a higher probability that doctors know each other if they have the same sex and are of equal age as there is a higher chance that they belong to the same social network. Therefore, we construct (v) another dummy that is equal to one if the GP and the specialist have the *same sex*. Similarly, (vi) the dummy *identical age group* is one if the GP and the specialist belong to the same age group.[16] Note, that we cannot measure the affiliation to the same social network in a direct way, our pair variables are proxies that capture a higher probability of being acquainted with one another. Since the networks are measured with error, our estimates are subject to attenuation bias and the results represent a lower bound of the true effect. As additional pair variable we include the geographic *distance* between GP i and specialist j measured in minutes.

It is important to note that the attributes used to construct the pair-variables are time-invariant at the physician level, but vary over doctor pairs. This is due to the fact that GP i is paired with different specialists j and vice versa. Thus, it is possible to include both GP and specialist fixed-effects denoted by γ_i and η_j, although we use time-invariant information of the individual physi-

[15] In the economics of trade, this type of equation is the well-known gravity model depicting the trade flows between different countries. Note that in our case exporting and importing countries are represented by GPs and specialists. The trade flows are typified by the number of referred patients and the resulting revenues of the specialist.

[16] We constructed two age groups along the median age of physicians.

cian. The doctor fixed-effects account for time-invariant heterogeneity such as education effects of universities or hospitals, and time-invariant ability. Consequently, the pair-variables should only capture a network effect but no idiosyncratic effect based on physician-specific attributes.

As time-varying characteristics of the GP (z_{it}) and the specialist (r_{jt}) we include the *doctors' experience* (current age minus age at the year of graduation from university) and the total yearly *number of patients* of each physician. In order to prevent reversed-causality we subtract those *referrals* and *revenues* which were referred by this pair. To control for general changes in the referral behavior over time we include period dummies (δ_t). Finally ϵ_{ijt} denotes the error term.

What sign do we expect for the coefficient of our pair variables reflecting the affiliation to the same social group? A negative sign would indicate that GPs refer less patients to specialists within the social network. This is reason to believe that on average GPs doubt the medical quality of specialists within the own social group and therefore refer patients preferably to doctors outside of the network. A positive sign of the pair coefficients in turn offers two possible explanations: (i) GPs are better informed about appropriate skills of specialists within the network. Hence, statistical discrimination would result in higher referral rates within the social group and patients would benefit from this behavior because referrals are more appropriate. (ii) Instead of searching the objectively best specialist for the patient, GPs shift rents to the doctors within their social network (also referred to as 'old boy network'). In this case, patients would not benefit from this behavior and may even be negatively affected.

Table 6 provides a first 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 can be found in the rows. Columns 2 and 5 show the means for referrals outside the network, columns 3 and 6 list the respective means for referrals within the networks. The p-values indicate that the differences in the means for all our social groups are statistically significant: We find on average more patients and higher revenues for referrals within the network as compared to referrals to specialists outside the network.

These first descriptive results are partly confirmed by Table 7 that summarizes OLS regression results on the determinants of referrals and revenues as dependent variables. The four different columns (*Base, GP FE, Specialist FE, Both FE*) indicate different specifications with respect to the inclusion of fixed-effects. In the specification *Base* we do not include any fixed-effect. In the second we include fixed-effects for GPs, in the third we control for fixed-effects of the specialists, and in the last specification we include fixed-effects for both doctor groups. Therefore, it is possible to determine the influence of the different time-invariant heterogeneities. Our results reveal that having worked at the same hospital and, additionally, having worked at the same time in the hospital are stable indicators for higher patient referrals and higher revenues. Given an unconditional sample mean of 1.82 referred patients and 93.64 Euro revenues the increase of 1.21 patients or 60.60 Euro revenues for having worked in the same hospital and additional 1.08 patients (72.82 Euro revenues) for having been co-workers are substantial. In the most comprehensive models

with fixed-effects for GPs and specialists the *same sex variable* remains statistically significant at the 10 percent level in explaining the number of referrals (left panel). There is some evidence for more referrals between alumni from the same university and even a negative relationship for alumni who have studied at the same time at the same university. These effects, however, vanish if we control for time-invariant heterogeneity of both doctor groups. Apparently, networks formed by the teaching hospital are more important than networks resulting from universities. This might be explained by the fact that we do not actually measure whether two doctors know each other personally. Our variables rather indicate the increased probability that they might have met each other. Consequently, this probability can be expected to be lower within the structures of a university as compared to the operational sequences in a hospital.

Other controls show expected signs: specialists with an ordination closer to the GP and specialists with a larger stock of patients receive more referrals. Whereas the experience of a GP has no influence on their referral behavior, younger specialists receive on average more patients. GPs with a high number of patients also refer more patients.

6 Social networks and the well-being of patients

After identifying the effects of social networks on the referral behavior, the question arises whether referrals within a network are an efficient or inefficient provision to specialists care. To answer this question, we analyze the effects of referrals within the network on the share of follow-up consultations.

As a follow-up consultation we define a consultation of a patient to another specialist of the same field within a period of quarters – with $q \subseteq \{1, 2, 3, 4\}$ – after the initial referral from GP i to specialist j. A follow-up examination may indicate that the initial referral was inappropriate and the patient was not satisfied with the treatment by the specialist. As a consequence, she consults a new specialist. Apart from the potential harm for the patients, follow-up consultations cause additional expenditures for the healthcare system.

We use the econometric framework presented above in equation 1 with the number of follow-up examinations as the dependent variable. Since this procedure is not applicable to GP-specialist pairs for which we do not observe referrals, we restrict our observations to those GP-specialist pairs with actual referrals greater than zero. In doing so, the number of observations in our estimation decreases from 1,502,333 to 220,698 GP-specialist pairs.[17]

Our results on the determinants of follow-up consultations conducted at a different specialist of the same field within one, two, three, and four quarters after the initial referral based on OLS

[17]For comparison reasons our estimations from Table 7 are replicated in Table 10 for the reduced dataset. The estimations for the reduced dataset show qualitatively identical results, however, with reduced statistical significance. Table 9 shows the corresponding results on the probability to refer at least one patient by the physician pair based on a linear probability model.

estimations are presented in Table 8. The left four columns represent the estimations without doctor fixed-effects, the right columns include fixed-effects for GPs and medical specialists. A significant negative sign for our pair variables x_{ijt} would indicate lower follow-up examinations for referrals within the social network. Apparently patients seem to be more satisfied with the specialist to whom they were referred to, so that the number of follow-up consultations with other specialists decreases. Moreover, lower costs for the healthcare system can be expected in this case.

Controlling for observed and unobserved doctor heterogeneity in the last four columns of Table 8, we find very small and statistically insignificant positive coefficients for studying at the same university and belonging to the *identical age group*. All other network coefficients indicate a negative sign. For being a *fellow student*, working at the same *hospital*, and *same sex*, we observe significant coefficients in at least one of four quarters. The coefficients indicate that the effects are of relevant magnitude. As an example, the coefficient of *hospital* in the fourth quarter of the fixed-effects estimation is -0.18. This reduction in follow-up consultations is driven by the fact that the GP and the specialist have been working in the same hospital. The decrease of 0.18 follow-up consultations represents about 10 percent of all follow-up consultations in this quarter (see the mean of 1.69 in Table 8).

To sum up, we do not find any indication that referrals within social networks cause more follow-up consultations. On the contrary, our data show lower follow-up consultations if the GPs refer patients within their social networks. This phenomenon may be explained by statistical discrimination. As GPs can better judge the abilities and technical possibilities of specialists within the network, they use the group membership of specialists as a selection criterion. In that way GPs acquire information on the skills of specialists which enables the GP to refer patients more appropriately.

7 Conclusions

We examine the determinants of GPs' referral behavior with a particular focus on social networks. To test the appropriateness of referrals we analyze whether referrals within networks result in lower or higher follow-up examinations.

(i) Based on Austrian health service utilization data we quantitatively demonstrate the effects of social networks on the referral behavior of GPs. We hypothesize that GPs use their personal networks to acquire information on the abilities of specialists and therefore overcome the information asymmetries concerning specialists' abilities. (ii) We test the appropriateness of referrals by exploiting information on patients' follow-up consultations at a different specialist in the same medical field up to one year after the initial referral. (iii) In contrast to the majority of previous studies, our analysis is based on comprehensive, administrative panel-data that allow controlling for time-invariant heterogeneity of both physician types.

Our results on the determinants of the referral rate are in line with previous studies. We also

find that the referral rate varies starkly across GPs, and about 40 percent of this variation can be explained by our set of independent variables. For the identification of social networks we use multiple pair variables that we expect to capture whether two physicians are acquainted with each other. Doctors may know each other either directly or via third-party connections. Among the social network variables the strongest effects on the referral behavior are found for the dummies whether two physicians have been working in the same hospital, either contemporaneously or in different time periods.

Moreover, sensitivity checks show that the results vary strongly when we control for fixed-effects of GPs and medical specialists. This implies that heterogeneity of physicians has to be taken into account in an analysis of the referral behavior. We conclude that patients are not negatively affected by referrals within the GPs's social networks. do not get stuck in old-boy networks that would affect them negatively. On the contrary, we find some indication that these networks reduce follow-up consultation and therefore improve the appropriateness of referrals. Moreover, the results on the follow-up consultations show how incomplete information about the abilities of specialists may affect the appropriateness of referrals. Consequently, a decline in the GPs' information asymmetry should improve the appropriateness of referrals and decrease healthcare costs.

References

M. Allard, I. Jelovac, and P. Léger. Treatment and referral decisions under different physician payment mechanisms. *Journal of Health Economics*, 30:880–893, 2011.

D. Anthony. Changing the nature of physician referral relationships in the us: the impact of managed care. *Social Science & Medicine*, 56:2033–2044, 2003.

K. Arrow. The theory of discrimination. In O. Ashenfelter and A. Rees., editors, *Discrimination in labor markets*. Princeton University Press, Princeton,N.J., 1973.

N. Blundell, A. Clarke, and M. N. Interpretations of referral appropriateness by senior health managers in five pct areas in england: a qualitative investigation. *Quality and Safety in Health Care*, 19:182–186, 2010.

A. Coulter. Managing demand at the interface between primary and secondary care. *British Medical Journal*, 316:1974–1976, 1998.

D. Crombie and D. Fleming. General practitioner referrals to hospital: the financial implications of variability. *Health Trends*, 20:53–56, 1988.

R. Cummins, B. Jarman, and P. White. Do general practitioners have different referral thresholds? *British Medical Journal*, 282:1037–1039, 1981.

R. Dowie. General practitioner and consultants. a study of outpatient referrals. Technical report, King's Fund., 1983.

S. C. Earwicker and D. K. Whynes. General practitioners' referral thresholds and choices of referral destination: an experimental study. *Health Economics*, 7:711–722, 1998.

C. Foot, C. Naylor, and C. Imison. The quality of gp diagnosis and referral. Technical report, King's Fund., 2010.

P. Gompers, V. Mukharlyamov, and Y. Xuan. The cost of friendship. *NBER Working Paper No. 18141*, 2012.

D. Grembowski, K. Cook, D. Patrick, and A. E. Roussel. Managed care and physician referral. *Medical Care Research and Review*, 5591:3–31, 1998.

J. Hippisley-Cox, C. Hardy, M. Pringle, R. Carlisle, K. Fielding, and C. Chilvers. Effect of deprivation on general practitioner's referral rates. *British Medical Journal*, 315:884, 1997a.

J. Hippisley-Cox, C. Hardy, M. Pringle, K. Fielding, R. Carlisle, and C. Chilvers. The effect of deprivation on variations in general practitioners referral rates: a cross sectional study of

computerized data on new medical and surgical outpatient referrals in nottinghamshire. *British Medical Journal*, 314:1458–1461, 1997b.

C. Horne. The enforcement of norms: Group cohesion and meta-norms. *Social Psychology Quarterly*, 64(3):2553–2566, 2001.

D. Jones. A survey of hospital outpatient referral rates 1985, wales. *British Medical Journal*, 295: 734–736, 1987.

R. L. Ludke. An examination of the factors that influence patient referral decisions. *Medical Care*, 20(8):782–796, 1982.

R. Madeley, J. Evans, and B. Muir. The use of routine referral data in the development of clinical audit and management in north lincolnshire. *Journal of Public Health Medicine*, 12:22–27, 1990.

C. Manski. Economic analysis of social interactions. *Journal of Economic Perspectives*, 14:115–136, 2000.

B. Marinoso and I. Jelovac. Gp's payment contracts and their referral practice. *Journal of Health Economics*, 22:617–635, 2003.

A. Noone, M. Goldacre, A. Coulter, and V. Seagroatt. Do referral rates vary widely between practices and does supply of services affect demand? a study in milton keynes and the oxford region. *The Journal of the Royal College of General Practitioners*, 39:404–407, 1989.

C. O'Donnell. Variation in gp referral rates: what can we learn from the literature? *Family Practice*, 17(6):462–471, 2000.

E. Phelps. The statistical theory of racism and sexism. *American Economic Review*, 62:659–661, 1972.

A. Rashid and C. Jagger. Comparing trainer and trainee referral rates: implications for education and allocation of resources. *The British Journal of General Practice*, 40:53–55, 1990.

M. Roland and R. Morris. Are referrals by general practitioners influenced by the availability of consultants? *British Medical Journal*, 297:599–600, 1988.

S. Salam-Schaatz, G. Moore, M. Rucker, and S. Pearson. The case for case-mix adjustment in practice profiling: When good apples look bad. *The Journal of the American Medical Association*, 272:871–875, 1994.

C. Salisbury. How do people choose their doctor? *British Medical Journal*, 299:608–610, 1989.

W. Schaffer and F. Holloman. Consultation and referral between physicians in new medical practice environments. *Annals of Internal Medicine*, 103:600–605, 1985.

S. Shortell. Patterns of referral among internists in private practice: A social exchange model. *Journal of Health and Social Behavior*, 14:335–348, 1973.

A. Soetevent. Empirics of the identification of social interactions. an evaluation of the approaches and their results. *Journal of Economic Surveys*, 20:193–228, 2006.

T. Sorensen, K. Olsen, and P. Vedsted. Association between general practice referral rates and patients' socioeconomic status and access to specialised health care: a population-based nationwide study. *Health Policy*, 92:180–186, 2009.

A. Vehvilainen, E. Kumpusalo, S. Voutilainen, and J. Takala. Does the doctors' professional experience reduce referral rates? evidence from the finnish referral study. *Scandinavian Journal of Primary Health Care*, 14:13–20, 1996.

P. Verhaak. Analysis of referrals of mental health problems by general practitioners. *The British Journal of General Practice*, 43:203–208, 1993.

D. Whynes, G. Reed, and P. Newbold. General practitioners' choice of referral destination: a probit analysis. *Managerial and Decision Economics*, 17:587–594, 1998.

D. Wilkin and A. Smith. Explaining variation in general practitioner referrals to hospital. *Family Practice*, 4:160–169, 1987.

8 Tables

Table 1: Average referral rate, 1998-2007

Year	Patients	Referrals	Referral rate
1998	3,145	483	15.1
1999	3,482	545	15.29
2000	3,564	549	15.1
2001	3,660	587	15.91
2002	3,801	639	16.46
2003	3,907	644	16.11
2004	3,997	682	16.6
2005	4,195	597	14.01
2006	4,292	379	8.69
2007	4,345	396	9.01

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

Table 2: Sample composition

	# of docs	Patients	Referrals	Referrals rate	Revenues	Rev. (ref.) abs.	Rev. (ref.) %	Rev./ r. pat.	Rev./ nr. pat.	Female share	Mean age
GP	575	3,249	477	14.68	120,644	-	-	-	36.9	11	53.94
Eye specialist	45	4,156	682	16.41	176,227	27,612	15.67	35.24	35.97	33	53.93
Surgery	16	1,110	476	42.88	134,768	56,523	41.94	58.78	66.97	1	56.24
Dermatologist	32	4,855	959	19.75	185,874	38,187	20.54	34.72	32.17	33	53.62
Gynecologist	69	3,218	474	14.73	164,329	23,840	14.51	42.4	41.67	9	56.1
Internists	44	1,426	422	29.59	168,012	55,129	32.81	99.55	84.93	3	55.77
Pediatricians	36	2,253	70	3.11	175,535	5,480	3.12	55.02	52.78	43	54.71
ENT specialist	29	2,852	742	26.02	177,484	47,593	26.82	49.52	46.22	13	52.34
Pulmonary specialist	22	2,530	931	36.8	185,727	68,156	36.7	64.93	64.17	10	55.75
Neurology & Psychiatry	29	1,015	661	65.12	134,363	84,948	63.22	54.81	61.79	32	55.79
Orthopedics	27	3,050	869	28.49	207,553	55,026	26.51	59.01	63.91	4	54.09
Radiology	18	6,795	2,979	43.84	493,937	207,495	42.01	50.48	55.31	14	56.5
Urology	15	2,658	867	32.62	159,103	41,869	26.32	39.93	53.15	1	57.31

Note: This table provides summary statistics on the physicians included in the estimation sample covering the period from 1998 through 2007. The first column shows the number of physicians per medical field. In total we observe 382 medical specialists. The annual, average number of patients and referrals are shown in column two and three, respectively. Thereafter follows the referral rate in percentage. The first entry represents referrals conducted by the GP, whereas for the specialists these numbers denotes the referrals received. The annual average revenues from medical attendance are shown in column five. Column six shows the revenues of specialists that are due to referred patients and the corresponding percentage value is illustrated in column seven. The revenues per referred and non-referred patient are shown in column eight and nine, respectively. Finally, column ten and eleven depict the percentage of females and the average age per medical field. All monetary values are expressed in 2007 Euros.

Table 3: Referral relationships between GPs and specialists

(Panel a)

Ranking of specialist[a]	Obs	Mean	SD	Min	Max	Cumulative
1	606	21.14	11.35	5.36	96.43	21.14
2	606	11.12	5.44	2.04	50.00	32.26
3	604	8.27	2.89	1.02	20.05	40.53
4	603	6.80	2.21	0.51	15.79	47.33
...						
11	593	2.49	0.81	0.24	4.79	74.80
...						
24	558	0.64	0.39	0.02	1.76	90.37
...						
35	513	0.34	0.23	0.01	0.97	95.33
...						

(Panel b)

Ranking of GP[b]	Obs	Mean	SD	Min	Max	Cumulative
1	387	10.05	7.61	2.47	100	10.05
2	386	7.24	3.29	1.98	20.54	17.29
3	386	6.03	2.55	1.83	17.86	23.32
...						
10	382	2.95	0.86	1.13	5.35	51
...						
23	375	1.24	0.43	0.07	2.33	75.59
...						
44	346	0.39	0.24	0.01	0.96	90.13
...						
61	307	0.23	0.18	0	0.63	95.08
...						

Note: Panel a shows to how many different specialists a GP refers her patients. Panel b shows from how many different GPs a specialist receives his patients.

[a] The number of specialists to whom a GP refers her patients in descending order of her respective referral share.

[b] The number of GPs from whom a specialist refers her patients in descending order of her respective referral share.

Table 4: Determinants of the referral rate

	(1)	(2)	(3)
GP characteristics			
Experience	0.718***	0.488***	0.423***
	(0.165)	(0.157)	(0.153)
Experience squared	−0.012***	−0.008**	−0.007*
	(0.004)	(0.004)	(0.004)
Female	2.154**	1.235	0.966
	(0.994)	(0.895)	(0.931)
Single	1.006	2.008	2.200
	(1.748)	(1.713)	(1.669)
Divorced	0.565	−0.406	−0.471
	(0.881)	(0.854)	(0.823)
Graz[b]	0.278	1.104	1.379
	(2.126)	(1.781)	(1.701)
Vienna[b]	0.441	0.415	0.494
	(0.801)	(0.710)	(0.673)
Practice characteristics			
City		3.711***	3.814***
		(0.775)	(0.800)
Practice size[c]		0.558***	0.530***
		(0.168)	(0.171)
Number of GPs		−0.144*	−0.186**
		(0.080)	(0.078)
Number of specialists		0.131**	0.166***
		(0.059)	(0.058)
Patient characteristics			
Share of females			0.013
			(0.065)
Mean age			0.236***
			(0.074)
Share of unemployed patients			−0.524***
			(0.166)
Share of retired patients			−0.353***
			(0.064)
Share of other patients[d]			−0.116**
			(0.049)
Observations	4,823	4,823	4,823
R^2	0.27	0.37	0.39
Mean	14.12	14.12	14.12

Note: This table summarizes estimation results on the effects of GP, practice, and patient characteristics on the referral rate (annual number of referrals divided by annual patients expressed in percentage). The results are based on Ordinary Least Squares (OLS) estimation and standard errors (in parentheses) are robust to clustering at the GP level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. Each estimation also controls for, hospital and period fixed-effects. [b] In comparison to GPs who studied at the medical university of Innsbruck. [c] Measured in thousands of patients. [d] Comprising mothers on maternity leave, conscripts, persons on rehabilitation and co-insured children.

Table 5: Summary statistics of variables used in pairwise regressions

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-worker	0.02		0	1
Identical age group	0.51		0	1
Same sex	0.76		0	1
Distance	65.08	30.30	0	205.75
GPs' experience	22.17	5.62	5	43
Specialists' experience	23.41	5.82	10	48
GPs' patients	3.907	1.409	0.276	10.7
Specialists' patients	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 annual summary statistics for the variables used in the subsequent regressions. The number of GPs and specialists represents all physicians included in the estimation sample. The sample comprises 1,502,333 observations; however, only in 220,698 observations we observe at least one referral between a physician pair. The figures of the summary statistics are based on all observations.

Table 6: Mean comparison tests for referrals and referred revenues

	Referrals			Revenues		
	No	Yes	p-value	No	Yes	p-value
University	1.536	1.916	0.000	73.38	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-worker	1.577	4.518	0.000	80.715	234.599	0.000
Identical age group	1.735	6.269	0.000	88.749	338.471	0.000
Same sex	1.782	1.865	0.000	91.321	95.907	0.000
Mean[a]		1.820			93.64	
Observations		1,502,333			1,502,333	

Note: This table shows mean comparison tests of referrals and revenues for each binary pair-variable. Columns 2 and 5 show the means if the binary variable equals zero and columns 3 and 6 show the means otherwise. The p-values indicate whether the differences in means are statistically significant.

[a] Refers to the unconditional sample mean.

Table 7: Determinants of the 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-worker	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)
Identical 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 sex	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)
GPs' 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)
Specialists' 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)
GPs' 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)
Specialists' 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	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 the referral behavior based on Ordinary Least Squares (OLS). The referral behavior is either measured as the annual number of referrals for each physician pair (left panel) or the annual specialists' referred revenues (measured in 2007 Euro) for each physician pair (right panel). Standard errors are robust to clustering at the GP level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for period fixed-effects. In the specification *Base* neither GP, nor specialist fixed-effects are included. In the specification *GP FE* fixed-effects for the GPs only are included, and in the specification *Specialist FE* we only control for fixed-effects of medical specialists. In Both FE we include GP and specialists fixed-effects simultaneously.

Table 8: Determinants of follow up referrals

	Q1	Q2	Q3	Q4
University	0.006	−0.005	0.018	−0.010
	(0.036)	(0.044)	(0.049)	(0.052)
Fellow students	−0.064	−0.070	−0.129*	−0.114
	(0.050)	(0.059)	(0.070)	(0.073)
Hospital	−0.094	−0.116	−0.151*	−0.177**
	(0.060)	(0.072)	(0.081)	(0.083)
Co-worker	−0.040	−0.061	−0.106	−0.090
	(0.075)	(0.085)	(0.096)	(0.100)
Identical age group	0.044	0.028	0.062	0.062
	(0.032)	(0.037)	(0.040)	(0.042)
Same sex	−0.140**	−0.145*	−0.121	−0.127
	(0.067)	(0.081)	(0.085)	(0.089)
GPs' experience	0.018***	0.024***	0.024***	0.011*
	(0.005)	(0.005)	(0.006)	(0.006)
Specialists' 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)
GPs' patients	0.070	0.042	0.052	0.043
	(0.047)	(0.054)	(0.064)	(0.066)
Specialists' patients	0.042*	0.087***	0.124***	0.138***
	(0.025)	(0.032)	(0.035)	(0.037)
Mean	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 consultation conducted at a different specialist of the same field within one, two, three, and four quarters after the initial referral based on Ordinary Least Squares (OLS). Standard errors are robust to clustering at the GP level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. Since the follow-up consultations can only be determined for doctor-pairs with positive referrals these figures are based on 220,698 observations.

Table 9: Determinants of the referral behavior (participation effect)

	Base	GP FE	Specialist FE	Both FE
University	0.004**	0.002	0.005**	0.001
	(0.002)	(0.001)	(0.002)	(0.001)
Fellow students	0.003	0.002	0.001	0.002
	(0.003)	(0.002)	(0.003)	(0.002)
Hospital	0.081***	0.066***	0.077***	0.052***
	(0.006)	(0.005)	(0.007)	(0.006)
Co-worker	0.062***	0.059***	0.064***	0.054***
	(0.008)	(0.007)	(0.007)	(0.006)
Identical age group	−0.002	−0.001	−0.001	−0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Same sex	0.013***	0.015***	0.009	0.004***
	(0.003)	(0.001)	(0.007)	(0.002)
GPs' experience	0.002***	0.007	0.002***	0.009
	(0.001)	(0.022)	(0.001)	(0.032)
Specialists' experience	0.002***	0.001***	0.007***	0.004***
	(0.000)	(0.000)	(0.001)	(0.001)
Distance	−0.005***	−0.007***	−0.006***	−0.009***
	(0.000)	(0.000)	(0.000)	(0.000)
GPs' patients	0.004*	0.006***	0.002	0.006***
	(0.002)	(0.002)	(0.003)	(0.002)
Specialists' patients	0.013***	0.011***	0.014***	0.015***
	(0.001)	(0.000)	(0.000)	(0.000)
Mean	0.15	0.15	0.15	0.15
Nr. of observations	1,502,333	1,502,333	1,502,333	1,502,333

Note: This table summarizes the results on the determinants of the probability to refer at least one patient by the physician pair based on a Linear Probability Model (LPM). The dependent variable is a binary variable equal to one if at least one patient was referred and zero otherwise. Standard errors are robust to clustering at the GP level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for period fixed-effects. In the specification *Base* neither GP, nor specialist fixed-effects are included. In the specification GP FE fixed-effects for the GPs only are included, and in the specification Specialist FE we only control for fixed-effects of medical specialists. In Both FE we include GP and specialists fixed-effects simultaneously.

Table 10: Determinants of the referral behavior (conditional on non-zero referrals)

	Referrals				Revenues			
	Base	GP FE	Specialist FE	Both FE	Base	GP FE	Specialist FE	Both FE
University	0.458	0.189	0.304	0.216	47.078**	33.521*	30.189*	25.159
	(0.354)	(0.336)	(0.323)	(0.318)	(19.972)	(18.571)	(18.200)	(17.767)
Fellow students	−1.157**	−0.922*	−0.395	−0.519	−63.899**	−52.854*	−21.180	−28.496
	(0.580)	(0.517)	(0.528)	(0.491)	(32.348)	(29.838)	(29.876)	(28.633)
Hospital	1.875**	1.970***	2.578***	1.925***	93.242**	101.051***	121.489***	85.806***
	(0.727)	(0.567)	(0.602)	(0.542)	(36.691)	(28.870)	(30.401)	(26.959)
Co-worker	1.595*	1.359	0.498	0.761	137.356***	122.609***	50.467	60.366
	(0.922)	(0.830)	(0.808)	(0.788)	(50.627)	(47.417)	(43.815)	(43.575)
Identical age group	0.436	0.374	0.296	0.318	22.739	19.045	16.122	17.267
	(0.277)	(0.279)	(0.245)	(0.244)	(15.535)	(15.739)	(13.418)	(13.441)
Same sex	3.443***	3.694***	0.586	0.800**	211.510***	240.054***	16.061	31.723
	(0.458)	(0.358)	(0.526)	(0.401)	(23.911)	(19.346)	(27.781)	(20.545)
GPs' experience	0.136**	−0.501***	0.167***	−0.532***	7.953**	−35.943***	9.460***	−34.236***
	(0.067)	(0.017)	(0.051)	(0.033)	(3.532)	(0.943)	(2.689)	(1.700)
Specialists' experience	−0.267***	−0.151***	−1.276***	−2.236***	−12.391***	−6.512***	−39.000**	−83.545***
	(0.032)	(0.030)	(0.192)	(0.311)	(1.632)	(1.556)	(16.366)	(17.673)
Distance	−0.328***	−0.743***	−0.377***	−0.750***	−16.842***	−37.787***	−18.947***	−37.570***
	(0.019)	(0.032)	(0.019)	(0.026)	(1.012)	(1.662)	(0.996)	(1.362)
GPs' patients	1.304***	1.328***	1.872***	1.307***	64.140***	61.003***	93.960***	61.348***
	(0.269)	(0.161)	(0.225)	(0.167)	(14.262)	(9.318)	(12.031)	(9.343)
Specialists' patients	2.298***	2.594***	2.038***	2.118***	88.773***	104.117***	70.634***	74.716***
	(0.150)	(0.152)	(0.162)	(0.163)	(8.458)	(8.509)	(8.502)	(8.524)
Mean	12.42	12.42	12.42	12.42	637.41	637.41	637.41	637.41
Nr. of observations	220,698	220,698	220,698	220,698	220,698	220,698	220,698	220,698

Note: This table summarizes the results on the determinants of the referral behavior based on Ordinary Least Squares (OLS) when at least one patient was referred by the physician pair. The referral behavior is either measured as the annual number of referrals for each physician pair (left panel) or the annual specialists' referred revenues (measured in 2007 Euro) for each physician pair (right panel). Standard errors are robust to clustering at the GP level and to heteroskedasticity of unknown form. *, ** and *** indicate statistical significance at the 10-percent, 5-percent, and 1-percent levels, respectively. The estimations also control for period fixed-effects. In the specification *Base* neither GP, nor specialist fixed-effects are included. In the specification *GP FE* fixed-effects for the GPs only are included, and in the specification *Specialist FE* we only control for fixed-effects of medical specialists. In Both FE we include GP and specialists fixed-effects simultaneously.