Care to Share?
Impact of General Practitioner-Specialist Collaborative Structures on Health Care Outcomes

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Abstract
Recent health care reforms focus on improved patient care coordination to achieve better health outcome measures at reduced cost. Perhaps, the most critical element of this coordination is the professional, formal collaboration between general practitioners (GPs) and specialists (SPs). However, assessing the results of system-level patient care coordination is lacking. This study, using scarcely available data and a novel measure of patient care coordination between GPs and SPs, offers insights into locally relevant issues of global importance; it discusses consequences of shared treatment of diabetes patients segmented on degrees of professional collaboration between general practitioners (GPs) and specialist (SPs). The coordination measure is based on the assumption that higher number of shared patients increases the probability of developing strong collaborative relationships. Thus, the outcome measures of patients of GPs characterized by strong collaborative relationships are compared with those characterized by fragmented collaborative structures. Specifically, the paper examines possible associations between collaborative structures and patient health status, proxied by the number of comorbidities diagnosed and treated, as well as between collaborative structures and pharmacy costs. There is mixed evidence for strong collaborative relationships resulting in enhanced health statuses. However, the efficiency of care coordination is reflected in cost savings—patients treated in strong collaborative structures by their GPs involve significantly lower pharmacy costs than those treated in fragmented collaborative structures. In other words, this paper presents evidence that the more socially embedded patients in the GP-SP diad may lead to more cost efficient health care thus lending some support for offering narrow network plans.
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1 Introduction
All over the world, governments face pressures of health care budget reductions while aiming at maintaining or even improving the level of service. One way to achieve these conflicting goals may be through better integration of primary and secondary care and utilizing the advantages of better collaboration between general practitioners and specialists. This integration is most frequently equated with shared care in the UK, managed care in the US, transmural care in the Netherlands, and other widely recognized formulations such as collaborative care, comprehensive care and disease management (Kodner 2002). Although both shared care and managed care is based on inter-professional practice, the shared-care model in the UK advances communication and co-operation between care providers, whereas the managed care provided by the Health Maintenance Organizations (HMO) in the US rather focuses on the provision of healthcare through service utilization monitoring and cost containment (White 2010). However, many current health care reforms in the US seek to improve coordination of care through building integrated networks of providers offering complex care to overcome issues of lost patients, late service deliveries, declining quality and patient satisfaction measures and diminished cost-effectiveness—characteristics of disintegrated professional practices and fragmented patient care (Fisher et al. 2011).
Professional collaboration between general practitioners (GPs) and specialists (SPs) is one critical element of this integration. Professional collaboration reflects the extent to which GPs and SPs work together to achieve optimal outcomes for a given patient and may result from better interpersonal information exchange and reflect longstanding relationship between doctors. GPs have developed guiding principles worldwide to advance comprehensiveness and forms of integration as key professional goals. For example, in Europe GPs are encouraged to take a comprehensive, person-centered approach, including exercising responsibility for the co-ordination of care (WONCA Europe 2002). Similar recommendations were made on primary care by the U.S. Institute of Medicine (1996).

Parallel to primary and secondary care integration, some degree of freedom in choosing healthcare providers is advocated in several developed countries including the United States (Bevan and Van De Ven 2010, Corlette et al. 2014). Theory assumes and available data confirm that some portion of patients who are offered a choice will exercise it in order to access perceived higher-quality services (Dixon et al. 2010). In the UK, when offered a choice, an additional 5-14 per cent of patients travel beyond their local or nearest provider (Dixon et al. 2010). In the US, several states enacted laws to restrict the ability of managed care insurers to selectively contract with providers. These state laws either took the form of 'any willing provider' or 'freedom of choice' laws (Corlette et al. 2014, Hellinger 1995). The latter law has been introduced in 23 states and allows an insured to receive health care services from any qualified provider, even if the provider has not signed a contract with the health plan. In response to the continuous pressure on managed care insurers to offer patients wider access to providers, they shifted to broader networks in the late 1990s and early 2000s (Corlette et al. 2014). However, offering completely free choice or wide access to providers to patients may increase care fragmentation by forcing GPs to collaborate with more providers.

The context of this study is the shared-care model for treating diabetes by specialists and GPs as described by Hill (1978), and Worth et al. (1990). In particular, this study examines possible associations between collaborative structures and patient health status, proxied by the number of comorbidities diagnosed and treated, as well as between collaborative structures and pharmacy costs. The direction of causality is unknown—higher patient health status and lower pharmacy costs might be prerequisites to strong collaborative structures, or might be consequences thereof. In line with intuition and empirical evidence, this study favors the latter—building up strong collaborative relationships with a few SPs enable GPs better and smoother care coordination.

This study investigates the characteristics of formal collaborative structures between GPs and SPs in shared care—outcome measures of patients treated by GPs with strong collaborative relationships are compared with those characterized by fragmented collaborative structures.

In this study we develop a novel measure for coordination of patient care activities between GPs and SPs. Care coordination measures are limited in their practical utility today, because they involve time and cost intensive survey that cannot be used to assess the function of health care systems on a large scale (Bynum and Ross 2013). In the past, system-level care coordination has been impossible to measure. Recent availability of administrative data

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1 The term general practitioner (GP) is synonymous with family doctor, family medical practitioner, generalist medical practitioner, and primary care doctor—GPs provide continuing and comprehensive medical care to individuals, families, and communities. In contrast, the term specialist (SP) refers to a medical practitioner who focuses on certain disease categories, types of patients, or methods of treatment. The term doctor describes any medical practitioner who holds a professional medical degree. (WHO 2010)
enabled researchers to develop a new measure of care coordination applicable to system-level (Barnett et al. 2011, Pham et al. 2009, Pollack et al. 2013, Uddin et al. 2011). This new measure of care coordination relies on the number of shared patients, and assumes that the higher the number of shared patients, the higher the probability of developing collaborative relationships is. Collaborative relationships create opportunities for direct communication and information sharing that may lower barriers to care coordination and ultimately lower costs. Previous research focused on ties in which the number of shared patients were high—provider-level care coordination measure has not been developed yet. This study fills this gap—our novel care coordination measure has the GPs in its focus acknowledging the GPs role as gatekeepers and the most important patient care coordinators.

This paper contributes to the literature by assessing whether the type of collaborative relationship GPs have built up with SPs is associated with patient health status and pharmacy costs. To the authors’ knowledge, no large-scale quantitative study has ever investigated this association. Previous research either did not develop a system-level care coordination measure (Bosch et al. 2009, Lemieux-Charles and McGuire 2006), or did not perform a provider-level analysis. For example, the patient-sharing network analysis of Barnett et al. (2012) was at the hospital level, Pollack et al. (2013) carried out their analysis at patient level by quantifying the amount of patient sharing among patients’ providers, whereas Uddin et al. (2011) developed collaboration network-level metrics. We find no clear evidence that a strong collaborative relationship results in enhanced health statuses. However, the efficiency of care coordination is reflected in cost savings—patients treated in strong collaborative structures by their GPs involve significantly lower pharmacy costs than those treated in fragmented collaborative structures.

This study also bears important policy implications with regards to care fragmentation—GPs may struggle to coordinate care, if they have to share patients with more SPs as a result, and the pharmacy costs would be higher. Healthcare strategists need to advocate a healthcare system with lower care fragmentation at the level of primary care providers by offering patients limited rather than unrestricted choice. In Europe, completely free choice of healthcare providers should not be advocated, whereas in the US managed care plans should follow a narrow network strategy.

2 Theoretical background: the context

One key element of the shared-care models introduced in many European countries and the managed care programs in the US is better care coordination, especially for people with chronic illness. Care coordination, as defined by the Agency for Healthcare Research and Quality (AHRQ), is “the deliberate organization of patient care activities between two or more participants (including the patient) involved in a patient’s care to facilitate the appropriate delivery of health care services. Organizing care involves the marshalling of personnel and other resources needed to carry out all required patient care activities, and is often managed by the exchange of information among participants responsible for different aspects of care” (McDonald et al. 2007, p. 41). Thus, better care coordination implies collaboration among health professionals.

Collaboration is an important aspect of team work—it is an intricate concept with multiple attributes including sharing of planning and goal setting, making decisions, solving problems, assuming responsibilities, working together cooperatively, and communicating and

Health systems and healthcare institutions are among the most complex and interdependent organizations (Kodner and Spreeuwenberg 2002). First, healthcare services are the responsibility of many sectors, jurisdictions, institutions and providers. Second, healthcare services vary in terms of culture, language, professional roles and responsibilities, and clinical or service approaches. Third, healthcare services are financed from separate funds with often conflicting regulation. Without appropriate collaboration at various levels, several aspects of health care performance might suffer; patients experience worse access to treatment, poorer outcomes, and higher costs.

Recently, a new measure of care coordination has been developed (Barnett et al. 2011, Pham et al. 2009, Pollack et al. 2013, Uddin et al. 2011). Collaborative relationship between two doctors exists if they care for at least one patient together. The higher the number of shared patients, the higher the probability of advice seeking and referral relationship between doctors is. This new measure of care coordination has been validated for predicting the existence of collaborative relationships among doctors by Barnett et al. (2011). The authors show that the probability of two doctors having a recognized professional relationship increases with the number of patients shared—for example, doctors sharing nine or more patients have an 82 per cent probability.

In the literature on shared care, there is mixed evidence as to whether or not the level of care coordination is positively related to health outcomes. On the one hand, Lemieux-Charles and McGuire (2006) and Bosch et al. (2009) report in their systematic literature reviews that good teamwork among medical professionals improves clinical performance and outcomes. On the other hand, several other systematic reviews on shared care suggest that the degree of collaboration does not predict clinical outcomes (Greenhalgh 1994, Craven and Bland 2006, Smith et al. 2007, Renders et al. 2001). Craven and Bland (2006), for example, report that although there is a trend toward positive outcomes occurring more often in studies with moderate or high levels of collaboration, some studies with lower levels of collaboration also have positive outcomes. Similarly, the systematic review of Smith et al. (2007) on the effectiveness of shared care concludes that overall there are no consistent improvements in any of the health outcome measures (physical, mental, psychosocial) reviewed. Finally, Renders et al. (2001) evaluate the effectiveness of interventions targeted either at health-care professionals or at the structure of care and conclude that complex interventions in which patient education is added and/or the role of a nurse is enhanced leads to improvements in patient outcomes; the influence of the remaining interventions is not straightforward.

The recent literature using the newly developed measure of care coordination finds evidence for the positive association between the level of care coordination and health outcomes (Barnett et al. 2012, Hussain et al. 2015, Pollack et al. 2013, 2014, Uddin et al. 2011). The higher the number of patients shared, the better patient health status is, most probably due to the consolidation of clinical information and the management of patient care. The health outcome measures ranged from the number of hospital days (Barnett et al. 2012), to the rates...
of hospitalization (Pollack et al. 2013, 2014), readmission rate (Uddin et al. 2011), and mortality (Hussain et al. 2015).

Although the literature on patient-sharing unambiguously suggest improvements in health outcomes when high number of patients are shared (Barnett et al. 2012, Hussain et al. 2015, Pollack et al. 2013, 2014, Uddin et al. 2011), previous systematic reviews on shared care suggest that the degree of collaboration does not predict clinical outcomes (Greenhalgh 1994, Craven and Bland 2006, Smith et al. 2007, Renders et al. 2001). Thus, it is reasonable to hypothesize that patient health status should be at least the same, when GPs develop strong collaborative relationship with SPs. GPs with strong collaborative structures does not necessarily share high number of patients with SPs. Instead, they share the majority of their patients, even if small in number, with a few SPs (see subsection 3.4).

In addition to improved quality of care, with shared-care programs policy makers and payers in both public and private sectors aim to lower cost of care, or at the very least to ensure that health care resources are used more wisely (Kodner and Spreeuwenberg 2002). Empirical evidence shows that this aim is better served. For example, the systematic review of van Walraven et al. (2010) finds that better care coordination is associated with lower health utilization, including lower hospitalization and fewer emergency visits. The recent literature using the newly developed measure of care coordination finds evidence for the significant association between the level of care coordination and cost of care as well (Barnett et al. 2012, Pollack et al. 2013, 2014, Uddin et al. 2011). Barnett et al. (2012), for example, find that the more connections physicians with other physicians via shared patients have, the higher total spending and the number of physician visits are. Similarly, Pollack et al. (2013, 2014) report that patients treated by doctors who share high numbers of patients between them tend to have lower costs of care.

Empirical evidence consistently shows that healthcare delivery is more cost-efficient when the numbers of shared patients are higher, most probably due to the consolidation of clinical information and the management of patient care.

3 Data and methods

3.1 Healthcare in Hungary

The Hungarian healthcare system is primarily publicly funded, through taxation. Its universal health coverage sets minimum standards and aims to extend access as widely as possible. The National Health Insurance Fund of Hungary (NHIFH)—the central official agency of health insurance—provides benefits in kind and cash to insurees (NHIFH 2014). Patients are free to choose their GPs, who act as gatekeepers for the secondary and tertiary care provided by SPs. A capitation adjusted to patient age is the main source of GP revenue. A fee-for-service payment method finances outpatient services, with a limit on the volume of billable services. Most SPs are public employees, guaranteed minimum salary levels on a pay scale that takes into account qualifications and years of experience.

Due to pressures on hospital expenditure, the care of patients with chronic conditions is shared between GPs and SPs. In shared care, GPs act as first points of contact, for patients, and as gatekeepers, for secondary care, whereas SPs test, diagnose, and treat patients. When SPs initiate therapies with specialist medication, usually of high cost, GPs have to prescribe
that medication for a time, usually for one year, significantly decreasing SPs’ workload and increasing their own. To obtain prescribed medication, patients have to visit their GPs monthly, allowing GPs to filter out—and refer back to SPs—cases where the health status had worsened under treatment. GPs channel patients—including those in shared care—to healthcare providers designated by NHIFH as nearest to either patient or GP. However, GPs can refer patients to any outpatient services in Hungary, provided that patients make such requests on referral—and that compliance with such requests does not endanger the treatment of patients in the catchment area of the preferred outpatient services.

3.2 Sample

This study uses prescription data for the years 2010–2011 available from DoktorInfo Ltd, a health data collection and information services company based in Hungary. Twenty per cent of the GPs practicing in Hungary feed real-time prescription data into this database voluntarily—they are representative of the entire Hungarian GP population in both age and location (defined by region and population size). GPs are compensated for providing information such as GP identification number; prescription date; prescribed drug characteristics [brand name, Anatomical Therapeutic Chemical (ATC) code, and dosage]; International Classification of Diseases (ICD) codes; prescribed drug subsidy; patient characteristics (age and gender); and, since January 2009, for patients whose care is shared, identification number of the therapy-initiating SP. The identification numbers of GPs and SPs enable the detection of collaborative relationships between prescribing GPs and therapy-initiating SPs.

This study concentrates on shared diabetic patients, defined as patients who receive at least one specialist drug from the A10 group—for example, insulin or an oral antidiabetic agent. Following data cleaning, GPs who treated fewer than 20 diabetic patients were excluded from analysis—they may have been working only part time, or feeding data into the database only for a few months. The final sample thus includes 794 GPs and 318 SPs in endocrinology who shared care for 31,070 diabetic patients. During the observation period 2010–2011, GPs issued 509,281 specialist medication prescriptions for antidiabetic agents, initiated additional 332,635 antidiabetic therapies for which they did not require prior SP approval, and wrote an additional 3,243,191 prescriptions for other agents. A typical GP treated 39 diabetic patients and wrote 1060 prescriptions for antidiabetic agents—14 prescriptions per patient per year.

3.3 Identifying collaborative relationships among doctors

GPs and SPs enter in informal collaborative relationships when they email, call, or curbside one another with specific clinical matters. For example, GPs may seek information or advice from SPs prior to referring patients for care (Keating et al. 1998). GPs and SPs enter in formal collaborative relationships when GPs refer patients to SPs and subsequent requests for information are formalized (Barnett et al. 2011). This study investigates the characteristics of

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3 Drugs are classified into groups by the World Health Organization—through the Anatomical Therapeutic Chemical (ATC) Classification System. Groups reflect the organ or system on which drugs act and/or their therapeutic and chemical characteristics.
5 ATC code for drugs used in diabetes.
formal collaborative structures between GPs and SPs in shared care—the formal collaboration is materialized in referral and prescribing of specialist medications.

Diabetes, the area of interest for this research, is a particularly good choice for the purpose of identifying collaborative relationships among doctors for several reasons. First, the number of diabetic patients is already high and diabetes prevalence is increasing all over the world, due to changing food and lifestyle habits (WHO 2011). In Hungary, diabetic patients form the largest patient sharing subnetwork, with the highest frequency of specialist medication prescriptions. Second, diabetes is a clinical condition for which patient care coordination is likely important (Pollack et al. 2013, Wagner et al. 1996)—complex activities require conscious interactions among parties, including timely transfer of accurate clinical information, effective communication, appropriate follow-up, and shared decision making (Pham et al. 2009). Third, SPs treating patients with diabetes form a well-defined subgroup of doctors, with a rather dense patient sharing network.

In this study, similar to the patient-sharing networks constructed recently by Barnett et al. (2011), Pham et al. (2009), Landon et al. (2012), and Pollack et al. (2013), a collaborative relationship between two doctors exists if they care for at least one patient together—information readily and unambiguously available from prescription data, where the identification numbers of prescribing GPs and therapy-initiating SPs both appear on prescriptions. This allows measuring the structure of collaborative relationships in a way that would be almost impossible with survey data, and less prone to missing data—it can capture all doctors who collaborate, not just those who respond to surveys, and all relationships, not just those that can be extracted from responses to surveys. In our sample, there were 6,723 GP–SP connections identified, representing 5.33 % of all potential ties between GPs and SPs. On average, a GP coordinated care with eight SPs. (See Figures 1-3 in Appendix for more information on the structure of the collaborative relationship between GPs and SPs.)

3.4 General practitioners with strong versus fragmented collaborative ties

The structure of collaborative relationships between GPs and SPs depends on both the number of SPs with whom GPs coordinate care and patient distribution across SPs. GPs channeling the majority of their patients to a few SPs build up strong, collaborative relationship with SPs, whereas GPs channeling their patients to many SPs build up weak, fragmented collaborative ties.

The structure of collaborative relationships between GPs and SPs is measured by the Herfindahl-Hirschman Index (HHI), a widely used concentration measure in industrial organization—the sum of the squares of the proportion of GP’s patients shared with SPs (Rhoades 1993). The higher the index (it ranges from a very small number close to zero to 10,000 in case of a monopoly or 100% share), the more concentrated the collaborative structure of GPs, which implies stronger collaborative relationships among doctors. The two graphs below, taken from the sample data, show examples of GP–SP collaborative structures: GPs with strong collaborative structure vs. with fragmented collaborative structure. The number assigned to each link indicates the number of patients treated in that GP-SP connection, whereas the percentages indicate the proportion of GP’s patients treated in that GP-SP connection.
GPs build up strong collaborative relationship with SPs, if the HHI is in the uppermost decile; if HHI is in the lowest decile then GPs have weak, fragmented ties with SPs. GPs with strong collaborative ties may be strongly tied to more than one SP. In this particular sample, GPs with a HHI higher than 6.258 qualify for strong collaborative relationship with SPs; whereas GPs with a HHI smaller than 1.743 qualify for weak, fragmented relationships.

In additional sensitivity analyses we carried out, GPs with strong collaborative relationships were defined as GPs with a HHI in the top quintile/tertile, and GPs with weak, fragmented relationships as GPs with a HHI in the bottom quintile/tertile. The figure above shows two examples of GP–SP collaboration structures. In the first example, GP1 is characterized by strong collaborative relationship with SPs. GP1 is strongly connected to one SP through 30 patients, representing 83% of GP1’s diabetic patients; the HHI is 7,083. In the second example, GP2 is not connected strongly to any SP—10 patients, representing 17% of GP3’s diabetic patients, is the highest number of patients shared with an SP. The collaborative structure in this example is very fragmented; the HHI is 1,163.

### 3.5 Outcome measures

Health is a multidimensional concept defined by the WHO as “a state of complete physical, mental and social well-being, and not merely the absence of disease” (WHO 1948). Health can be considered in terms of both health status and quality of life; the former referring to a person’s body structure and function and the presence or absence of disease or signs, while the latter referring to the extent to which a health condition affects the person’s normal life. Individual health status may be measured by performing an examination and rating the individual along several dimensions; or by the patients themselves (self-assessed health status). Individual health status measurements may focus on signs (blood pressure, blood glucose level), symptoms, comorbidities, or adverse events (amputation, pain, re-admission) (Blackwood 2009). Health of a population may be measured by indices such as the life expectancy, mortality, and the prevalence of particular diseases—health status indicators widely used, for example, by the OECD (2015) and WHO (2015).
In this study patient health status is proxied by the number of comorbidities diagnosed and treated—evidently, the higher the number, the poorer the health status. Although comorbidity indices only capture one particular dimension of health status, vast empirical evidence shows that they are good predictors of mortality, which is a health status indicator that is widely used for populations (Charlson et al. 1987, Lix et al. 2013, Li et al. 2008, Sharabiani et al. 2012, Quail et al. 2011, Quan et al. 2011, Huntley et al. 2012). Thus, significant differences in the number of comorbidities between patients treated by GPs characterized by strong collaborative relationships and by weak, fragmented ties would signal significant differences in mortality which, in turn, highlights inequalities in health status between these two patient populations. In addition, comorbidity indices are also good predictors of adverse events (amputation, hospitalisation, longer inpatient stay, re-admission to hospital), another important dimension of health status (Lix et al. 2013, Quail et al. 2011, de Groot et al. 2003, Kieszak et al. 1999, Rochon et al. 1996).

This study uses three diagnosis-based comorbidity measures, including the Charlson comorbidity index (Charlson et al. 1987), the Quan-modified Charlson comorbidity index (Quan et al. 2011), and the Elixhauser measure (Elixhauser et al. 1998) identified by Sharabiani et al (2012) as the most common. As suggested by Quan et al. (2005), ICD-10 codes are employed to identify which of the comorbid conditions apply to the patients in the sample. The Charlson comorbidity index predicts mortality for a range of 19 diseases selected and weighted based on the strength of association with mortality. Although the index was originally developed to predict the 10-year patient mortality (Quan et al. 2011), in the current literature it is widely used to predict short-term, for example, 12-month mortality (Li et al. 2008, Quail et al. 2011, D’Hoore et al. 1996). However, since mortality is likely to have changed since the development of the original index in 1984, the Quan-modified Charlson comorbidity index uses updated weights. The Elixhauser measure contains 30 carefully selected comorbid conditions. To control for potential bias in ICD-10 coding, this study also measures comorbidity by counting the number of third-level ATC codes\(^6\) on which the patient received at least one prescription semi-annually. All four comorbidity measures are applied to the prescriptions written by GPs in addition to prescriptions for antidiabetic agents.

Comorbidity indices are based on principles indicative of health status. The three diagnosis-based comorbidity scores increase with the number of chronic diseases under treatment. In case of the Charlson and the Quan-modified Charlson comorbidity index, potentially life threatening or progressive diseases have a higher score. Some studies show that comorbidity indices are indeed associated with specific or overall health status (Bayliss et al. 2005, de Jonge et al. 2006, van Manen et al. 2003, Rebollo et al. 2000). In primary care and community setting, Huntley et al. (2012) found evidence for the validity of both the Charlson comorbidity index and simple counts of medications in predicting health outcomes (mortality, quality of life, healthcare utilisation).

*Pharmacy costs* are measured at GPs’ patient panel level as the sum total of the retail prices for drugs, including all agents, prescribed by GPs in 2010–2011—they include the amount paid by patient as well as any drug subsidy. Private and public pharmaceutical expenditure are thus considered jointly to assess the total cost to society.

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\(^6\) The third level of an ATC code includes the main anatomical group (first level, one letter), the main therapeutic group (second level, two digits), and the therapeutic/pharmacological subgroup (third level, one letter), but excludes the chemical/therapeutic/pharmacological subgroup (fourth level, one letter) and the chemical substance (fifth level, two digits) (WHO 2003).
3.6 Statistical analysis

GPs are classified based on the strength of their collaborative relationships with the SPs. The means of the outcome measures are then calculated for patient panels of GPs with different kinds of collaborative structures, and compared. The skewed distribution of the collaborative relationship measures (HHI)—as well as the associations with patient health status and pharmacy costs, assumed nonlinear, similarly to Pollack et al. (2013), suggest a decile-based categorization. GPs characterized by strong collaborative structures form the uppermost decile, whereas GPs characterized by fragmented structures belong to the lowest decile (see subsection 3.3). The health and cost implications of strong versus fragmented collaborative structures are therefore evaluated using t-tests, considered significant if the p-value is less than 0.05. Sensitivity analyses are also carried out for the alternative definitions of strong and weak ties.

4 Results

Table 1 compares characteristics of patients treated by GPs who built up strong collaborative relationships with SPs with those of patients treated by GPs who are connected to SPs with weak, fragmented ties. Table 1 shows mean values or proportions, as appropriate. Patients treated in strong collaborative relationships have more diabetes-related complications, receive less prescription for antidiabetic agents, and consult more frequently with their GPs. The two cohorts do not differ significantly in age, gender mix, type of therapy, number of prescriptions in total, or frequency of consultations with SPs.

Table 1
Strong collaborative structures vs weak, fragmented structure: patient characteristics

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>GPs with strong collaborative ties (uppermost decile)</th>
<th>GPs with weak, fragmented ties (lowest decile)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>52.59</td>
<td>52.89</td>
<td>0.8140</td>
</tr>
<tr>
<td>female</td>
<td>47.41</td>
<td>47.11</td>
<td></td>
</tr>
<tr>
<td>Average age</td>
<td>65.48</td>
<td>65.68</td>
<td>0.3293</td>
</tr>
<tr>
<td>Diabetes (%, based on ICD-10 codes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with complications</td>
<td>61.24</td>
<td>56.33</td>
<td>0.0000</td>
</tr>
<tr>
<td>without complications</td>
<td>38.76</td>
<td>43.67</td>
<td></td>
</tr>
<tr>
<td>Treatment (% , based on third-level ATC codes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>insulin based</td>
<td>71.18</td>
<td>71.26</td>
<td>0.9409</td>
</tr>
<tr>
<td>non-insulin based</td>
<td>28.82</td>
<td>28.74</td>
<td></td>
</tr>
<tr>
<td>Prescriptions per patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for all agents</td>
<td>127.41</td>
<td>130.05</td>
<td>0.2679</td>
</tr>
<tr>
<td>for antidiabetic agents</td>
<td>25.28</td>
<td>27.27</td>
<td>0.0000</td>
</tr>
<tr>
<td>Consultations per patient</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>with the GP, for all prescriptions</td>
<td>22.55</td>
<td>21.53</td>
<td>0.0023</td>
</tr>
</tbody>
</table>
In Table 2, two comorbidity measures indicate that collaboration structure does not affect patient health status, whereas two comorbidity measures indicate that strong, collaborative structures improve patient health status. For GPs with strong collaborative structures the patient health status is thus at least the same than for GPs with fragmented collaborative structures. At the same time, the collaborative structure does affect pharmacy costs, which are 5.88% lower for patients treated in strong GP–SP collaborative structures than for those treated in fragmented collaborative structures. Sensitivity analyses for the alternative definitions of strong and fragmented collaborative structures confirm these findings with p-values very similar to those presented in Table 2.

Table 2
Strong ties versus weak ties between GPs and SPs: outcome measures

<table>
<thead>
<tr>
<th>Outcome measures</th>
<th>GPs with strong collaborative ties (uppermost decile, mean value)</th>
<th>GPs with weak, fragmented ties (lowest decile, mean value)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient health status (excluding diabetes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charlson comorbidity index</td>
<td>0.88</td>
<td>0.94</td>
<td>0.0264</td>
</tr>
<tr>
<td>Quan-modified Charlson comorbidity index</td>
<td>0.59</td>
<td>0.58</td>
<td>0.5183</td>
</tr>
<tr>
<td>Elixhauser measure (based on ICD-10 codes)</td>
<td>1.92</td>
<td>2.01</td>
<td>0.0058</td>
</tr>
<tr>
<td>ATC-based comorbidity count (based on third-level ATC codes)</td>
<td>7.86</td>
<td>8.02</td>
<td>0.1749</td>
</tr>
<tr>
<td>Pharmacy costs (based on retail prices as of January 2010; thousand HUF - Hungarian Forint)</td>
<td>586.58</td>
<td>623.22</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

5 Discussion

The health status of patients treated by GPs who build up strong collaborative relationships with SPs is at least the same than the health status of patients treated by GPs characterized by fragmented collaborative structures (see Table 2). Collaborative structure is thus not clearly associated with variation in patient health status. If strong collaborative structures are characterized by efficient care coordination, then this efficiency does not reflect in enhanced patient health status in all health status proxies.

This mixed evidence is in line with previous literature (see section 2). Based on small-scale care coordination measures some authors report that good teamwork among medical professionals improves clinical performance and outcomes (Bosch et al. 2009; Lemieux-Charles and McGuire 2006), whereas others conclude that the degree of collaboration does not predict clinical outcomes (Greenhalgh 1994, Craven and Bland 2006, Smith et al. 2007, Renders et al. 2001). Authors using system-level care coordination measures tend to find evidence for the positive association between the level of care coordination and health
outcomes (Barnett et al. 2012, Hussain et al. 2015, Pollack et al. 2013, 2014, Uddin et al. 2011). These latter studies, however, did not perform an analysis on the level of primary care providers.

This study finds that pharmacy costs for patients treated by GPs who build up strong collaborative relationships with SPs are significantly lower than for patients treated by GPs characterized by fragmented collaborative structures (see Table 2), a major benefit for the society as a whole. The significant difference in pharmacy costs is not related to the total number of prescriptions patients receive (see Table 1).

The finding that GPs with strong collaborative structure involve lower pharmacy costs is based on a bivariate analysis that does not account for confounding variables. To address the issue of confounding, a multivariate regression analysis is performed—the variation in pharmacy costs is explained by the type of collaborative structure, the Quan-modified Charlson comorbidity index, and potentially important patient characteristics. Most importantly, the multivariate analysis confirms that the type of collaborative structure is a statistically significant determinant of pharmacy costs (see Table 1 in Appendix). In addition to the type of collaborative structures, both the treatment method and the presence of diabetes complications is an important determinant of pharmacy costs—patients treated by the generally more expensive insulin and patients who have diabetes complications involve significantly higher pharmacy costs.

The finding that collaborative structures affects pharmacy costs is in line with previous literature reporting that better care coordination is associated with lower health utilization, including lower hospitalization and fewer emergency visits (Barnett et al. 2012, Pollack et al. 2013, 2014, Uddin et al. 2011, van Walraven et al. 2010). This article finds empirical evidence for this association on system-level for primary care providers—association never tested in the literature before. Moreover, the care coordination measure developed in this study overcomes the counterintuitive nature of the care coordination measure used by Pollack et al. (2013). When the authors split the overall costs into components such as outpatient, inpatient, and pharmacy costs, they counterintuitively find higher pharmacy costs for diabetic patients with higher care density (a patient-based quantifier of patient sharing).

This study might bear important policy implications with regards to care fragmentation—GPs may struggle to coordinate care, if they have to share patients with more SPs as a result, and the pharmacy costs would be higher. If future research shows that total costs are indeed lower for patients treated in strong collaborative structures when numerous other specialties (cardiology, neurology, ophthalmology) are considered as well, then healthcare strategists need to advocate a healthcare system with lower care fragmentation. Lower care fragmentation, coupled with enhanced medical education and technical infrastructure might benefit patients, by savings on travel times and costs, and the wider society, by savings on healthcare costs. In Europe, this might be achieved through offering patients limited rather than unrestricted choice—patients need excellent providers, in small numbers and close geographic proximity. In the US, healthcare insurers should follow a narrow provider network strategy. In response to recent healthcare reforms many qualified health plans inside the exchange have already started to follows this strategy because narrow networks allow them to offer lower premiums (Corlette et al. 2014).

In sum, this paper is the first to present evidence that the more socially embedded patients in the GP-SP diad may lead to more cost efficient health care. In the operations management
literature the benefits provided by socially embedded customers was proved in many other domains, such as supply chains, mobile providers, and professional associations (Choi and Kim 2008, Benedek et al. 2014, and Palla et al. 2007, respectively).

This study has a number of limitations worth future further exploration. First, formal professional relationships between GPs and SPs were concluded based on prescription data, a technique validated by Barnett et al. (2011). Sharing patient care is likely to generate enhanced information exchanges and interactive communication—it is therefore plausible that patients treated in stronger GP–SP connections receive better coordinated care than those treated in weak GP–SP connections. However, what particular information and/or behaviors—if any—pass along the ties defined by shared patient care is unknown. The approach adopted in this article suggested conditions more or less favorable towards coordinated care. Nevertheless, high numbers of shared patients do not necessarily lead to information exchanges between two doctors on every single patient. Second, the significant associations revealed in this article are based on an observational study—results should not necessarily be interpreted as causal and the adequacy of the assumed causal mechanisms should be further explored. Third, sampling bias might be present due to GPs supplying prescription data voluntarily, patient self-selection into the shared-care program, and excluding remote or recently opened/closed practices during data cleaning. Fourth, diagnoses data entering into the comorbidity scoring is incomplete. If a diagnosis made by a specialist in an outpatient or in an inpatient health care facility did not imply a further need for GP prescription, then the diagnosis was not listed among the patients’ comorbid conditions. In addition, when working with administrative data, misclassification may arise due to inaccuracies in the assignment of diagnostic codes. Fifth, the authors developed a proxy for patient health status, but were unable to assess whether patients treated in stronger GP–SP connections perceived better care—or were more satisfied—than others. Sixth, pharmacy costs are just one element of the total patient care costs—additional analyses are necessary to examine other elements, such as outpatient and inpatient costs, as main outcome measures. Seventh, identifying doctors’ professional and socio-demographic characteristics was beyond the scope of this article, but would offer further insights into lowering pharmacy costs, not least for healthcare strategists and policy makers. Eighth, potential improvement in clinical outcomes and lower pharmacy costs are only two aspects when the functioning of shared-care schemes is to be evaluated. A number of other factors to be considered include, for example, the degree of participation by patients and healthcare teams; the long-term continuity of care; therapeutic adherence; and the level and ease of communication between SPs and GPs. Ninth, the SPs analyzed in this article were all endocrinologists—future research needs to investigate results for validity with other specialties. Tenth, formal professional relationships between GPs and SPs are likely to be in flux—their future analysis should be enhanced by longitudinal data.

6 Summary

In chronic illness care, many patient outcomes may only be achieved if the clinical activities of different health professionals—such as GPs and SPs—are intentionally coordinated. Improving patient care coordination has become a key focus in healthcare reform and a national priority in numerous countries. However, assessing patient care coordination is as challenging as achieving it. This study took a leap forward in measuring the possible impact of different kinds of collaborative structures on patient health and the cost of patient care. In particular, it investigated whether the structure of collaborative relationships between GPs and
SPs is associated with the number of comorbidities diagnosed and treated, but found no clear evidence that a collaborative relationship through many shared patients results in enhanced health statuses. However, the efficiency of care coordination was reflected in cost savings—patients treated in strong collaborative structures involve significantly lower pharmacy costs than those treated in fragmented collaborative structures. Overall drug expenditure may thus be reduced by lowering patient care fragmentation through channeling a GP’s patients to a small number of SPs. To harvest the financial benefits stemming from efficient patient care coordination, healthcare policy strategists need to advocate limited patient choice rather than complete freedom of choice.

**Ethical standards**

The prescription data used in this study were collected by a reputable government-endorsed organization in agreement with the relevant Hungarian and international legislation—they are available for market research by subscription. This study used the prescription data in an aggregate format, in no way detrimental to individual or collective patients and doctors—patients and doctors cannot be identified either individually or collectively on the basis of this study. The use of prescription data in this study was in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments and as such was approved by the Ethics Committee of Corvinus University of Budapest.

**Acknowledgements**

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**References**


Appendix

**Figure 1a:** GP-SP network

![GP-SP network](image)

**Figure 1b:** GP-SP subnetwork

![GP-SP subnetwork](image)

Fig. 1a is visualized using the Fruchterman–Reingold algorithm. The subnetwork in Fig. 1b is subtracted by the breath first search algorithm around a randomly selected GP and all his neighbors at two degrees of separation were reached. A multiple-star network configuration is obtained, the central nodes are the SPs—several GPs might build up collaborative relationship with a particular SP.

**Figure 2:** Histogram for the number of SPs providing care for a GP’s patients

![Histogram](image)

On average, a GP coordinates care with eight SPs. More than 65% of the GPs coordinate care with five to 11 SPs. Around 15% of the GPs, not necessarily the ones with the lowest patient load, coordinate care with one to four SPs. Less than 8% of the GPs collaborate with more than 15 SPs.
Figure 3: Histogram for patient split

Figure 3 displays how the GPs’ patients are split among SPs with decreasing rank. A typical GP shares almost half (45.7%) of his patients with the SP ranked as the number one collaborator in treating diabetic patients. GPs share, on the average, 20% of their patients with the SPs being the second most popular professional in the SP peer of the GPs. Top 5 SPs, whose composition vary from GP to GP, treat almost 90% of GPs’ patients.

Table 1: Determinants of pharmacy costs: multivariate regression analysis on type of collaborative structures and patient characteristics*

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Standardized Coefficients</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPs collaboration with SPs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong, collaborative structure (0/1)</td>
<td>-0.020</td>
<td>0.001</td>
</tr>
<tr>
<td>Weak, fragmented structure (0/1)</td>
<td>0.014</td>
<td>0.001</td>
</tr>
<tr>
<td>Quan-modified Charlson comorbidity index</td>
<td>-0.011</td>
<td>0.013</td>
</tr>
<tr>
<td>Patients’ age</td>
<td>0.164</td>
<td>0.000</td>
</tr>
<tr>
<td>Patients’ age squared</td>
<td>-0.261</td>
<td>0.000</td>
</tr>
<tr>
<td>Patients’ gender (0-female, 1-male)</td>
<td>-0.024</td>
<td>0.000</td>
</tr>
<tr>
<td>Diabetes without complications/ with complications (0/1)</td>
<td>0.015</td>
<td>0.001</td>
</tr>
<tr>
<td>Treatment method (0 - non-insulin based, 1-insulin based)</td>
<td>0.196</td>
<td>0.000</td>
</tr>
<tr>
<td>Prescriptions per patient for all agents</td>
<td>0.581</td>
<td>0.000</td>
</tr>
<tr>
<td>Consultations per patient (with the SP for therapy-initiating prescriptions)</td>
<td>0.062</td>
<td>0.000</td>
</tr>
</tbody>
</table>

R² = .408

* Variables excluded from the multivariate regression analysis due to high correlation (<0.6): Charlson comorbidity index, Elixhauser measure, ATC-based comorbidity count, Prescriptions per patient for antidiabetic agents, Consultations per patient with the GP.