



**TURUN
YLIOPISTO**
UNIVERSITY
OF TURKU

ESSAYS IN HEALTH ECONOMICS

Mikko Nurminen



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ABSTRACT

This doctoral thesis studies efficiency in health care provision, with a dual focus on two themes. The first theme studies empirically how the introduction of health information technology affects access to prescription drugs, quality of prescribing and coordination between providers. The second theme studies empirically competition and mergers and acquisitions (M&As) in the private health care market. The thesis consists of an introductory chapter and four separate essays.

The first essay considers how the introduction of electronic prescribing (e-prescribing), a technology that is designed to make prescribing and renewal of prescriptions easier and to improve patient monitoring, impacts access to and use of prescription drugs in the Finnish primary health care. We study a class of essential prescription drugs used in the treatment of mental health conditions and insomnia, but which are also highly addictive in long-term use. We find that e-prescribing increases the use of these prescription drugs in younger patients through the easier renewal of prescriptions. We do not find any improvement in health outcomes in this population, but find a significant increase in prescription drug abuse diagnoses and suicide attempts. The results imply that easier access without sufficient monitoring may facilitate the overuse of prescription drugs.

The second essay studies how e-prescribing affects coordination between providers and quality of prescribing in terms of harmfully interacting prescriptions. We document a large discrepancy in the prevalence of interacting prescriptions with rural areas overrepresented. We find that e-prescribing decreases the probability of prescribing interacting prescriptions by 36 percent in rural municipalities, but not in urban municipalities. The decrease is largely explained by decreases in the probability in settings with different prescribers and unspecialized physicians. E-prescribing can enhance coordination among providers by improving information flow, especially when multiple physicians are involved and physicians are less experienced.

The third essay studies the impacts of M&As on physician service markets in Finnish private health care. This essay considers how M&As affects competition between physicians through labor market outcomes, and how this translates to physician prices. We find that prices increase most for gynecologists, a physician group where switching costs and inertia are high. We find that local competition decreases among these physicians through job losses after M&As. This increases the market power of incumbent physicians in the acquired health care units. The essay shows that local competition has a meaningful impact on prices and that labor market outcomes can influence this competition.

The final essay studies how M&As affect diagnostic service prices in the Finnish private health care sector. I study separately three different procedures: blood tests, X-rays, and MRIs. I find that M&As increase blood test prices significantly in the acquired health care units but do not meaningfully impact X-ray and MRI prices. Furthermore, I find that, in the same markets, the prices increase similarly in the acquiring firms' other units, but not in the rivaling units. I proceed to estimate a patient demand model, which reveals that prices have little impact on the choice of the provider of blood tests. Instead, the referring physician has a large influence on the choice. Additionally, due to the small price coefficient, the change in consumer surplus from increased prices is negligible. Because of the patients' low sensitivity to prices, firms may be able to increase their price-cost margins after M&As.

KEYWORDS: Health information technology, health care quality, mergers and acquisitions, natural experiment, health care prices

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TIIVISTELMÄ

Tämä väitöskirja koostuu kahdesta eri teemasta, joissa tutkitaan tehokkuutta terveydenhuollon tarjonnassa. Ensimmäinen teema tutkii empiirisesti, miten terveysteknologian käyttöönotto vaikuttaa lääkkeiden saatavuuteen, lääkkeiden määräämiseen ja määrääjien väliseen koordinaatioon. Toisessa teemassa tutkitaan empiirisesti kilpailua, yritysostoja ja fuusioita yksityisillä terveydenhuoltomarkkinoilla. Väitöskirja koostuu johdantoluvusta ja neljästä erillisestä esseestä.

Ensimmäisessä esseessä tarkastellaan, miten sähköisten reseptien (e-resepti) käyttöönotto vaikutti reseptilääkkeiden saatavuuteen ja käyttöön julkisessa perusterveydenhuollossa Suomessa. E-resepti on suunniteltu helpottamaan reseptien määräämistä ja uusimista, sekä parantamaan potilaan monitorointia. Tutkimme reseptejä, joita määrätään erityisesti ahdistuneisuushäiriöiden ja unettomuuden hoitoon. Nämä reseptit aiheuttavat myös riippuvuutta pitkäaikaisessa käytössä. Havaitsemme, että e-reseptien käyttöönotto lisää näiden reseptien käyttöä nuoremmilla potilailla, mikä johtuu erityisesti lisääntyneestä reseptien uusimisesta. Emme havaitse parannusta potilaiden terveystulemissa, mutta havaitsemme tilastollisesti merkitsevää kasvua nuorten potilaiden lääkkeiden väärinkäyttödiagnooseissa ja itsemurhayrityksissä. Tulokset havainnollistavat, että reseptien helpompi uusiminen ilman riittävää monitorointia voi johtaa lääkkeiden liikakäyttöön.

Toisessa esseessä tutkimme, miten e-resepti vaikuttaa lääkkeiden määrääjien keskinäiseen koordinaatioon ja määräämisen laatuun. Mittarina käytämme haitallisia lääkeinteraktioita. Dokumentoimme isoja alueiden välisiä eroja interaktioiden yleisyydessä, missä maaseutumaiset aluet ovat yliedustettuina. Havaitsemme, että e-reseptin käyttöönotto vähentää todennäköisyyttä määrätä interaktioiva resepti 36 prosentilla maaseutumaisissa kunnissa, mutta kaupunkimaisissa kunnissa emme havaitse muutosta. Vähentäminen johtuu pitkälti interaktiotodennäköisyyksien vähentämisestä asetelmissa, joissa reseptejä määrää useampi eri lääkäri samalle potilaalle ja määrääjä on erikoistumaton lääkäri. E-resepti voi tehostaa koordinaatiota lääkkeenmäärääjien välillä parantamalla informaation kulkua.

Kolmas essee tutkii yritysostojen vaikutusta Suomen yksityisillä lääkärimarkkinoilla. Tässä esseessä tarkastellaan yritysostojen vaikutusta lääkäreiden väliseen kilpailuun ja hintoihin työmarkkinatulemien kautta. Havaitsemme, että hinnat kasvavat eniten gynekologeilla—lääkäriryhmä, joilla asiakasuskollisuus ja vaihtamiskustannukset ovat korkeat. Havaitsemme, että yritysostojen jälkeen paikallinen kilpailu näiden lääkäreiden välillä vähenee työpaikkojen vähentämisen myötä. Tämä kasvat-
taa yksikköön jääneiden lääkäreiden markkinavoimaa yritysoston kohteena olevassa

yksikössä. Tämä essee osoittaa, että paikallisella kilpailulla voi olla merkittävä vaikutus hintoihin ja muutokset työmarkkinatulemissa voivat muuttaa paikallista kilpailua.

Viimeisessä esseessä tutkitaan yritysostojen vaikutusta diagnostisten palveluiden hintoihin Suomen yksityisellä terveydenhuoltosektorilla. Havaitsen, että yritysostot kasvattavat verikokeiden hintoja merkittävästi oston kohteena olevissa yksiköissä. Röntgen- ja magneettikuvausten hinnoissa en havaitse muutosta. Myös samalla markkinalla olevan ostavan yritysten muissa yksiköissä verikokeiden hinnat kasvavat. Estimoin potilaan kysyntämallin, mistä havaitsen, että hinnoilla on vain pieni vaikutus tutkimuspaikan valintaan verikokeissa. Sen sijaan lähetteen antavalla lääkäriellä on suuri vaikutus valintaan. Potilaiden alhaisen hintajousto voi myötävaikuttaa yritysten mahdollisuuteen nostaa hintoja.

ASIASANAT: Terveysteknologia, terveydenhuollon laatu, yritysostot, luonnollinen koe, terveydenhuollon hinnat

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List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

- I Böckerman, Petri; Kortelainen, Mika; Laine, Liisa T.; Nurminen, Mikko; Saxell, Tanja. Information Technology, Access, and Use of Prescription Drugs.
- II Böckerman, Petri; Laine, Liisa T.; Nurminen, Mikko; Saxell, Tanja. Information Integration, Coordination Failures, and Quality of Prescribing.
- III Nurminen, Mikko; Saxell, Tanja. Physician Prices and Competition: Evidence from Acquisitions in the Private Health Care Sector.
- IV Nurminen, Mikko. Mergers and Acquisitions in the Markets for Diagnostic Services: Evidence from the Finnish Private Health Care Sector.

1 Introduction

This thesis consists of four essays that examine the efficiency of health care provision. The first two essays study how information technology in health care affects the allocation of resources and organizational coordination. The last two essays study competition and the impacts of consolidation through mergers and acquisitions (M&As) on the Finnish private health care market. The efficient allocation of scarce resources is a fundamental economic problem. Health economists study questions around this problem in markets that are thought to be different from other markets—a notion that dates back to the seminal work by Arrow (1963). The combined features of uncertainty in both demand and supply, derived demand for health, information asymmetries between parties, and externalities make health care markets unique (Hurley 2000). This thesis advances the current literature by empirically studying the question using high quality nationwide Finnish administrative data. The first two essays emphasize the prospects of using health information technologies in the prescribing process of medication but also the unintended consequences of these technologies. The last two essays emphasize the importance of physician markets in reduced competition in health care markets.

1.1 Background

A tremendous amount of resources are put into health care throughout the world.

In 2018, health expenditures, as a share of total GDP, comprised 9.0 percent in Finland, 10.9 percent in Sweden, 11.5 percent in Germany, and 16.9 percent in USA (OECD 2021a). Compared to forty years ago, in Finland, the share was 5 percent, and in the US, where the health care sector has expanded an astonishing amount, the share was 6.2 percent (OECD 2020). The large size of the health care sector also means that a significant amount of the working age population is employed by the health care sector.

In many European countries, the public sector plays a major role in financing health care through taxes or compulsory social insurance payments. Measured by the percentage of the total health care spending that comes from these sources, Finland was slightly below the EU-27 average of 79.4 percent with 75.1 percent in 2017 (Eurostat 2020a). Even in the US, where the health care system heavily relies on private markets, 50 percent of the expenditures were funded from public sources in

2017 (OECD 2020), with Medicare and Medicaid being the largest public insurance schemes for elderly and poorer members of American society.

A unifying element in every country is the interest in providing more cost-efficient health care. A challenge that each developed and developing country faces is aging populations. Elderly populations suffer disproportionately from chronic diseases and disabilities that require frequent care. The increasing elderly populations increase health care expenditures while the shrinking working-age populations leave the financing of the services to a smaller share of people. In Finland, the share of those aged over 65 is predicted to increase from 22 percent in 2018 to 27 percent in 2035 (Official Statistics of Finland (OSF) 2019b). In the EU countries, the old-age dependency ratio (populations aged 65 and over to populations aged 15–64) is predicted to fall from 31.4 in 2019 to 52.0 in 2050 (Eurostat 2020b). This inevitably means that the resources that must be allocated to a growing number of patients are becoming even scarcer. To sustain the functioning of the health care markets under the aforementioned conditions requires an increase in the efficiency of health care provision. Governments are under pressure to reform their health care systems in order to maintain treatment quality under increasing demands. At the same time, governments have to balance the introduction of expensive new medical technologies and advancements and assess the cost-effectiveness.

In traditional markets, consumer preferences help to allocate resources so that the most valuable outputs are produced at the market price. However, in health care markets, the prevalence of uncertainty and information frictions is bound to cause allocative inefficiency where the mix of the inputs are used in a suboptimal way with respect to the desired health status of the population: for example, prescribing medications and laboratory tests to patients whose marginal benefits are small and hindering access to treatment for those that would benefit the most. Providing excessive and inefficient treatment to one group of patients may deny access to other patients who could better benefit from the treatment. Channeling additional resources into health care services is not an alternative remedy for shifting resources towards more effective use. An example is the US, which, despite having much higher health care expenditures than other OECD countries, is among the worst performing OECD countries in terms of life expectancy (OECD 2021b)

Governments and policymakers have been seeking solutions to more effective health care provision by accelerating the adoption of health information technologies. The great promise is that health information technologies simultaneously reduce costs and improve health outcomes (Hillestad et al. 2005; Buntin and Cutler 2009). The attractiveness of these technologies is their potential to provide the clinically relevant information to physicians in an information-rich environment but where the information is asymmetrically dispersed among providers and patients. This type of fragmentation is a universal phenomenon in health care that occurs when multiple physicians treat the same patient and each physician is responsible for

one fragment of a relevant set of health care decisions (Elhauge 2010). Essentially, it is a phenomenon of disconnected information communication between treatment providers. One physician may not know what medicine the other physician has prescribed to the patient; if the physician prescribes a duplicate or contraindicated prescription, it may ultimately harm the patient and increase health care costs. In the US, preventable medication errors cause harm to at least 1.5 million patients per year (Institute of Medicine 2007), and, according to estimates, the overall direct costs of medical errors in 2008 were \$19.5 billion (Andel et al. 2012). As one of the central goals of information technologies is to amalgamate information, they potentially provide an important opportunity for more integrated decision making.

Another central aim of health information technologies is to reduce barriers to access to health care and medication. Computerized remote connections to physicians and the ordering or refilling of medications have the potential to offer faster and more cost-effective access to health care. For example, improved access to medication can decrease the underconsumption of essential drugs and increase adherence to medication. Alone in the US, barriers to medication adherence result in estimated annual costs of \$100 billion in avoidable hospitalizations (Osterberg and Blaschke 2005; Cutler and Everett 2010). However, a balance of access and monitored medication use is needed, because easy access to some medications can lead to overconsumption of drugs. This can be a problem for prescription drugs that induce addiction (opioids, benzodiazepines) or have population-wide negative externalities in the long run (antibiotics). In addition to reducing avoidable health complications and prescription drug abuse, health information technologies are well positioned to improve the delivery of targeted treatment to vulnerable patient groups.

Perhaps because of the wide interest of policymakers in health information technologies and the fundamental economic problems that they may resolve, a growing number of health economists have been drawn into studying these technologies. The first two essays of this thesis contribute to the literature by studying the impacts of electronic prescribing (e-prescribing) technology, which replaced traditional paper prescriptions and digitized the prescriptions and renewal of medications. The nation-wide, staggered implementation of e-prescribing across different geographical areas in Finland provides a truly unique setting in which to study the technology. Together with the high quality administrative Finnish register data, the large-scale quasi-experimental setting allows a detailed analysis of the causal impacts of the technology.

The first essay asks how e-prescribing has affected patients' access to benzodiazepine prescriptions, the use of these prescriptions, and patient health outcomes. Benzodiazepine prescriptions are widely prescribed for anxiety, panic disorders and insomnia. They are effective when used appropriately but also addictive when overused. These characteristics make them an ideal class of prescriptions to focus on when studying the monitoring and access-overuse aspects of health information technol-

ogy. The second essay focuses on the impacts of e-prescribing on coordination and information integration between physicians. These impacts are measured by quantifying the probability of prescribing harmfully interacting prescriptions. This essay considers the potential interactions between Warfarin and non-steroidal anti-inflammatory drugs (NSAIDs), one of the most common harmful interactions. Warfarin is a blood thinning drug that is used to treat or prevent blood clots. NSAIDs, such as ibuprofen, are used to treat inflammation and pain. When used together, NSAIDs enhance the effects of warfarin, leading to an increased risk of bleeding that may result in hospitalizations or even death.

Another way decision makers have been trying to introduce efficiency to health care provision and to improve access to health care is by increasing competition between care providers. Recently, many governments have reformed, or are attempting to reform, their health care markets towards a more market-oriented approach where the public markets are opened to private providers and patients have more freedom in their choice of care provider. Notable examples are Sweden, Denmark, England, and the Finnish social and health services reform. Incentives provided by the competitive interactions of health care providers are the cornerstone of the force that shapes behaviors affecting the costs, prices and quality of services (Gaynor and Town 2011). Likewise, a lack of competition is harmful to the function of health care provision based on market forces. As health care is arguably one of the most important and largest industries, the functioning of the health care markets is essential for the well being of the society.

Health care markets are typically quite concentrated (Gaynor et al. 2015), and market consolidation can be further accelerated by M&As. Market consolidation achieved by M&As is hard to reverse afterwards; however, M&As can also enhance welfare if they increase efficiency through synergies, that result in lower marginal costs of production (Farrell and Shapiro 1990). The literature has documented that health care industry has become increasingly concentrated across developed countries (Angeli and Maarse 2012; Fulton 2017). This consolidation also reaches physician markets; for example, in the US, practice sizes have been growing and hospitals have been increasingly acquiring physician-owned practices (Baker et al. 2016; Muhlestein and Smith 2016; Capps et al. 2017). Higher market concentration has been shown to be associated with higher physician prices (Dunn and Shapiro 2014; Baker et al. 2014; Austin and Baker 2015). Given the association between increased concentration and price increases, it is crucial to study the consequences of M&As, especially in the context of health care markets.

The third and fourth essays of this thesis explore how M&As have impacted competition and prices in the Finnish private health care market. The private health care sector plays a crucial role in health care markets worldwide, but the scale of the market varies across countries. In the US, the private sector plays a strong role while many European countries rely on public provision, although the importance of

private sector provision has increased over time. In Finland, private health care costs covered by National Health Insurance (NHI) constituted approximately 10.4 percent of the total costs of public primary and specialized health care (Finnish Institute for Health and Welfare (THL) 2019). From the economics output of the entire health and social services, firms' total share was 24.3 percent in 2018 (Official Statistics of Finland (OSF) 2019a). Around one-third of the Finnish citizens use private health care services annually (Hiltunen et al. 2017).

The third essay studies the causal effects of M&As in the Finnish private health care market on physician prices, physician labor markets and the competition between physicians. The majority of physicians typically rent their office spaces from health care units and work as independent contractors. This means that physicians compete with each other both across different firms and health care units and within the health care unit. If a merger leads to a reduced labor force in a health care unit, it can cause reduced competition within the unit and increased prices for the remaining physicians. Conversely, if a merger increases the number of physicians in the unit, it can lead to decreased prices through tougher competition between physicians. The essay contributes to the literature by empirically studying whether prices have increased after M&As and how the M&As have simultaneously affected physician within-unit and market-wide concentrations among different physician specializations.

In the fourth essay, I focus on how M&As affect prices in diagnostic service markets. In contrast to the physician market, the prices for diagnostic procedures are the same regardless of which physician the patient visits in a particular health care unit. To further test which factors inform the choice of a provider, I estimate a patient demand model for health care units. With the demand model, I assess the influence of the prices and the referring physician in the choice and quantify the extent to which the price changes caused by M&As affect consumer surplus.

The following section provides a more detailed overview of health information technology from an economic point of view. Section 1.3 discusses how M&As affect market competition and the policy aspects of M&As, with a particular focus in health care markets. Section 2 presents summaries of the essays in this thesis.

1.2 Health Information Technology and Health Care Transformation

In policy debates and academic writings, the meaning of the term "health information technology" is context specific, and covers a vast number of different technologies and their tools and features in health care. These range from electronic medical record (EMR) e-prescribing systems to different clinical decision support systems and alert tools. All the information and data is computerized and shareable between the users of these systems. The purpose of health information technology is to en-

hance health care efficiency by improving the information flow between patients and different treating physicians, promoting access to health care, and streamlining patient care. In this way, at least in theory, health information technologies help clinicians to review patient medical history and current illness and prescription use faster, thus helping clinicians to evaluate the best choice of treatment which does not overlap with other treatments or harm the patient. With e-prescribing systems, for example, patients can access their own prescription information and request a repeat prescription (prescription renewal) online or through a pharmacy, increasing patient convenience and saving time and health care resources. Ideally, health information systems reduce often-fragmented health care delivery options.

A lot of hope has been placed on the performance of health information technology. Health policy analysts have long advocated that the increased adoption of health information technology can improve health care quality and reduce costs (Hillestad et al. 2005). Hillestad et al. (2005) estimate that health information technologies, if widely adopted, result in \$77 billion of net savings annually in the US. A less optimistic estimate by Buntin and Cutler (2009) puts the number at \$196 billion between 2010 and 2019. An initial problem was the low uptake rate of these technologies in health care units. To increase the uptake rate, governments have been heavily involved in the promotion of adopting health information technologies. In the US, this culminated in the 2009 HITECH Act, which provided up to \$27 billion to clinicians and hospitals to incentivize the adoption of EMR systems (Dranove et al. 2015). According to Dranove et al. (2015), the adoption of EMR in independent hospitals increased from 48 percent in 2008 to 77 percent in 2011. In the EU, the eHealth Action Plan 2012–2020 was passed to address barriers in cross-border electronic health record availability and system interoperability and to promote the uptake and wider deployment of electronic health systems (European Commission 2012).

In Finland, The Finnish Ministry of Social Affairs and Health put forth a strategy to apply information technology to health care in 1995 (Hyppönen et al. 2015). The goal was to have a widespread infrastructure that integrates social and health services. During the first half of the 2000's, a number of different piloting programs were implemented in different parts of Finland, including the first e-prescribing pilot program, from 2002 to 2006 Hyppönen et al. (2015). This led to legislation in 2007, which mandated public health care providers to integrate their operations with an electronic archiving system (Act 159/2007). The legislation that mandated health care providers to join the national e-prescribing system came into effect during the same year (Act 61/2007). What was unique in the Finnish e-prescribing system is the architecture of centralized databases and standardized technology, meaning that systems became interoperable and the prescription information became technically accessible to all health care providers using the technology.

The first municipality to test the e-prescribing system was Turku, in May 2010, followed by the municipality of Kotka in the spring of 2011. The goal was to grad-

ually expand the e-prescribing system across regions. However, because of many technical difficulties in the integration of the system with health care units and pharmacies, auditioning the system, and training the health care workers, the deadlines for the adoption of e-prescribing had to be postponed several times. These factors induced regional variations in the adoption. Finally, by October 2012, all pharmacies had adopted the system, and all public health care units had adopted the system by the end of 2013. Private health care units had less strict deadlines to join the system by the beginning of 2015, except those units that prescribed less than 5,000 prescriptions annually, which were given until January 2017.

The adoption and maintenance costs of health information technologies are high and subsidization by governments may be justified if the collective benefits outweigh the costs and potential adopters do not have incentives to invest into these technologies (Dranove et al. 2015). Despite the optimistic expectations of how health information technology is supposed to transform health care, the transformation has not been painless. Aside from the high costs, physicians' sometimes report their clinical work has been transformed negatively by these technologies. The list of drawbacks include less time devoted to patients and more time entering patient records to the system, issues with software functionality and user interfaces, and disruptions to physicians' workflows (Buntin et al. 2011; Kim et al. 2017; Stanford Medicine 2018). Surveys about e-prescribing delivered to Finnish physicians and pharmacists reveal similar drawbacks. While generally finding e-prescribing to be helpful in establishing patient's overall medication and potentially increasing quality of care, physicians sometimes found the system inflexible and time consuming (Kivekäs et al. 2014; Vänskä et al. 2014; Kauppinen et al. 2017). Although, pharmacists felt that e-prescriptions improved medication safety and eased prescription renewal, they reported issues related to technicalities and the inflexibility of modifying and correcting e-prescriptions (Timonen et al. 2016; Kauppinen et al. 2017a,b).

While, in principle, the mechanisms of how health information technology increases health care efficiency through easier access to patient data are clear, health economics research using quasi-experimental approaches has found mixed results. The positive impacts have mostly been found for special groups that demand higher information management and coordination. Miller and Tucker (2011) find that EMRs reduced neonatal mortality only in conditions that require careful monitoring, while McCullough et al. (2016) find no relationship between health information technology and the average patient. However, the latter find that health information technology improves outcomes for high-risk and complex patients. In contrast, Agha (2014) find no evidence that health information technology adoption leads to better quality of care, measured by several outcomes, but that, instead, it seems to slightly increase medical expenditures, which is partly explained by increases in "upcoding" where physicians assign patients to more complex diagnosis groups. Buchmueller and Carey (2018) and Grecu et al. (2019) study Prescription Drug Monitoring Pro-

grams (PDMPs), which are electronic databases that track track controlled substance prescriptions. Both studies find that, when provider access is mandatory, PDMPs decrease prescription drug abuse. However, when the access is not mandatory, the studies find little effect on prescription drug abuse.

Even if the studies have not been able to quantify the larger effects of health information technology adoption, it does not necessarily mean that efficiency improvements are nonexistent or cannot occur later in the long run when combined with alternative policies. The lack of materialization of gains from information technology has historically been called the “productivity paradox.” The use of the term is attributed to Solow (1987), who used it in relation to the coincidental productivity slowdown and high investments in information technology in the 1970s and 1980s. Later, it was noted, in various industries, that there can be a considerable lag between the technology adoption and efficiency gains (David 1990; Brynjolfsson and McAfee 2014). Information technologies may need complementary innovations and organizational changes to spur productivity growth (Brynjolfsson and McAfee 2014), and information technology in health care industry may be subject to a similar evolution (Wachter and Howell 2018). As such, it may take more time for productivity and efficiency gains to materialize.

The usual limitation in these studies is that they do not observe the actual uptake rates or the intensity of the use. As most of the studies on health information technology are from the US, where hospitals compete in the private sector for profits, the uptake of these technologies may remain low as it may be challenging for hospitals to transfer quality increases into profits (Lee et al. 2013). Furthermore, patient preferences may be weakly correlated with quality improvements and large fraction of revenues come from fixed reimbursement schedules that limit hospitals from charging higher prices for higher quality of care (Lee et al. 2013). Another crucial barrier can be the lack of interoperability between different providers and systems. If the systems are not connected to each other, physicians cannot easily share their patients’ data with physicians in different organizations. The HITECH Act pushed interoperability in a fairly limited way, and the provider incentives and market demand are not in line with prioritizing interoperability of the systems (Adler-Milstein 2017). Thus, in the US, the problem of health information not following the patient throughout care has remained (Perlin 2016).

In the first two articles we add to this quasi-experimental literature by studying the nationwide adoption of e-prescribing technology. In contrast to the previous literature, in the administrative register data we are able to observe the intensity of the e-prescribing use. Furthermore, in Finland, the technology is standardized and the prescription data is centrally stored, we study the impacts of the technology that is fully interoperable across providers.

1.3 Competition and Mergers and Acquisitions in Health Care Markets

In most cases, competition is beneficial for the consumers and society. Without competition or the threat of competition, a firm may have no incentives to lower prices, provide better service, find more efficient ways to produce goods, or invent new products in order to distinguish from a competing firm. Antitrust laws (also known as competition laws) focus on maintaining the basic rules of competition that enable the competitive interaction between firms (Whinston 2007). Antitrust laws are shaped by antitrust economics, a broad area, that covers topics ranging from market power and collusion to mergers and behavior of market exclusion (Kaplow and Shapiro 2007). The role of competition authorities is to enforce the antitrust laws and maintain healthy competition by challenging anticompetitive practices. A common challenge for these authorities is to evaluate the potential anticompetitive aspects of M&As.

Horizontal M&As, defined as the acquisition or union of firms in same sector of economic activity, may yield efficiency gains in the form of scale and scope economies, but may also give rise to negative effects in the form of eliminating the competition, which may yield an increase in market power to the unified firm (Barros and Martinez-Giralt 2012). In contrast, *vertical M&As*, in which a firm acquires or merges with a downstream customer or an upstream supplier. (Williamson 1968) conducted an early static analysis on horizontal M&As and recognized that, in order to evaluate the consequences of M&As, a calculation of the trade-off between market power and cost-efficiency is necessary, that is, the comparison of the deadweight loss from the post-merger higher price and the merger-induced cost savings. If there is no reduction in costs, the merger reduces aggregate surplus; if there is no price increase, the merger increases aggregate surplus. Even though this static analysis is unrealistically simplified, it illustrates the general idea of welfare effects of M&As.

The bulk of the literature on M&As in health care markets comes from the US where the health care provision is largely based on private markets and, thus, the results are not easily extrapolated to other institutional settings.¹ The system in the US contains both horizontal and vertical structures in the competitive environment. The competitive pressure that restrains hospital and influences hospital behavior comes not only from other hospitals, but also from the health insurance market, as the bargaining between providers and payer networks determines the reimbursement rates and the physician and hospital networks. For example, Gowrisankaran et al. (2015) show that mergers between hospitals can give the merged system better bargaining

¹The lack of M&A studies in the EU, as compared to the US, is not only limited to health care but to other industries as well (Ormosi et al. 2015). Reasons may include lack of proper datasets, lack of academic researchers in competition authorities, or juridical views towards ex-post evaluations (Ormosi et al. 2015)

leverage vis-à-vis insurers resulting in higher negotiated prices. Given the significant role of bargaining in complex price determination in the US, the Finnish private health care setting that is the focus of the last two essays in the thesis resembles more of a traditional industry in a free-market system where prices and non-price factors, such as quality, are determined via horizontal competitive forces and consumer demand in the market.

Empirical studies of M&As in health care markets can be roughly divided to two separate branches: structural approaches and reduced form approaches. Structural approaches rely on estimating models that have a foundation in economic theory and make explicit assumptions about the economic actors' objectives, environment, and choices being made within the model (Low and Meghir 2017). In the context of M&As, this usually involves specifying and estimating a demand model and an oligopoly supply model. Using estimated parameters, simulations can be performed to evaluate how M&As affect, say, prices (Weinberg and Hosken 2013). Usually these approaches are used in the analysis of case-studies and proposed and hypothetical mergers (see Gaynor et al. (2015) for a summary of the literature). In contrast, reduced form approaches—also called retrospective analysis—analyze consummated M&As. The reduced form approach allows researchers to be somewhat agnostic about the underlying theoretical model and thus let the data speak directly of the relationships between the variables of interest (Gaynor and Town 2011). Despite lacking a more sophisticated modeling approach to competition, reduced form approaches have the advantage of feasibility for studying numerous M&As simultaneously and observing the results of M&As (Cooper et al. 2018).

The predominant reduced form approach has been difference-in-differences estimation, where the acquired health care units are compared to other health care units that are not part of the acquisitions. A sheer before-after comparison of prices in acquired units imposes the risk of misleading inferences regarding the underlying change in the competitive environment, for example, because of inflation or provision quality changes (Gaynor and Town 2011). The challenge is to find a control group that meets the assumptions behind the difference-in-differences inference, that is, the prices in the control group need to follow parallel trajectory to acquired health care units during the pre-acquisition period. At the same time, the control group should remain unaffected by the acquisitions. M&As can affect the prices of other health care units nearby as the whole market becomes more concentrated. Thus, using health care units that are geographically proximate to the acquired units runs the risk of inducing downward bias in the estimated impact due to the spillover effect (Gaynor and Town 2011). To alleviate this problem, recent literature has formed the control group from those health care units that are outside the market area of the treated health care units (Schmitt 2018; Dafny et al. 2019; Beaulieu et al. 2020). Nevertheless, the choice of a proper market area is usually arbitrary and has varied between studies. In the third and fourth essays of this thesis, I base the size of the

market area on actual patient flows observed in the data.

The common finding in the literature—which mostly comes from US health care markets—is that prices increase after horizontal mergers (Gaynor and Town 2011). Similarly, evidence of increased quality after increased consolidation is scarce (Gaynor et al. 2015; Beaulieu et al. 2020). Much of this literature is devoted to analyzing hospital markets. A principal challenge has been the accurate measurement of prices, as hospital contracts are complicated, and different services have different payment structures. Usually the studies have relied on estimated transaction prices based on hospitals' charges, or weighted averages across different hospital products and across different payers, rather than on actual transaction prices. Those studies that use more detailed price data are limited to a specific geographical area or local market. Furthermore, Cooper et al. (2018) show that the correlation between hospital charges and transaction prices is rather low. Also, perhaps due to data availability, another avenue that has lacked research in the context of M&As is the physician service market. The nature of the horizontal and vertical structures in physician service markets where physicians work in independent practices, multi-physician groups, or as part of a larger integrated health system make a compelling topic of research.

The third and fourth essays of this thesis focus on the impacts of M&As on physician service markets in the Finnish private health care market. The administrative nation-wide Finnish data contain records of all visits and services in the private health care sector. Crucially, the data include the prices paid for each service with IDs for physicians, which allows researchers to follow physicians across time. The third essay estimates the impacts on physician visit prices, the utilization of their services, and physician employment across different specializations. Because physicians commonly work as independent practitioners in firms, they horizontally compete with each other even within the same firm, meaning that employment is crucially linked to level of competition; physician employment reduction after a merger can decrease within-firm competition. The fourth essay estimates the impacts on diagnostic service prices, and quantifies the price changes to consumer surplus by estimating a patient demand model.

2 Summary of the Essays

2.1 Information Technology, Access, and Use of Prescription Drugs

Barriers in access and non-adherence to medication can substantially worsen health, lead to hospitalizations and death, and increase health care costs. At the same time, overuse of addictive prescription drugs may lead to addiction and worsen health outcomes. Health information technology can provide a solution by facilitating easier access to prescription renewal while improving the transparency and monitoring of prescription history. E-prescribing is a technology that provides both features and can help in targeting prescribing to patients with the highest marginal health returns.

In the first essay, we explore how the introduction of a nationally standardized and interoperable e-prescribing system affects access and use of benzodiazepine prescriptions that are effective in the treatment of mental health disorders and insomnia, but also highly addictive with prolonged use. Benzodiazepines are commonly used for non-medical purposes and are a common cause of emergency department visits, especially when consumed in combination with alcohol or opioids. We leverage the exogenous variation in the timing of the introduction of e-prescribing to municipalities' primary health care units during the years 2010–2013 in a difference-in-differences framework. We validate the underlying assumptions of this estimation framework by estimating event study regressions that reveal any pre-trends and long-run dynamics in the outcome of interest.

The prescription data used in this study is provided by the Social Insurance Institution of Finland (Kela). The unique and comprehensive prescription-level data cover all prescriptions reimbursed by the Finnish NHI scheme for 2007–2014. To measure patient health outcomes during this period, the prescription data is linked to the public specialized health care discharge data maintained by The Finnish Institute for Health and Welfare. This allows the joint follow-up of prescription drug use and patient health.

This essay has four main results. The first result is that after the introduction of e-prescribing, the uptake rate of e-prescriptions increases considerably to around 60 to 70 percent after one year of adoption. The second result is that benzodiazepine consumption increases by 5 percent after the introduction of e-prescribing for populations under 40 years of age, but not for the elderly population. The third result is

that increased benzodiazepine consumption does not improve health outcomes. The fourth result is that, for patients under 40, the health harms from increased benzodiazepine consumption increases: compared to the mean level, the probability of a prescription drug abuse diagnosis and suicide attempts increases by approximately 20 percent.

Little empirical evidence exists to explain how health information technology affects the trade-off between access to and the targeting of medical treatments. Prior literature on health information technologies and prescription drug monitoring programs has mainly focused on the information channel and broader health measures. This essay highlights how improved medication access can lead to overuse of medication in the case of suboptimal monitoring of patients. Overall, the results raise fundamental questions about how well health information technologies can replace physician-patient face-to-face communication, especially in the case of high risk or complex patients.

2.2 Information Integration, Coordination Failures, and Quality of Prescribing

Coordination failures in health care are especially consequential as they can lead to suboptimal decision making that can harm patient health. Organizational fragmentation and poor information flows enhanced by searching costs and incompatible health information systems can hamper the delivery of high quality care. Medical errors are a major cause of hospitalizations and increased health care costs. Therefore, health information technology that improves coordination between providers and the monitoring of past treatment decisions of patients has the potential to decrease these medical errors.

The second essay continues the thesis' investigation of the e-prescribing system. The focus of this essay is in the information channel of e-prescribing and how it may improve coordination among physicians treating the same patient. As e-prescribing computerizes information pertaining to a patient's current medication and prescription history, it potentially helps the current treating physician to avoid prescribing overlapping or harmfully interacting prescriptions. We study the co-prescribing of warfarin and non-steroidal anti-inflammatory drugs (NSAIDs). Warfarin is a blood thinning drug and NSAIDs are used regularly in inflammation and pain treatment. NSAIDs enhance the effect of warfarin prescriptions and may lead to excessively thin blood and hemorrhage.

We use a difference-in-differences framework to study how the introduction of e-prescribing across municipalities' primary health care units affects the probability of prescribing NSAID on top of a warfarin prescription and vice versa. We use prescription data provided by the Social Insurance Institution of Finland. As prescribed daily doses are available in the data—as is usually the case—we proxy for these with

the defined daily doses, a measurement provided by the World Health Organization that indicates the average maintenance dose per day for the drug. With defined daily doses and the prescription dates we can identify interacting prescriptions.

We first document large regional disparities in the shares of harmfully interacting prescriptions, with rural municipalities over-represented among the worst performing municipalities. Second, we find that e-prescribing decreases the probability of prescribing interacting prescriptions in rural municipalities by 36 percent compared to the mean level, but that this is not the case in urban municipalities. Third, we find that the decrease largely comes from unspecialized physicians, that is, those physicians that have the least amount of education. Fourth, in outcome decompositions, we find that a larger proportion of the decrease comes from situations where the previous prescriber is a different physician. This result supports the hypothesis that e-prescribing provides critical information, especially in settings where treating physicians change, and mitigates coordination failures.

Overall, the study shows that interoperable health information technologies can improve coordination in a complex system, such as health care, where information is typically dispersed. The results show that health information technologies can reduce regional disparities in prescribing quality and help to reduce information acquisition costs for physicians with less education who may also have less experience treating complex patients, and between multiple treating physicians.

2.3 Physician Prices and Competition: Evidence from Acquisitions in the Private Health Care Sector

Health care markets in both hospital and physician markets have become increasingly concentrated during the last two decades. M&As directly increase market concentration, but they may also affect physician labor market structures. In physician markets where physicians compete with each other, labor markets can affect the competitive environment. Because comprehensive physician prices and practice data have rarely been available, the empirical analysis of physician service markets has been challenging and little is known about how M&As affect physician employment in health care units and how this, in turn, changes competition and physician prices in the physician markets.

The third essay considers how M&As affect physician prices and competition between physicians through labor market in the Finnish private health care market. Physicians typically work as independent contractors for firms and rent their office spaces. Decreases in physician employment in a health care unit can decrease physician within-unit competition while leaving cross-unit competition unchanged. Using detailed nationwide register data, from the Finnish private health care system, that contain exact physician prices, physician IDs, and information on their workplaces, we can follow the movement of physicians across health care units, as well

as their price levels before and after an acquisition.

To study changes in the outcomes, we estimate difference-in-differences and event study regressions where we compare physicians working in acquired units to physicians working in units outside the market area of the acquired units. To determine the proper radius of the market area and to diminish the threat of spillovers from treatment group to control group, we measure the actual distances patients travel to visit their physicians. We focus on four different physician specialties with different degrees of concentration, education, and switching costs (patient loyalty and repeat visits): primary care, gynecology, orthopedics, and ear, nose and throat diseases.

We find a robust visiting price increase of 5 percent after one year of an acquisition for gynecologists, a smaller increase for primary care physicians, and statistically insignificant effects for other specialties. We do not find evidence of an increase in overall health care use or market shares in the acquired unit. However, in gynecology, we find evidence of job losses in the acquired unit as departing physicians are not replaced with new physicians, resulting in an increasing share of visits to incumbent physicians. We also document an increase in the within-unit concentration in these units, which may partly explain the observed price increase. In gynecology, incumbent physicians may gain market power as patients typically have a long lasting treatment relationship with the gynecologist and repeat checkups are common.

These results are directly relevant to antitrust policy. Even if an acquisition may not cause market-wide changes in the competitive environment or prices, it may still have a significant local effect on the competition. Thus, assessing changes in the competition in the product market, at the market level, may not be enough to determine the nature of the acquisition. Conversely, promoting tight competition within health care units can alleviate upward pricing pressure. These results are relevant to other industries and sectors in which independent contractors or freelancers have a vertical contract within the same platform but still compete with each other horizontally.

2.4 Mergers and Acquisitions in the Markets for Diagnostic Services: Evidence from the Finnish Private Health Care Sector

Previous studies on health care market consolidation and M&As have mostly focused on the impacts on aggregate price levels or approximated hospital prices where the average is taken across different hospital products. While measures on aggregate level provide important information, it is equally important to study what happens at the micro-level. One significant sub-market, which arguably plays a crucial role in patient care and has received very little attention in the literature, is the diagnostic service market.

In the fourth essay, I study how M&As in the Finnish private health care sector

impact the prices and use of three different diagnostic products: blood tests, X-rays, and MRIs. In contrast to physician service markets, the prices of diagnostic procedures are set at the health care unit or firm level and are the same regardless of the physician from whom the patient gets the referral. Using difference-in-difference regressions, I study the impacts separately on the acquired units, on the units that belong to the acquired firm, and on the other rivaling units in the market. As, after getting a referral from a physician, the patient is free to choose the provider of the diagnostic service according to his or her own preferences, I proceed to estimate a patient demand model for health care units providing these services. The purpose of the structural model is to offer a more comprehensive idea how of prices affect decisions and how much influence the referring physician has on the choice. In the estimations, I use comprehensive register data provided by the Social Insurance Institution of Finland, which contain information on all transactions that were reimbursed by the NHI scheme.

My difference-in-difference estimations show that M&As increases blood test prices statistically significantly, by 6-9 percent, in the acquired units. Within the same markets where the acquisitions take place, the prices increase of a similar amount in the acquiring firms' other units, but not in the rivaling units. For X-rays and MRIs, I do not find a statistically significant price increase. The reason for this could be that the markets were already more concentrated for these procedures and the firms have less room to increase their price margins. My demand model estimations show that patients are quite insensitive to blood testing prices when choosing their provider. Additionally, the referring physician has a notable influence on the decision; patients are more inclined towards choosing the same firm in which the physician works. Low price elasticity may contribute to the firms' ability to increase their blood testing prices; however, as the price coefficient in the demand model is small, the estimated impact on the consumer surplus from the price increases is negligible.

For policymakers, the results provide useful information on switching costs and frictions in these markets. Increasing transparency in prices and choice options could promote price-shopping behavior. If the patients chose the cheapest alternative on their choice set, the cost savings would be approximately 43 percent compared to the mean price. One way to increase transparency would be to mandate referring physicians to offer a list of prices and possible choices on the market. Increased sensitivity through transparency may constrain acquiring firms from increasing their markups.

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