# Essays on policy instruments and incentives in health care in Norway

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**Summary**

Equal access to quality health care services, efficient resource use and cost containment are Norway's health care policy objectives (1). To reach these goals, policymakers use financial incentives and organizational structures. Efficient use of these policy instruments requires that policymakers understand how health care providers and users react to them. This thesis contributes to this knowledge.

The first two papers present research into financial incentives. In 2008, policymakers changed the reimbursement scheme for radiology providers to cut costs. Paper 1 examines how the change supplemented the general practitioner (GP) gatekeeping role. Paper 2 evaluates how the change affected the provision of radiology at the municipality level in different regions and centralities, depending on difference in travel time between private and public radiology providers. Paper 3 studies the organizational structure of the Norwegian regular GP scheme where patients can change GPs twice a year. This paper identifies patterns in disenrollment among patients with chronic diseases. Such patterns could indicate otherwise unobserved care quality.

Paper 1 concludes that the payment system for specialist providers might serve as a rationing tool and supplement gatekeeping. Paper 2 indicates the reimbursement change contributed to reduced services for populations with only private providers nearby, patient reallocation from private to public providers, and a reduction in the difference between municipality centralities in their consumption pattern, but an increase in the difference between Regional Health Authorities. Paper 3 suggests that most patient groups tend to remain with GPs with a greater share of arthritis, asthma, and depression patients, which can indicate high quality care. The results are relevant for both researchers and policymakers interested in policy instrument development.

**Acknowledgements**

Today, upon completion of my PhD dissertation, I feel both relieved and thankful. I am grateful to all those people who were by my side in this uneasy, nevertheless interesting process of creating a piece, a contribution to science.

I remember when I was working on my bachelor degree, I always looked up to the PhD students. They were something out of this world for me. When I myself was admitted to a PhD program, I understood that to be a researcher you didn't need to be from a different planet, but you had to be curious and a very hard working and dedicated person. Another thing I have learned was that researchers are people who look on this world in a very detailed manner. Deep into the roots. You have to be able to ask questions, often outside of the box, and most importantly, you have to be patient. Patience is a virtue that researchers acquire. It takes time to answer a question. To write an article may take many months, sometimes years of remodeling and reassessing. To publish an article might take several journals and several rounds of reviews, and thus many months of work on top of writing the draft. The PhD period was a good school for me to develop the necessary skills and the ability to complete my projects in order to see them published. My supervisors, Tor Iversen and Knut Reidar Wangen were excellent role models for me on how to complete the projects.

My first two publications (papers 1 and 3), were written in co-authorship with each of them and it taught me a lot about the way you approach scientific writing, analysis, and the publication process so that I could apply this knowledge on my third publication (paper 2). I am thankful to Tor and Knut for their generosity in sharing knowledge, for support, feedback and discussions, and for introducing me to the science as a process and craft.

I have met many good people during my work at university. I also want to thank all of my fellow colleagues for being there for me and for the conversations and time spent together. In particular, Anita, Yvonne, Mathyn, Søren, Gudrun, Camilla and Liv for being warm and supportive and Hans Olav Melberg, Terje Hagen and Ole Berg for always being kind and helpful. I was blessed to have Anita as an awesome officemate. She has become a close friend and I am thankful, not only for the fun we had and for the uplifting energy we created together, but also for all our conversations, her support and brainstorming together, especially towards the end.

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Finally, I wish to thank my family and friends for their enormous support; I am particularly grateful to my husband, Javier, and my mom for their patience and love.

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**List of Papers**

**Paper 1**: Supplementing gatekeeping with a revenue scheme for secondary care providers. Iversen, T. & Mokienko, A. Int J Health Econ Manag. (2016) 16: 247. https://doi.org/10.1007/s10754-016-9188-2

**Paper 2**: Effect of a funding change and travel times on delivery of private and public radiology services in Norway: Register-based longitudinal study of Norwegian claims data. Mokienko. Submitted to BMC Cost Effectiveness and Resource Allocation.*

**Paper 3**: Disenrollment from general practitioners among chronic patients: a register-based longitudinal study of Norwegian claims data. Mokienko, A., Wangen, K.R. *BMC Fam Pract* **17,** 170 (2016). https://doi.org/10.1186/s12875-016-0571-3

*Paper 2 was published $16^{th}$ October 2019: Effects of a reimbursement change and travel times on the delivery of private and public radiology services in Norway: a register-based longitudinal study of Norwegian claims data. Mokienko, A. *Cost Eff Resour Alloc* **17,** 22 (2019). https://doi.org/10.1186/s12962-019-0190-7

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**Abbreviations**

ABF: Activity-based funding

CAT: Computerized axial tomography

DRG: Diagnosis-related group

DT1: Type 1 diabetes

DT2: Type 2 diabetes

FFS: Fee for service

GP: General Practitioner

HELFO: Norwegian Health Economics Administration (Helseøkonomiforvaltningen)

KUHR: Control and payment of reimbursements to health service providers (Kontroll og Utbetaling av HelseRefusjon)

MCs: Marginal costs

MRI: Magnetic resonance imaging

NHI: National health insurance

RHA: Regional Health Authority

X-rays: Radiography

## Preface

I have been interested in the topic of intrinsic and extrinsic motivation for behaviour for a long time. In my early career, when I had to lead and motivate a team of colleagues, I questioned the definition of leadership. I continued this questioning in broader perspective when I started my PhD studies at University of Oslo while researching policy implications in Norwegian health care. I saw a commonality between leading a team of people and creating policies. In both instances, knowing one's own and one's team's strengths and weaknesses is necessary, as is creating incentives for certain actions or behaviours. In terms of health care policies, this idea means knowing the implications of various policy instruments and how the whole system works to create incentives for health care actors to behave in certain way.

## 1 Introduction

> *'Whilst we must assume that financial incentives are effective instruments, the Directorate finds that good solutions must also be promoted using other policy instruments, such as management and organization, clear lines of responsibility and correct prioritization on the basis of medical factors. .... it is an acknowledgement of the fact that one instrument alone cannot make a direct contribution to achievement of goals in all areas'. (Ministry of Health and Care Services of Norway pp. 8-9 in (2))*

Norway's health policy is directed toward both efficiency and redistribution and fairness (p. 4 in (3)). The financing system in Norway supports three main goals for health care policies: increasing the quality of health care services (including accessibility regardless of where patients live), cost containment and effective use of resources (1, 4, 5). High-quality services are defined as those that are effective, safe, user-centred, and coordinated and are characterized by continuity, resource utilization, availability and fair distribution (4, 6).

Creating and implementing health care policies is complicated. The process starts when the government reports on policies to Parliament by issuing white papers or parliamentary reports (in Norwegian *melding til Stortinget* or 'St. Meld'). White papers are used when the government would like to present cases to Parliament without a proposal for specific decisions or new or amended legislation. These papers are usually used to report analyses, plans and ambitions within a particular policy area (7). For instance, the Ministry of Health and Care Services issued 'Future primary health care - proximity and wholeness' (White paper 26 in 2015), yearly papers 'Health Care Quality and Patient Safety' (White Papers 11, 12, 13, 6 for 2013, 2014, 2015, 2016 correspondingly), and White Paper 23 from 1997 about Regular General Practitioner Scheme (5, 8-12).

After Parliament approves the white paper from the Ministry of Health and Care Services, the Ministry and the Norwegian Directorate of Health 'translate' it to the language of legislation proposals, incentives, produces decisions and guidelines, and creates incentives for the health institutions to behave in a desired way.

To determine which incentives to use, the policymakers should clarify the effects and outcomes of the actions: when they change some constraints, financial or organizational, the market for health care services adjusts. The aim of this thesis is to contribute to the evidence on the impact of financial and organizational incentives and policy instruments. I dedicate the first two papers to studying the outcomes of the cost containment policy for radiology providers and the third paper to studying disenrollment patterns of the patients with chronic diseases as a possible indicator of high-quality care.

The first two papers in this thesis focus on extrinsic or financial incentives and their outcomes. These sections study the change in the remuneration scheme for radiology providers in Norway in 2008. The goal of policymakers was to cut costs in radiology. Thus, according to the Royal proposition for the state budget for 2008, the radiology budget was cut and the reimbursement scheme was changed from a 50/50 split to a 60/40 split (basic and variable parts accordingly) (13).

Paper 1 investigated whether the change may supplement the gatekeeping mechanism in regulating utilization of radiology services and studied outcomes for different modalities of radiology. Paper 2 examined how the change affected the provision of radiology on the municipal level in different regions and centralities depending on travel time between private and public radiology providers.

The second part of the thesis, the third paper, is dedicated to organizational structures or incentives. This section studies disenrollment patterns among patients with chronic diseases because they could indicate otherwise unobserved GP quality. In 2001, the introduction of the Regular General Practitioner Scheme aimed to increase quality and continuity of care and control over costs. To increase quality and competition between GPs, the patients were allowed to change GPs up to two times a year (12, 14). Patients choose their GPs and remain with him (her) or switch for various reasons, such as patient-GP relationships, GPs' qualifications, and patients' satisfaction with services, access, and GP referrals. All these factors affect patients' perception of service quality. We considered using patients' disenrollment patterns as quality indicators. As such, the third study elucidates disenrollment choices of patients with chronic diseases and contributes to potential quality identification in general.

The remainder of this thesis is structured as follows. Chapter 2 describes the institutional healthcare settings for primary and secondary care in Norway, including radiology providers and their financing options. The third chapter presents the concepts, theory and empirical literature as a background for the study. Chapter four provides a summary of the three essays' aims. Chapter 5 discusses the approaches in all three essays with regard to data, methods, and results. Chapter 6 provides a conclusion to the research.

# 2 Institutional background

## 2.1 Organization of health care system

### 2.1.1 Health care in Norway

Norway offers universal health insurance (i.e., all residents are insured through the taxation system). Residents pay a small consultation fee until they reach the threshold of 2,369 NOK (around 235 EUR) per year (15), above which treatment is free. Health expenditures amount to approximately 9.9 % of gross domestic product (GDP) (data for 2015) (16). National health insurance covers planned and acute primary, hospital and ambulatory care, rehabilitation and some drugs, as well as dental care for children up to 18 years and for certain disadvantaged groups.

This section is dedicated to policy-making and structure of health care in Norway. Policy is created when Parliament issues political decisions. The Ministry of Health and Care Services sets these decisions into the action with the help of legislation and documents guiding the work of the Directorate of Health[1] (16-18) (its executive agency), Regional Health Authorities and other agencies[2] under it (19-27). Figure 1 presents a flow chart depicting the organization of the health care system in Norway

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[1] The Directorate is responsible for clinical guidelines, new health technologies, national quality indicators, reporting and learning system for adverse events in hospitals, fee setting for diagnosis-related groups (DRG) and projects on the strategies to ensure quality of care. In 2016, the Directorate of eHealth was established; its role is to develop information technology in health care.

[2] These agencies include the Medicine Agency that decides which medications to reimburse patients for up to a certain threshold; the Norwegian Institute of Public Health, which works with research and surveillance of public health, holds several registries (merged with Norwegian Knowledge Center for health services in 2016); Norwegian Board of Health Supervision audits the health care system in regard to complaints against both institutions and individuals, the Radiation Protection Agency System of Patient Injury Compensation, the Biotechnological Advisory Board, the Norwegian Registration Authority for Health Personnel (under HD) and the Health and care services ombudsmen who helps patients who do not receive care they need.

(16). In the next sections, I review the structure of primary and specialist health care, in particular the provision of radiology health services. Due to the thesis's focus, I do not address mental health care and long-term health care.

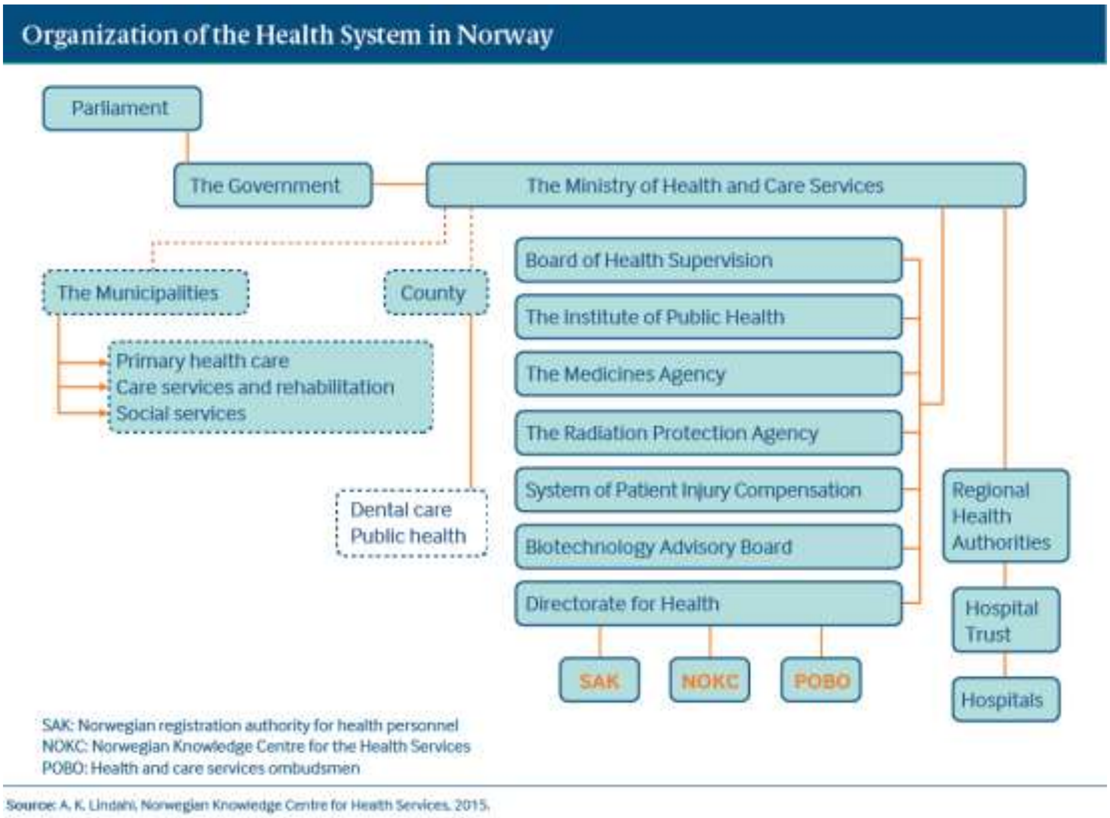


Figure 1. Organization of the health care system in Norway (borrowed from (16))

### 2.1.2 Primary care

The municipality provides primary healthcare. According to the Regular General Practitioner Scheme, implemented in 2001, each resident has the opportunity to be listed with a GP in the municipality (although some small municipalities share GPs). Almost all five million Norwegian residents are listed with a GP. The responsibility for the Regular GP Scheme lies with the Norwegian Health Economics Administration (Helfo), which is a subordinate institution directly linked to the Norwegian Directorate of Health[3] (28).

General practitioners decide the maximum number of patients they list and accept additional patients until the maximum number is reached. Each GP had on average 1,127 patients in 2015 (16). Patients are able to find a GP's availability and the maximum and current lengths of their patient lists. Patients can switch to another GP online, according to availability, up to two times annually. On average, 3% of patients choose to switch annually (29, 30).

General practitioners provide initial medical services other than those involving emergencies. Additionally, primary healthcare functions as a gatekeeping system for secondary healthcare. Thus, to receive coverage for specialist treatment or undergo an examination, a patient needs a referral from a GP (16, 31).

### 2.1.3 Specialist care

Norwegian Regional Health Authorities (RHAs) are responsible for specialist healthcare, including radiology diagnostics[4] (32). In 2007, the number of RHAs was reduced from five to four, South-Eastern Norway, Northern Norway, Western Norway, and Central Norway. In total, RHAs are responsible for 19 public hospital trusts.

Inpatient specialist care is mostly provided by hospital trusts, although some is provided by contracted private facilities (32). Patients have free choice of specialists and

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[3] In addition, this directorate directs payments to health care providers, handles individual reimbursement for certain medicines, dental and health services abroad and issues European Health Insurance cards.

[4] The responsibilities for ownership and financing were moved from 19 counties to the central government, and hospitals were organized as hospital trusts within RHAs during the hospital reform in 2002.

hospitals (33, 34). Outpatient care is delivered by (1) public providers, which are part of hospitals, and by (2) private physician specialists and private institutions with a lifelong RHA contract. In addition, some private providers contract with RHAs after a tendering process. Private specialists and private institutions account for around one-third of outpatient consultations. To see a public specialist or a specialist who contracts with an RHA, patients need a referral from the GP.

## 2.2 Financing

### 2.2.1 Patient copayments

The patient copayments constitute 155 NOK (15 euro) for a visit to an ordinary GP, 204 NOK (21 euro) to a GP specializing in general medicine, and 351 NOK (35 euro) to a specialist per visit in 2019 (35). X-rays copayment is 250 NOK (25 euro), while blood tests are 55 NOK (6 euro). A few groups are granted exemptions from these payments: patients with communicable diseases, children under 16 years old, mothers and children undergoing antenatal and postnatal follows up, patients with work related injuries, and young people under 18 years old who are under psychotherapeutic care (16, 35).

The patients pay their copayments directly to the provider until they receive an exemption card (in Norwegian *Frikort*). There are two exemption card schemes in Norway: one for user fee group 1 and one for user fee group 2. The first covers consultations at a GP, psychologist, hospital or laboratories and some medicines. The exemption card for user fee group 1 is generated automatically once a patient has paid more than 2369 NOK (in 2019) in user fees. The second card covers physiotherapy, rehabilitation, some particular teeth and gum diseases and treatment trips abroad. This card is generated automatically when a patient has paid more than 2085 NOK in user fees. Afterward, the patient no longer needs to pay the provider because Helfo pays providers directly (15, 36).

### 2.2.2 Private health insurance

About 9% of the Norwegian population has private health insurance: 91% through the employer, and the rest buy it privately. Private health insurance ensures quicker access to specialists and a broader choice of private providers, as well as providing access to some treatments not offered in the public health service (16, 37). However, to see a specialist, except physiotherapists and psychologists, patients still need a referral from a GP if the patient wants it to be covered by private health insurance. Patient who choose to pay in full out of pocket can visit specialists without referral.

### 2.2.3 Primary care physician

There are two types of GPs: 5% are salaried and 95% are self-employed. Salaried GPs are more common in sparsely populated areas, as the salary removes their financial risk and improves GP recruitment at the periphery. Self-employed GPs receive a capitation fee from the municipality, a fee for service (FFS) from the state, and copayment from patients (each constituting approximately one-third of the GP's income) (38).

### 2.2.4 Secondary care physicians

Specialists based in hospitals are salaried. Privately practicing specialists that have contract with RHA are paid in the following way: (1) lump sum (35%), (2) fee for service (35%), and (3) patient fee (30%). The specialists that do not have agreements with RHA are not regulated and set their prices themselves. Patients pay them directly and in full either out of pocket or with the help of private health insurance.

### 2.2.5 Hospitals and secondary care

Public hospitals are financed through RHAs. Somatic services are funded 50% by block grants and 50% through activity-based funding (ABF) based on diagnosis-related groups (DRG) (for 2015 (16)). Norway has used ABF for secondary healthcare providers since 1997 when the system of global budgeting was replaced by, partly, ABF. The remuneration schemes have changed several times since 1997; ABF reimbursement percentages varied between 40% and 60%: 55% in 2002, 60% in 2003 and 2005, and 40% in 2004 and 2006 (2, 32, 39). The purpose of ABF is to encourage achievement of activity targets. If these targets are not met, the RHA loses income. If the activity level exceeds the target, costs are partially compensated (p. 12 in (2)).

## 2.3 Radiology services

### 2.3.1 Structure

Since a greater part of the thesis is dedicated to radiology providers, I present the organization and financing of radiology services in this section. There are two types of radiology providers in Norway: private and public. Private providers operate as for-profit institutions, while public providers are hospital radiology departments.

Regional health authorities choose a number of private radiology providers via a tendering process and sign contracts with them for a number of services. These contracts specify the volume of the services and reimbursement; some specify an aggregated budget for services (40), while others are more detailed and specify a budget for each type of service (e.g., ultrasound imaging, magnetic resonance imaging (MRI), computerized axial tomography (CAT) scans and X-rays) (41).

These private providers are part of the National Health Insurance (NHI) Scheme but also accept privately paying patients. Contracts with private providers specify that patients pay the same copayments to private and public providers if covered by the NHI; private laboratories can receive self-paying patients, but they should not be prioritized or examined at the expense of NHI services (42). According to interviews with managers of private radiology providers, these providers treat patients according to wait time and severity.

A patient has to receive referral to radiology examination from a GP or specialist to be covered by the NHI scheme. The referral can be for any available provider, public or private. Specialists and GPs can also recommend that the laboratory accepts patients without adhering to the typical wait time if they suspect serious issues. However, severely ill patients are often directed to hospital laboratories.

Generally, patients are added to a wait list when laboratories receive referrals. If patients choose to pay private providers entirely out of pocket, they receive examinations without adhering to the typical wait time. Usually, private providers' wait lists are relatively shorter than those of public providers, but there are variations according to region and service type.

### 2.3.2 Financing

For radiology services, the change to ABF occurred first in 2005 ((2, 43, 44)). According to Ministry of Health and Care Services of Norway, 'the purpose of the changes in the financing scheme is […] that the regional health authorities should be given increased responsibility and a better opportunity to plan and prioritize the total provision of laboratory and radiology services in their own health region' (p. 248 in (45)).

On the 1st of September 2005, the financing of all radiology was changed to a 50/50 split between block grants (from RHA) and ABF (from Helfo). Afterward, private providers had to also enter into agreements with RHA to receive refunds and were required to produce an agreed number of services. However, they would still receive refunds from Helfo and patient copayments if they produced more services than agreed (43).

On the 1st of January of 2008, the proportion covered by the grant was changed from 50% to 60% for block grant and from 50% to 40% for ABF from Helfo. The aim of the change in 2008 was to harmonize financing of radiology provisions and specialist health care, encouraging achievement of activity targets and reducing spending (43). According to Norwegian Directorate of Health, 'On average, an activity-based funding share of 40% is regarded as being lower than the marginal cost. Nevertheless, the possibility of activity-based reimbursement at 40% covering the marginal costs in some cases cannot be ruled out. However, it is in conflict with the intentions behind the activity-based funding scheme if this consideration steers decisions as to which patients should be offered treatment first' (p. 13 in (2)).

Regarding public providers, RHA pays a fixed budget to the hospitals for their laboratories, which function as public providers. That portion of the budget cannot be distinguished from other budget components for each hospital (29). This system complicates control over the number of examinations provided. Therefore, relative to private providers, public providers have softer budget constraints (31, 46, 47).

Patients copay the same amount for services regardless of whether they visit a private or public provider as long as the provider is under the NHI scheme.

### 2.3.3 Regional variation over time

Figures 1A, 1B, and 1C illustrate the provision of radiology services in Norway in 2002 versus 2008. Figure 1A describes the total number of radiology examinations in years 2002 and 2008 in different health regions normalized per 1000 inhabitants (48). Figure 1B provides the same data but stratified by modality (48). Figure 1C depicts distribution between the private and public sectors, stratified by health region in 2002 and 2008 (48). The use of radiology services in 2008 became more uneven in different RHAs compared to 2002, increasing especially in the central RHA. The distribution of the modalities indicates that X-rays are the most popular service type in all RHAs, followed by CT, MRI and ultrasound. The distribution of the shares of the total number of the services performed at private providers has changed from 2002 to 2008, especially for South East RHA (a decline from 79% to 62%), West RHA (an increase from 15% to 27%) and Central RHA (an increase from 3% to 8%). Figure 2 depicts distribution of market share between private and public radiology providers on a national level over the years 2002 to 2009 (43), indicating that spending for private radiology continually increased until 2007 and started to decrease in 2008.

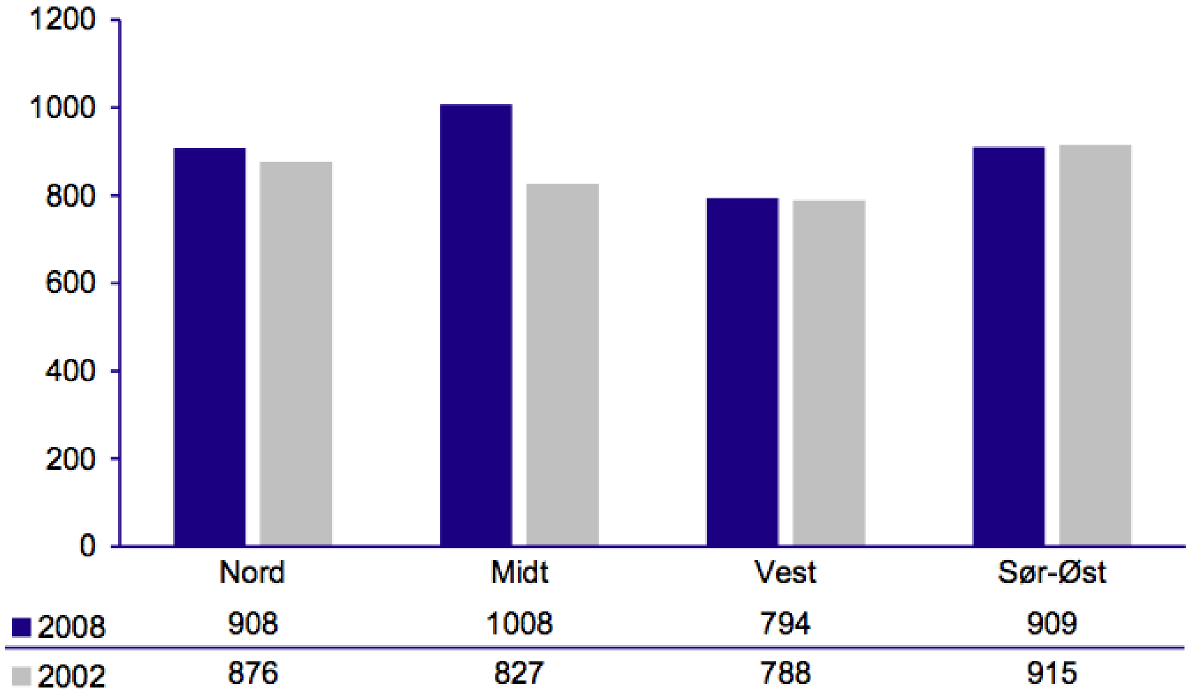


Figure 1A. Total number of private and public examinations per 1000 inhabitants in four different health regions: North, Central, West and South-East in 2002 and 2008 (Figure 3.3 in (48))

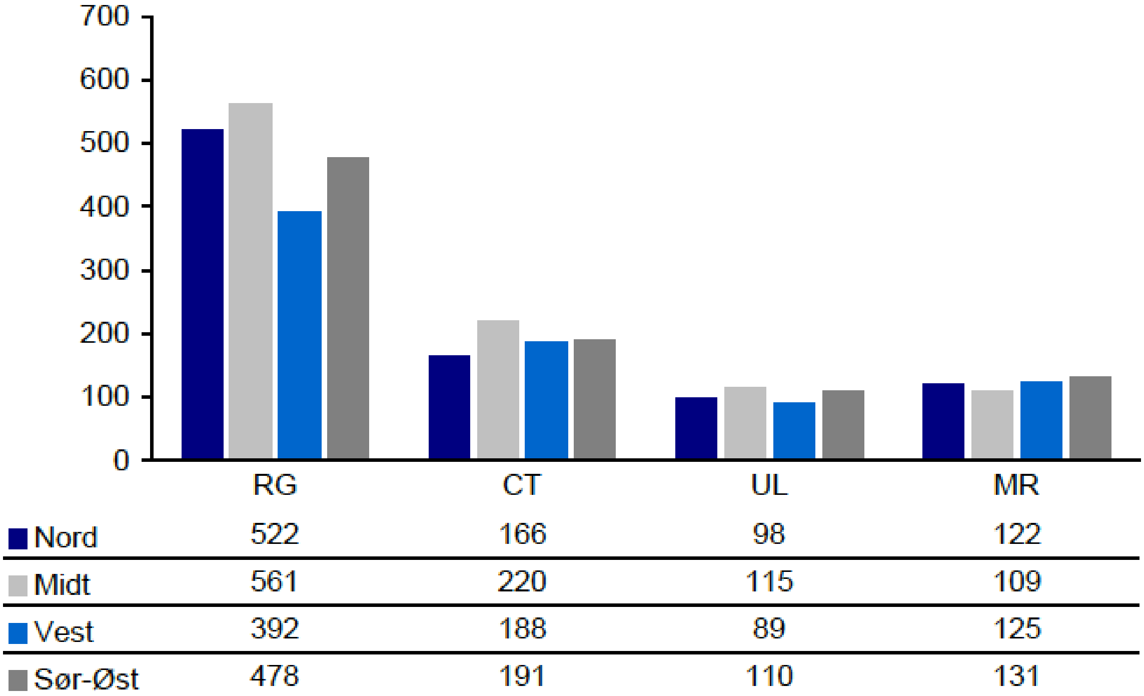


Figure 1B. Number of radiology examinations at private and public providers per modality (x-rays, computed tomography, ultrasound and magnetic resonance imaging), normalized per 1000 individuals per health region (North, Central, West and South-East) in 2008 (Figure 3.4 in (48))

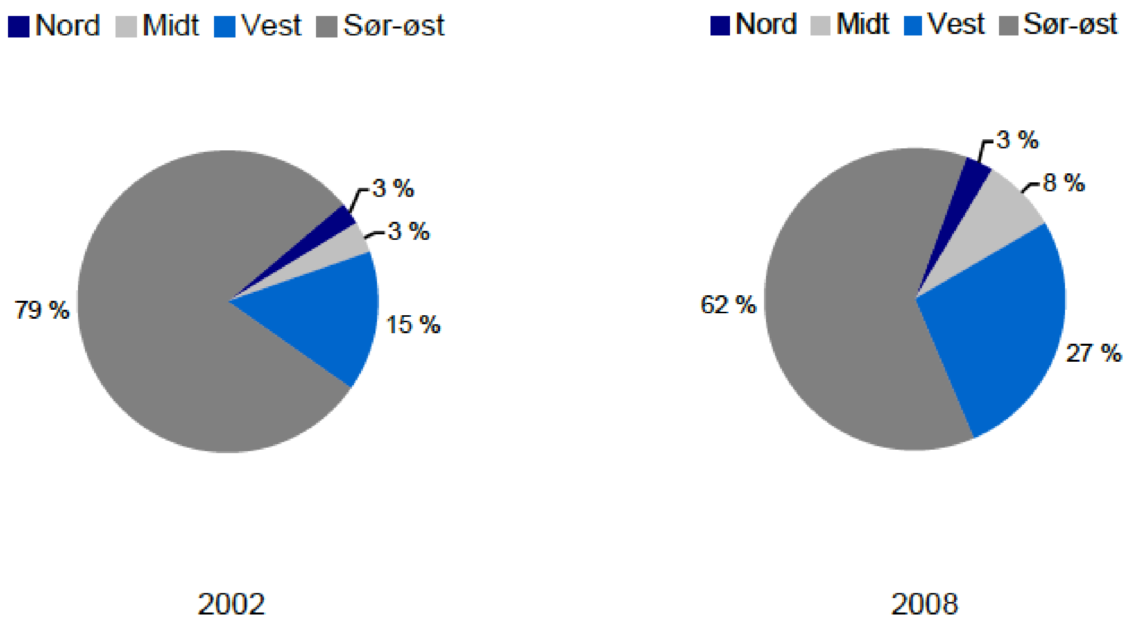


Figure 1C. Share of total number of private and public radiology examinations in different regions (North, Central, West and South-East) that were performed by private providers in 2002 and 2008. (Figure 3.9 in (48))

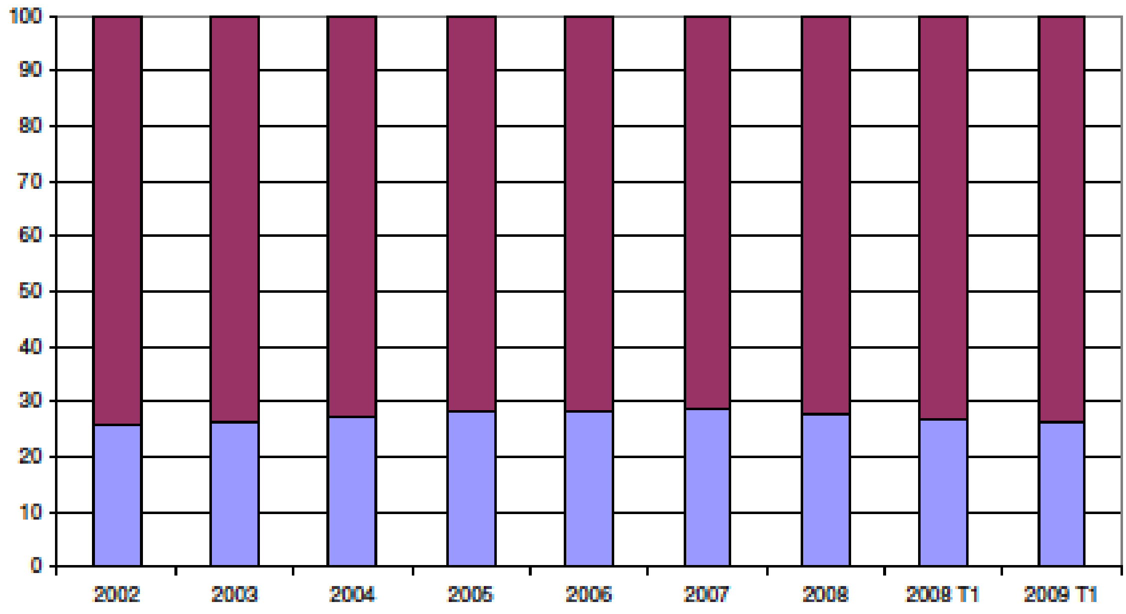


Figure 2. Market share in the costs between private (blue) and public (red) radiology providers in percent (Figure 3.4 in (43))

## 3 Concepts, theory and empirical literature

### 3.1 Policy instruments

This chapter introduces some theoretical background and empirical literature about policy instruments and incentives in health care.

According to the recent guidelines for the development of Norwegian health care[5], the main priority in Norwegian health care is to reduce costs and increase efficiency, improving the quality of care and making health care equally accessible regardless of patient group or geographic location (4, 5, 49-51). These goals are implemented through legislation and by creating incentives for the providers using policy instruments and by coordinating health care on national and local levels.

Public policy instruments are a set of techniques by which governmental authorities wield their power to support or prevent certain social changes ((52), p. 21). Organization (or organizational strategy) is a prerequisite for the application of the policy instruments ((52), p. 38). For instance, the fact that the patients are allowed to change GPs or to freely choose health care providers is an organizational strategy to promote competition.

Policy instruments are divided into (1) regulations (requirements and prohibitions), (2) economic means (financial incentives and disincentives and tools) and (3) information (transfer of knowledge, communication). Each of these categories can be affirmative or negative ((52), p. 250). Financial tools are rewards and penalties, or different structures

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[5] White Paper 34 (2015–2016) Values in the patient's health service - Report on prioritization, White Paper 11 (2015-2016) National health and hospital plan (2016-2019), White Paper 26 Future of Primary Health Care, National strategy for quality improvement for 2005-2015 and National strategy to reduce social inequality in health (2007)

of reimbursement (53-57). For example, the introduction of the ABF payment for radiology providers was a financial tool to cut spending. Non-financial tools, such as reputational incentives or elimination of informational barriers, may appeal to intrinsic motivation (58).

Both financial and non-financial incentive tools can be directed toward individual providers, institutions or patients (59, 60). Thus, policymakers implement policy goals by creating incentives for providers using payment mechanisms or changing certain organizational constraints (61-64).

### 3.2 Financial incentives

> *'The funding schemes are complex and fragmented. Objectives and policy instruments must be adapted to trends and developments in society and medicine. It is only natural that the funding schemes are under constant review and assessment'. (Ministry of Health and Care Services of Norway, pp. 8-9 in (2))*

Kazungu et al. (2018) highlight that purchasing decisions are the base of universal health care. Purchasing decisions include three main areas: (1) what health services to buy, (2) what providers to use, (3) how to buy these services (i.e., payment mechanisms, price, contracts). Provider payment mechanisms (PPM) are crucial because they create incentives to attain access, quality, quantity and efficiency goals (53). Jegers et al. (2002) classify PPM in two dimensions: variable versus fixed and prospective versus retrospective (65). Kazungu et al. (2018) elaborate and define six main PPM categories: 1) global budget (a prospective payment with total flexibility on how to spend it to deliver a set of services); 2) line-item budget (a prospective payment to spend on specific itemized services); 3) fee-for-service (FFS) (a retrospective activity-based reimbursement method for each provided service); 4) capitation (a fixed amount of money prior to service delivery to provide agreed services for each registered individual over a fixed period); 5) case-based or diagnosis-related groups (DRG groups) (a fixed amount per case such as for each diagnosis, admission or discharge); 6) pay for performance (a payment after the providers meet certain performance thresholds based on predetermined measures) (53, 66-68).

In Norway like in most countries there is a combination of the PPMs. For example, Norwegian hospitals recieve a global budget and DRG-based payment (with recent initialization of pay for performance); primary and secondary care physicians in Norway use FFS and capitation.

Empirical evidence indicates that healthcare providers react to financial incentives through PPMs (66). For example, two review studies by Kazungu et al. (2018) and Gosden et al. (1999) found that quantity of health care services (like hospitalization, number of procedures, number of diagnostic consultations, and number and time of clinical consultations) is reduced under capitation but increases under FFS (53, 61) Thus, regarding payments to GPs and specialist care, most research papers indicate that FFS creates greater incentives than salary does for providing services (64, 69-77) and capitation creates more incentives for referrals to specialist and hospital care (53, 78). In addition, Holte et al. (2016) in an experimental study found that GPs value losses from their current income level around three times higher than equivalent gains (79). Pedersen and Jarbol (2012) and Pedersen and Gyrd-Hansen (2014) also found that GPs are willing to change their practice location (for example to move to rural areas) or practice organization (such as to shared practice) if they are compensated financially and with non-pecuniary benefits (80, 81). However, another study found that GPs appreciate improvements in non-pecuniary attributes more than increases in income (82). There is also a difference between genders: while male GPs prefer the ABF system, female GPs prefer salaries (83, 84).

A new systematic review from 2019 indicates that GPs often respond to reimbursement incentive when delivering cancer care (85). For example, they may increase the volume of surgical procedures when surgical fees are increased (86, 87) or favour higher priced anti-cancer agents when reimbursed at a higher rate (88-90).

Changes to the reimbursement schedule also affect patient treatment for mental health care providers. Douven et al. (2015) found that after the introduction of a new reimbursement schedule (discontinuous discrete step function), self-employed mental healthcare providers treated patients longer to reach the next threshold and obtain a higher fee (91).

Considerable research has been conducted on financial incentives in hospitals, and although they are not the topic of this dissertation, I mention a few previous results because they also indicate that financial tools create certain incentives in providers' behaviour.

A study of the change to prospective payment in Medicare for inpatient rehabilitation facilities in 1997 to 1999 indicates that changes in payment lead to a reduction in costs and hospitalization duration (92). In Scandinavian countries, switching to ABF resulted in increased technical efficiency, and in some instances increased patient satisfaction, but not increased cost efficiency (93-95).

The results of the research on changes in reimbursement and diagnosis-specific prices for DRGs suggest that hospitals upgraded patients to diagnoses that provided greater reimbursements (96-99). This effect was particularly strong in for-profit hospitals (see review study of private and public sector in (100)), which supports earlier findings from Medicare about patients' upcoding to diagnoses with larger reimbursement, but provides no evidence that hospitals admitted more patients, increased the intensity of care or changed duration of hospitalization or actual costs (99).

Recent evidence from Norway from 2016 indicates that a 10% increase in DRG prices leads to a 0.8% to 1.3% increase in the number of patients treated with medical DRGs. However, the number of patients treated with surgical DRGs remained the same (98). An earlier Norwegian study from 2010 on the change to ABF funding in 1997 found that ABF change did not favor the most efficient hospitals, but it has contributed to reducing wait time and increasing the number of services in less efficient hospitals (39).

### 3.3 Organizational strategies

#### 3.3.1 Competition

One of the organizational strategies is competition framework. Within health care, competition occurs both between providers and between insurers. Competition between insurers is more relevant for markets like in the USA, while competition between providers can occur on several levels: primary, secondary, tertiary health care; inpatient and outpatient (101).

American and European studies on competition have diverse outcomes. Results based on American data indicate that competition and hospital care quality are negatively correlated (102-104), while results based on European data suggest competition and hospital care quality are either insignificantly or positively correlated (31, 105-110). These results differ primarily because of the difference in the organization and regulation of the health care systems between the two regions. The key is the price regulation. As theoretical evidence demonstrates when price is regulated, the competition raises its quality (or any of its available indicators) (101, 102, 111-113).

In the tax-financed health care systems, like Norway, there is little natural competition, and therefore, policymakers impose organizational structures to promote competition, for example by allowing patients to freely choose specialist or hospital and to change GPs up to twice a year. The next two sections are dedicated to the GP market and GP switching, as this dissertation focuses on the GP market in two essays.

### 3.3.2 GP market

The Norwegian model of GP system organization, allowing patients to switch GPs up to twice a year, provides the foundation for the competition between GPs, both to keep existing patients and to increase patient lists. The main incentive of GP competition is to improve performance and quality of services (105, 114-117). In addition, from a policy point of view, competition between GPs is an instrument to reduce growth in health care costs by inducing substitution of expensive hospital or specialist care through less costly primary care (101, 105).

Norwegian studies over time have found several important outcomes of the competition between GPs in regard to gatekeeping.

Gatekeeping is detrimental to patient satisfaction (118). The GPs' gatekeeping role operates when the only way to receive specialist healthcare is by obtaining a referral from a GP. Research suggests that gatekeeping reduces healthcare costs and 'unnecessary' interventions. Additionally, GPs have a better overview of quality and availability of secondary healthcare and thus can be better agents (64, 119-121). Simultaneously, increased competition between GPs could result in less strict gatekeeping because of the capitation system, as GPs attempt to satisfy patients to ensure these individuals remain on their patient lists (31). A study by Carlsen and Norheim (2003) indicates that GPs under the patient list system are less concerned with the gatekeeper role and more with providing better services to keep the patients (109). Several continuous studies by Iversen and Lurås, from 2000 to 2005, indicate that GPs with patient shortages likely provide more services per patient and have higher incomes per listed person (114, 115, 122, 123). Lurås (2007) found a negative association between patient shortage and patient satisfaction with general practitioners (124). A study by Kann et al. (2010) found that GPs prescribe 3% more reimbursement drugs in the areas with higher competition than in the areas with lower competition; a shortage of patients on GP lists also had impact. However, the longer the patient list, the lower the impact (125).

A study by Godager et al. (2015) suggests that competition has a small positive or negligible effect on overall referrals. The researchers did not support the policy claim that increased competition increases the number of the referrals. One arguments was that GPs earn more by treating the patients themselves (106). Supporting it, a newer study by Islam and Kjerstad (2017) found that intensified GP competition may reduce inpatient hospital admissions by inducing GPs to provide more services and may increase outpatient admissions (105).

### 3.3.3 GP switching

One way to increase competition between GPs in Norway is to allow patients to switch GPs, incentivizing the GPs to improve the quality of their services. This section describes patients' and GPs' characteristics regarding patients' preferences and reasons for switching.

A survey study by Billinghurst Whitfield (1993) about the reasons patients change to a GP indicated convenience as the most common reason (53%), followed by recommendation or reputation (36%) and positive expectation of service (37%) (126). The most common reasons to switch away from a GP was dissatisfaction with the doctor, such as loss of confidence, lack of interest in patients and their concerns or rudeness. Criticisms of practice organization were mainly focused on the lack of continuity, long wait lists and unhelpful receptionists (126).

Patients reported greater satisfaction with providers characterized with 'personal' care (64, 127-129). Patients also preferred GPs with observable characteristics similar to them, like age group and gender (130). Patients disenrolled less often from younger GPs and female GPs (124, 131).

In general, patients tended to switch more often from GPs who were already short on their number of patients (124, 132). However, patients without chronic diseases preferred GPs with shorter lists (more availability), while patients with chronic diseases preferred GPs with full lists (more popular and associated with higher disease detection) (131, 133-135).

Three groups of patients were found to switch GPs more frequently: patients belonging to racial and ethnic minority groups, those who use information to choose their physicians and those who switched physicians during the preceding five years because of dissatisfaction (136). Other factors influencing GP switching include sex, educational level, self-assessed health status and GP capacity at the municipality level. Older and wealthier patients switched their physicians less frequently than younger and less wealthy patients. Female patients and patients with chronic diseases, higher educational levels or fair or poor health tended to switch GPs more frequently than other patients (137).

A Japanese study indicated that chronic illness and patient-physician relationships are the main contributors to GP switching behaviour (138). Patients with chronic diseases visit their GPs frequently and are therefore well informed about healthcare quality. This pattern could be a further incentive to switch GPs if the patient is dissatisfied (the positive relationship between dissatisfaction with quality and GP switching is supported in (124, 139, 140)). However, this idea contradicts the theory that patients with chronic diseases experience higher costs, relative to those of other patients, when switching GPs and, therefore, are supposed to be less prone to changing their GPs. These costs include the cost of learning about new physicians, psychological costs resulting from disloyalty and costs related to uncertainty regarding the quality of untested brands (136, 137, 141).

Patients without chronic diseases use fewer healthcare services, are less informed about quality and benefit less from high-quality GPs than patients with chronic diseases. Therefore, these patients might be less concerned than patients with chronic diseases about the doctor they visit and less motivated to switch GPs (137).

# 4 Aims of the papers

## 4.1 Context of paper 1 and 2

The first and second studies are set in the context of the reimbursement change of 2008 for private and public radiology providers in Norway (described in the Section 2.3.2).

The reimbursement scheme was changed to keep spending on radiology within a certain budget and harmonize the financial scheme and system for financing outpatient medical services in Norway. Between 2005 and 2008, the ratio of ABF and block grants for radiology providers was approximately a 50/50 split and changed to a 40/60 split thereafter (13, 32). The new 40% ABF was intended to set spending limits by discouraging laboratories from exceeding contracted volumes (2, 13).

Both papers study the implications of the reimbursement change of 2008. Paper 1 investigates whether this reimbursement change supplements gatekeeping and involves service rationing to private radiology providers. Paper 2 examines the variation in the impact of the reimbursement change, depending on the difference in travel times to private and public providers in different municipalities.

These studies rely on existing research on the reimbursement changes for secondary healthcare providers (discussed in the previous chapter). While there is vast research on reimbursement changes for the hospitals, outpatient service providers do not benefit from the same attention. Papers 1 and 2 fill this gap. In addition to it, to my best knowledge, no other paper has studied this particular change.

### 4.2 Aims of Paper 1

Paper 1 studies the result of this reimbursement change and its connection to gatekeeping and competition in the GP market. The study relies on the existing research on (1) reimbursement changes and (2) GP competition and gatekeeping and contributes to the knowledge of whether reforms in reimbursement can contribute to the roles of GPs as gatekeepers.

**Information box 1**

The overall **objective of Paper 1** is to *determine whether the change in the revenue system for secondary care providers supplements gatekeeping mechanisms.*

The theory model argues how individuals are rationed and that individuals with least expected benefit are rationed first. Based on this theory model, we develop hypotheses.

The hypotheses are as follows:

1) With less FFS, we expect a reduction in the volume of radiology services performed by private providers
2) If post-2008 rationing occurred according to declining benefits, we would expect a greater reduction in number of examinations by private providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.
3) We hypothesize an increase in the number of examinations performed by public providers and a greater increase in number of examinations by public providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.
4) Because MRI examinations to a greater extent than the other modalities are located within the gray-area, we hypothesize a greater decline in the total number of MRI scans than for the other modalities and also a greater decline in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.

Table N1 in the appendix provides an overview of the aims and hypotheses for all three papers.

### 4.3 Aims of Paper 2

The number of radiology services varies within regions and municipalities. Understanding how this variation works and how it affects political and financial changes helps policymakers make more thorough decisions (Paper 2 (29)). Considering three factors is important. First, one of the policy goals in health care is greater geographical equitability in the range of services (51). Second, Norway's sparse population is unevenly distributed. Third, the distribution of private and public radiology providers is also uneven.

Paper 2 relies not only on the earlier research on financial incentives (described in the previous chapter) but also on research about geographical variation in the consumption of the health care services. Pedersen et al (2012) indicate that distance to the health care providers is an important factor for patients (142). McGrail et al (2015) suggest that geographical tolerance and the distances to providers affect the consumption of health care services because geographical tolerance differs between densely and sparsely populated communities (143). Residents from densely populated areas are less willing to travel to access a GP than residents from sparsely populated areas. For example, 41% of residents in sparsely settled communities were willing to travel for one hour to see a GP, while only 3% of residents from densely populated communities were willing to do the same (143). Research indicates that greater travel distances lead to reduced utilization of healthcare services (144-147). These two findings combined indicate that populations living greater distances from healthcare institutions visit these institutions less frequently but are willing to travel farther than those living in populated areas.

Moreover, research suggests that patients consume more services from nearby providers (31).

Paper 2's research fills a gap in the literature by studying relative distances to the private and public providers based on their institutional differences and differences in the reactions to the reimbursement change. This is an important topic in light of the priority in Norwegian health care to create greater geographical equitability in health care.

**Information box 2**

The overall **objective of Paper 2** is to *examine how the change in the remuneration system for radiology providers can contribute to a change in the radiology supply in different geographical regions, depending on the difference in the proximity of private and public radiology providers.*

The hypotheses are as follows:

1) There will be a larger decrease in the number of private services than public services based on the differences in their budget constraints.

2) The stream of patients who move between providers and the effect on the total number of services will be different depending on the difference in the proximity of private and public radiology providers. The changes at private, public and both providers will be following:

2A) Patients use private radiology more when these providers are relatively closer (i.e. *Time_difference* is negative or equal to zero), which means that, after 2008, the greatest reduction in the *Priv_Serv* will be in these areas. The reduction diminishes with the increase in *Time_difference*.

2B) The change for public providers consists of two effects. The first involves a reduction in the original public service users. The greater usage was before 2008, the greater the reduction in the number of services will become after 2008. In general, patients use public radiology more when these providers are closer (that is, when *Time_difference* is zero or positive). The second effect relates to users switching from private radiology. These patients are more likely to switch if they live closer to a public provider compared to a private provider (i.e. the greater the value of *Time_difference*). Depending on what effect is greater, the change will be positive, negative, or equal to zero.

2C) Since private providers are more affected, the greatest reduction in the total number of services occurs in the areas with negative *Time_difference*. This reduction will diminish with an increase in *Time_difference* because patients can more easily switch to a public provider.

### 4.4 Context and aims of paper 3

The third study relies on existing research for disenrollment patterns, and its connection to perceived quality and GP attributes. However, existing research does not cover the connection between disenrollment and patient list characteristics, except for list length. Paper 3 contributes to existing research by investigating how chronic patients' switching behaviour is connected to GP list composition, indirectly shedding light on the assessment of primary care quality. The aim was to investigate patterns of chronic patient disenrollment.

**Information box 3**

The overall **objective of Paper 3** is to *identify patterns in disenrollment among patients with chronic diseases because such patterns could indicate otherwise unobserved GP quality.*

The published version of the paper does not have a defined hypothesis. However, we proposed expectations, which functioned like hypotheses:

1) If patients switch between GPs until their demands are met, we expect these patients to be disproportionally distributed across GPs.

2) If disenrollment patterns of special groups of patients align with the pattern of other patient groups, then they might be used as quality indicators.

# 5 Discussion

## 5.1 Discussion of the data

Literature indicates many different approaches regarding data level choice. Most importantly, an appropriate data level, whether state, country, municipality or provider, depends on the research question (148-152). Thus, in this dissertation, I used several levels of data for the convenience of approaching research questions. An overview of the data and variables for all three studies is provided in the Table 2N in the appendix.

In the first paper the aim was to investigate whether the reimbursement change could complement gatekeeping, and thus, the choice fell on data on the GP level that most accessibly describe the GP market.

In the second paper, the aim was to examine how the proximity of the providers affects the number of services consumed in different municipalities after the reimbursement change, and as well to discuss whether the reimbursement change would contribute to or reduce geographical variation between municipalities and RHAs. Thus, I chose data on the municipality level. I could eventually use data on patient level to study characteristics of the patients as well. However, I did not have precise distances from the patients' homes to the health care providers, only the distances between the patients' municipalities to nearest private and public providers' municipalities. This limitation helped me to focus on the municipality level.

In the third paper, the aim was to study the connection between the patient's disenrollment choices and different characteristics of the GP's patient list. Thus, the most appropriate was to use data on patient and GP levels.

### 5.1.1 Paper 1

The study uses monthly claims data regarding private and public radiology services between 2007 and 2010 that were provided by the Norwegian Directorate of Health. Only examinations covered by NHI were included. Data were at the GP level, and information regarding both self-employed (95%) and salaried (5%) GPs were included. Claims data, data on GPs' characteristics and patient lists, and data on travel distances between municipalities of GPs and of providers were merged. Travel distance data was provided by Info Map Norway (153) and connected to our data through the municipality codes. After careful consideration, we decided to focus on self-employed GPs and remove salaried GPs since salaried GPs have the same salary regardless of the number of patients. We were left with 176,709 monthly observations of 4486 self-employed GPs. Our data covered the entire population of self-employed GPs who had contracts with municipalities in Norway.

The data provide information concerning consumption of radiology services according to modality (number of services consumed per 1,000 patients listed with the GP), which were our dependent variables.

For the main independent variables, we used two types of competition indicators based on the previous empirical literature.

The empirical literature provided two indicator types introduced first by Iversen and Lurås (2002) (and later used in Iversen and Ma (2011) and Godager et al. (2015)) (31, 106, 116). Iversen and Lurås called the first indicator a 'micro' indicator and labelled it 'Shortage'. Shortage was a dummy variable that indicated whether a GP needed more than 100 extra patients to complete his (her) desired list size (e.g., shortage = 1 if (desired list size – actual list size) > 100). The second indicator was called a 'macro' indicator and was labelled ‘Supply’. Supply characterized the municipality, indicating the ratio between the sum of the desired number of patients for all the GPs in the municipality and the population of that municipality.

Thus, in Paper 1, we used the micro indicator in the same way as previous research: as a dummy variable Shortage, where 1 indicates the GP needs more than 100 patients to complete his (her) desired list size. We found that approximately 19% of the GPs had more than 100 free spots on their lists.

Regarding the macro indicator, we made several modifications, which were also used in Iversen and Ma (2011) and Godager et al. (2015) (31, 106). Overall, we used two types of macro indicators: number of open practices (#Open) and number of open practices relative to population size (#Open/Capita).

We also used several variables describing the GPs and their patient lists as control variables because these variables often influence the GPs’ practice styles. For example, GPs who have more women on their lists would issue referrals more often connected to childbirth, prenatal, and postnatal periods than GPs without many female patients. Likewise, if an area has excess capacity among GPs, the referral rate might increase (31, 106). We used the following control variables for GP-patient characteristics: GP’s age and sex, GP’s specialization status, the GP’s share of female patients and patients over 70, the presence or absence of patient shortage and GP’s municipality (Table 1 in Paper 1 provide more details). We also controlled for travel time to the closest private and public providers. Table N2 in the appendix provides an overview of the data and methods for all three papers.

### 5.1.2 Paper 2

The second study used the same data set as the first study (claims data regarding private and public radiology services between 2007 and 2010 that the Norwegian Directorate of Health provided us, merged with GP data (both salaried and self-employed) and with the data on travel time between municipalities of patients and providers (provided by Info Map Norway (153)). This time, I aggregated all the claims at the municipality level (I removed GP characteristics data, as there was no use for them in the second study and left only the data on the municipality level, like centrality, region, distances and service consumption). I was left with 422 municipalities in 48 periods (monthly observations during 2007 to 2010), totalling 19,867 observations. Stratified summary statistics are displayed in Table 1 in Paper 2.

I used the monthly number of private and public radiology consultations per 1,000 individuals in the municipality as the dependent variable. This variable was calculated by accumulating services referred to and claimed in every municipality. Thus, if a patient from Municipality A went to take X-rays in Municipality B, the service was classified as a service to Municipality A.

The main independent variable for the regression analysis was *Time_difference*: *Time_difference* = *Privtime* – *Pubtime* (i.e., the difference between travel times to the nearest private and public providers). Travel times were measured as the travel time by car between the patient's municipality and the municipality of each type of provider in hours. Thus, if the patient had a private provider in his (her) own municipality, *Privtime* was set to zero. If the patient had the public provider in another municipality a half an hour drive away, *Pubtime* was set to 0.5 hours. In this example, *Time_difference* = 0 - 0.5 = -0.5 hours.

To choose main independent variable was not easy. I considered and tried several options: 1) Using discrete intervals for travel times. I was attracted to this option because I could study different combinations of distances. However, there were two difficulties with this choice: choosing the thresholds for the periods and interpreting the analysis was confusing; 2) Using *Pubtime* or *Privtime*. This option had a simple interpretation. However, from earlier studies, I already knew that the closest providers are the most used ones. In addition, this option was not suitable for researching importance of relative proximity of providers (i.e. which provider is closer affects outcome too); 3) Using *Time_difference.* It was chosen to be main independent variable used in the regression analysis, because when deciding between private or public providers in the settings of unevenly distributed providers, patients often choose the more available provider in terms of proximity and, since private and public providers have different institutional settings, it affects outcome. Thus, according to the aims of the study, using *Time_difference* gave the clearest interpretation of the regression results. 4) Using *Time_difference* and one of the travel times (*Pubtime* or *Privtime*). This option was appealing but lead to confusion with regard to interpretation because *Time_difference* already included both *Pubtime* and *Privtime*. Thus, option 3) was used and the main independent variable for the regression analysis became *Time_difference*.

I complemented the analysis with stratified summary statistics and calculations over variation change, using municipalities' characteristics, such as centrality and the health region they belonged to. The *Centrality* variable was constructed by Statistics Norway and indicates how central the municipality is, where 1 is the smallest and most remote municipality and 7 are regional centres with well-developed infrastructures (154). Thus, this variable indicates, first, the level of infrastructure development (i.e., ease of access to care) and, second, the municipality size and, thus, whether there is a choice of providers. Some literature indicates that the patients in the most densely populated areas visit health care providers more often than patients in the least populated areas, but patients from sparsely populated areas are willing to travel longer distances (143). Therefore, *Centrality* might be correlated with patients' willingness to travel. *Regions 1* through *4* are dummy variables describing whether the municipality belongs to South East (1), West (2), Central (3) or North (4) Regional Health Authorities.

### 5.1.3 Paper 3

The third study used a different dataset, consisting of combined panel data for six semiannual periods between 2009 and 2011, merged using the GPs' IDs: GP data (national register of regular GPs, covering the entire GP population) and patient data (claims data obtained from the KUHR registry (Kontroll og Utbetaling av Helse Refusjon) covering the entire Norwegian patient population). Figure 3 presents a flow diagram of the data and sample selection (155).

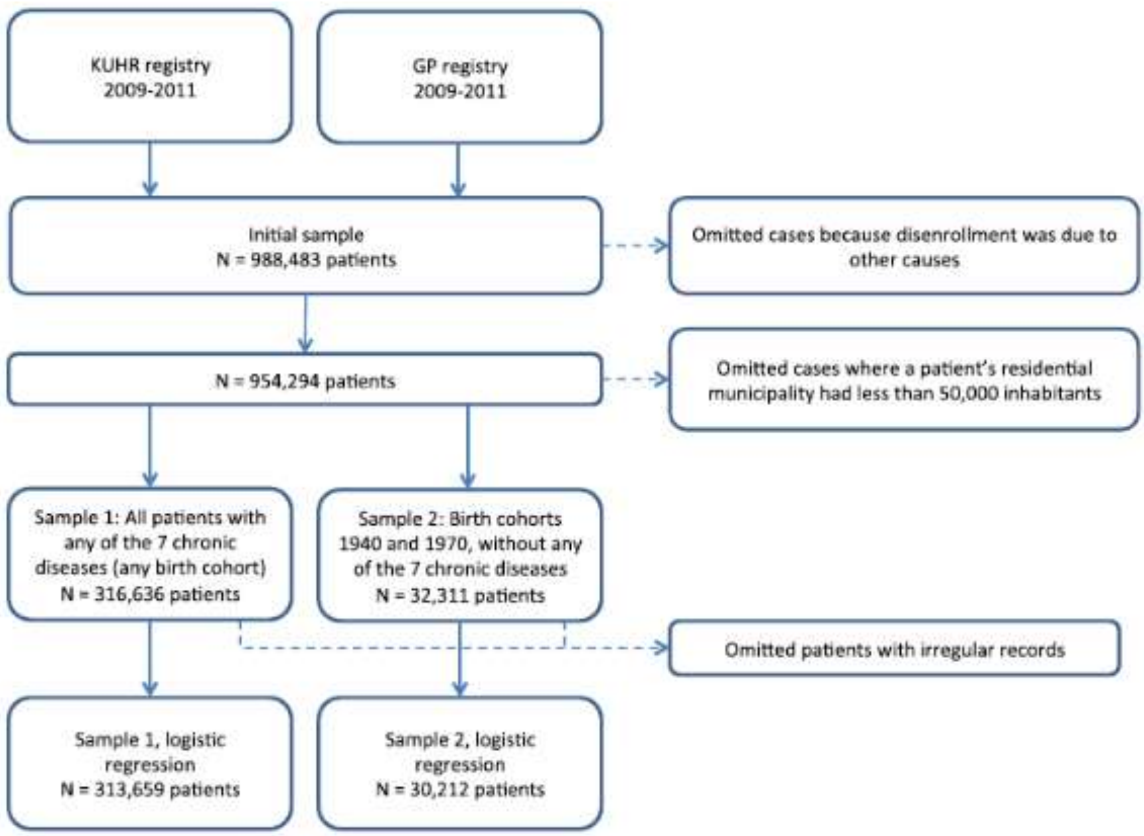


Figure 3. Flow diagram of sample selection in Paper 3 (155)

In general, we chose to focus on the choices of chronically ill patients because they need continuous follow up and their GP preferences might reveal unobservable characteristics of GPs. We had seven patient groups: type 1 diabetes (DT1), type 2 diabetes (DT2), asthma, arthritis, schizophrenia, depression and epilepsy. These patient groups were chosen due to their variation both in represented numbers of patients and in utilization of healthcare. We used two samples. Sample 1 included patients with at least one of the mentioned diagnoses; Sample 2 included a comparison group containing the entire cohorts of patients born in 1940 and 1970, excluding patients in Sample 1 (see more in Table N2 and Figure 3). Thus, after excluding cases in which disenrollment was irrelevant to our study purposes (for instance, connected to a GP's or patient's move or GP's replacement) and cases in which patients were from municipalities with less than 50,000 inhabitants (i.e., without a wide choice of GPs), we were left with 313,659 patients in Sample 1 and 30,212 patients in Sample 2 (343,871 in total).

We are aware that the present comparison group gives different age distribution from the treatment group. It would have being ideal to use all cohorts or a random sample of these as a comparison group. However, due to privacy concerns from the registers, we could not access all the data. Alternatively, using only Sample 2 and splitting it would give us too few observations of chronic patients. Nevertheless, our samples were rich and contained all the patients registered with the chosen chronic diseases in Norway (Sample 1). While in Sample 2, cohort 1970 represented a random sample of young adults and cohort 1940 represented a random sample of elder adults.

The main dependent variable was *Switch out*, a dummy variable that indicated a patient switched GPs from one semi-annual period to another. In our data, 4.52% of patients in Sample 1 (chronic patients) and 3.76% in Sample 2 (comparison group) switched GPs between the first and second halves of 2009 (see Table 2 in Paper 3 (155)).

The independent variables include information about the GPs' age, sex, specialization, and list length and patients' sex, birth year, and number of visits, as these variables may affect a GP's practice profile and a patient's preferences. These variables were chosen because earlier research indicated their importance for patient-GP relationships (130, 131, 133-135, 137, 138).

Table 1 in Paper 3 provides descriptive statistics on the patient level, where GP's characteristics denote the characteristics of the GPs with which particular groups of patients (e.g., DT1, DT2) are enrolled. (155)

In addition, we created a control variable *Pat_Comorb*, indicating number of the patients' comorbidities (0 to 6). For this variable, we counted how many of the remaining six diagnoses the patient had. Earlier research indicates that number of comorbidities is an important variable because it underlines the importance of appropriate management of chronic conditions and care coordination since those conditions often must be addressed by different specialists (136, 156, 157).

The variable *Diagnosis_Share* (where *diagnosis* is any of the seven diagnoses from the list; see Table 1 in Paper 3) was the main research variable. This variable indicated the share of patients with certain chronic diagnoses on the GP's list from each patient's perspective (i.e., for every GP-patient pair, we excluded the patient when calculating the GP's share). The other possibility was to calculate this figure from the GP's perspective, i.e. to find the share of the patients with a certain diagnosis from the total number of patients.

For example, a patient with epilepsy, which is a rare diagnosis, might be the only epileptic patient enrolled with a GP who has 100 patients on her list. From the GP's perspective, the share of patients with epilepsy is 1%, but this figure is of little relevance to the patient because, besides him, there are no other epilepsy patients on that list. Thus, from this patient's perspective, the share of other epilepsy patients on his GP's list is zero.

In the data analysis, we used patient level data, and therefore, we chose the patient's perspective to calculate this variable. A potential limitation is that the same GP might have been registered with different values for *Diagnosis_share*, depending on the diagnoses of the patient we examined. Thus, the values for *Diagnosis_share* could vary in the entries for the Sample 1, while for Sample 2, these values would be identical for identical GPs.

## 5.2. Discussion of the methods

### 5.2.1 Paper 1

In this section, I chronologically present and discuss the methods used in each study. The overview of all three papers' methods is displayed in Table 2N for easier understanding.

In Paper 1, in the regression analysis, we employed the fixed effect model with GP competition variables at the municipality level: #Open and #Open/capita. We performed regressions for all modalities combined and for each type of modality. Since many GPs in the same municipalities and hospital catchment areas communicated on formal and informal levels, their practice profiles could have been correlated. Therefore, to calculate standard errors, we clustered them by hospital catchment areas (21 areas) and checked for robustness by changing the cluster level to that of municipalities (395), changing weights from populations of municipalities to patient lists, and then dropping weights entirely.

I had a few considerations about weighing since robustness check showed some variation in the results. In general, the weighting gave the observations with smaller variance more weight because these observations provided more accurate information than those with large variation. However, since we used clusters on a group level, the weighting could have reduced precision. This reduction can occur when the group average effect is large and fairly homoscedastistic. In this case, weighting can impose heteroscedasticity and unnecessarily increase standard errors (158, 159). Thus, using weighting might not have been efficient for our model specification. The other thought was given to types of weights: first, municipality population, then GP's list length and then no weights at all. The model specification with #Open/capita included municipality population. To obtain a result by weighting municipality population increases precision in this particular model specification. Therefore, using other weights or no weights on this specification would naturally reduce precision.

### 5.2.2 Paper 2

Paper 2 employs several approaches to demonstrate geographical variation in the provision of radiology services and the reaction of radiology providers to the reimbursement change.

First, the paper presented stratified summary statistics for the number of services at private and public radiology providers and time difference before and after 2008 (12 month before and 36 month after) according to (1) centrality and (2) to RHAs (see Tables 1BC in Paper 2).

Second, the study presented fixed effect linear regression estimations (see Table 2 in Paper 2). The fixed effect model was based on standard assumptions that the errors were uncorrelated with the independent variables and that the errors were conditionally homoscedastic and not serially correlated (160). I expected that the relationship between the number of the services and the time difference might not be linear because patients have different consumption patterns with regard to different distances to providers and their own centrality (143-147). After trying several polynomial functions, I chose a quadratic function. I estimated three regressions for number of services at private, public and both private and public providers. I also considered the random effect model, but after testing it against the fixed effect model with Hausman test, I chose the fixed effect model. I could have also tried clustering the variables by hospital catchment areas for a robustness check, to control whether the municipalities had certain common policy programs or other traits shared in the hospital catchment areas. Also, controlling for life expectancy and socio-economic factors in the municipalities may have been beneficial since, in Norway, there is up to 10 to 12 years difference in life expectancy between men living in municipalities with the highest and lowest life expectancies, and much of this difference is due to variations in education, living standards, income, institutions (schools, workplaces) and proximity to natural resources (161). However, during this short time span, these characteristics were included in municipality fixed effects.

Last, the study presents a numeric analysis to measure the variation between different centralities and RHAs before and after 2008, based on the stratified summary statistics using 'mean value range'. A limitation of the method is that I did not consider the entire distribution of the radiology services. This method is not sophisticated, but it illuminates change in the variation. The method was inspired by 'observations range', or the difference between the highest and lowest observations. Observations range is easy to compute and understand, but it ignores all but two of observations, does not weight observations and is skewed by outliers (162-164). Mean value range, however, includes all the variables in the measure and is still easy to compute and understand and it describes change in the variation between centralities and RHAs.[6]

[6] Other popular measures under consideration were range ratio, the coefficient of variation and the Gini coefficient. However, they were ruled out because they were more difficult to interpret in the study's context.

### 5.2.3 Paper 3

We used both graphical and statistical analyses for Paper 3. First, we used graphs to analyse whether the distributions of the patients with chronic diseases were disproportionate across GPs. To accomplish this analysis, we used GP level data for the first quarter of 2009 and examined the proportion of patients with a particular diagnosis and a 95% confidence interval (we did the same procedure for every diagnosis, but illustrated it for DT2 in the paper).

To explain the results of the distribution, we subsequently calculated Spearman's correlation coefficients between GPs' characteristics (age, sex, list length, specialist status) and shares of patients with different diagnoses. We used data on GP level for the first quarter of 2009 (Table 4 in Paper 3).

We also calculated proportions for comorbidities (i.e., the probability of having one more chronic diagnoses when a patient already has a certain chronic diagnosis). We used patient level data for the first half of 2009 (Table 3 in Paper 3).

Finally, we performed a random effect (RE) logistic regression analysis of voluntary disenrollment for each diagnosis subsample (from Sample 1) and for the control cohorts (Sample 2) (for an overview of the random effect logistic regression method see (165, 166)). We used standard assumptions for a random model that patient specific effects were normally distributed and not correlated with independent variables. There we used the data on patient level described in Table 1 in Paper 3. We focused on patients in municipalities with more than 50,000 inhabitants, to make sure that patients have a sufficient choice of GPs.

We also considered other options for the regression analysis. First, we considered the fixed effect model, which allows patient-specific effects to be non-normally distributed or correlated with independent variables. Testing this model against the RE model with the Hausman test indicated that we could use the RE model. In addition, the RE model allowed us to include such time invariant variables as sex and birth year, which would have been excluded in the fixed effect model.

Second, we could have used multilevel mixed effects logit regression by clustering patients with GPs and GPs with municipalities (160). Thus, we could account for hierarchy in data, which could help us explore whether the clustering of different types of chronic patients could be ascribed to a GP effect or a municipality effect. This knowledge could have helped us determine whether clusters of patients with particular diagnoses were due to specific characteristics of the GPs (unobservable GP qualities) or of the municipalities (for example, certain policies, funding or educational programs or certain age distribution in population or particular climate that made the population more prone to certain diseases).

## 5.3 Discussion of the results

### 5.3.1 Paper 1

*5.3.1.1 Results*

The first study's result indicate that the number of private radiology services reduced after 2008, while the number of public services either stayed the same or increased (in accordance with Hypothesis 1 and 3). Figure 3 illustrates the averages of referrals to private and public laboratories by self-employed GPs, with monthly fluctuations due to seasonal variations. In addition, high referral rates and competition levels observed prior to 2008 indicate a larger reduction in private examinations conducted after 2008 (in accordance with Hypothesis 2). At the aggregate level, we are not able to reject that the total reduction in the number of investigations is unchanged irrespective of the level of competition (Paper 1 (29)).

Examination rates were also analysed according to modality (see Table 4 in Paper 1). The results suggest that for all modalities other than ultrasound, the absolute value of the reduction in the rate of examinations performed by private providers increased with increases in competition between GPs; in addition, a competition-dependent reduction was observed in the total number of MRI services (supporting Hypothesis 4).

Regarding the other variables, shortage of the patients, and higher proportion of elderly and female population are correlated with an increase in the number of the services for both providers. Variables reflecting travel distance to providers exerted a significant effect on examination rates in the first study. Greater travel distances to providers are associated with a lower number of services (i.e. increased distance to the nearest public provider reduces the use of that public provider; this result was also found for private providers). Increased distance to a private provider increases the use of a public provider, and vice versa. A summary of all three papers' results is also presented in Table N3 to provide an easier overview.

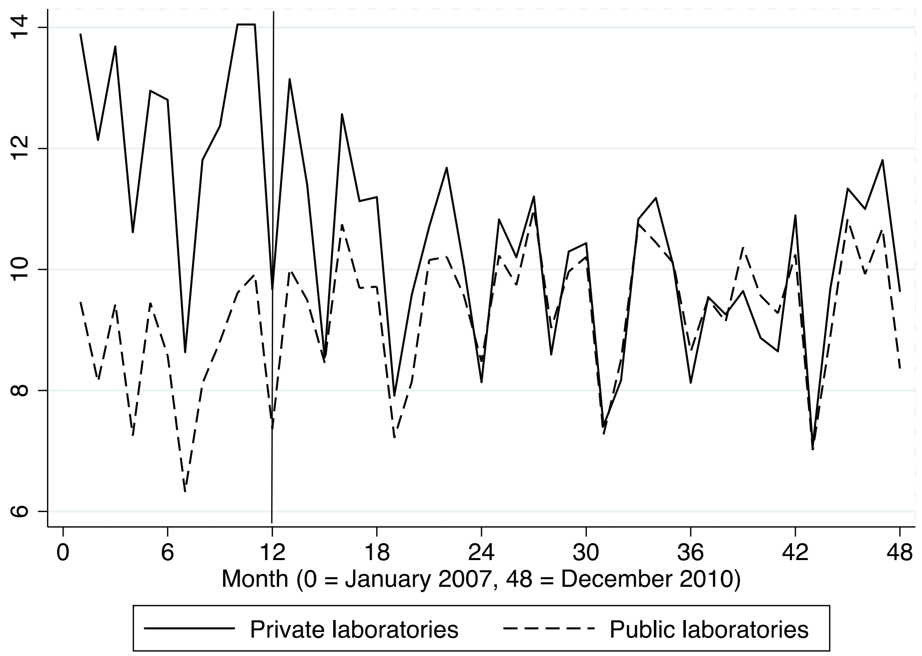


Figure 3. Referrals to private and public laboratories by self-employed GPs: Monthly average examination rates per 1,000 listed patients (vertical axis) and months from January 2007 to December 2010 (horizontal axis). Source: Paper 1

**Information box 4: Results of Paper 1**

1) The number of private radiology services reduced after 2008, while the number of public services either stayed the same or increased.
2) A greater reduction in the number of examinations by private providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.
3) The hypothesis was not supported for total (private and public together) numbers, indicating a greater flow of patients from private to public providers in the most competitive areas.
4) The hypothesis was, however, supported for the MRI services, indicating a reduction in the highly competitive areas for private and public providers together.

Thus, regarding policy implications, the revenue system has the potential to be supplemented for gatekeeping for certain types of treatments and when the providers face hard budget constraints. In this case, the result is valid for MRI (29).

*5.3.1.2 Discussion of the results*

**5.3.1.2.1 Rationing**

The first results in Paper 1 indicated that the number of private and public radiology examinations after the reimbursement change decreased and increased, respectively. We find a greater reduction in the number of examinations by private providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs. The overall effect was inconclusive. The results of the competition indicators for overall rates suggest an increase in the number of examinations performed by public providers compensated for the reduction in the number of examinations performed by private providers, and competition did not exert a negative effect on total examination rates. In other words, public providers performed some of the examinations that had previously been performed by private providers in areas with high competition levels. The result underlines the importance of hard budget constraints for reimbursement changes to have effect. This implication could have been more clearly spelled out in the paper.

In regard to rationing, the results with the exemption on MRI suggest that rationing by private providers does not necessarily carry over to rationing in the system as a whole. It is not necessarily efficient for public providers to examine excess referrals previously made in high competition areas at private providers.

**5.3.1.2.2 Modalities**

When examination rates in the first study were analysed according to modality (see Table 4 in Paper 1), only MRIs had an overall reduction in areas with high levels of competition between GPs, indicating the rationing of patients with low expected benefit. MRI is considered a grey area of healthcare services, since MRIs have less clear indications, implying discretionary referrals; it is also called supply sensitive care (167). Regarding other services, we found that patients shifted from private to public providers, but the average number of services was constant.

This result could indicate that when outpatient care is set under the constraint, only services in the grey area of medicine with the least clear indications are rationed. We should also take into consideration that there is a higher threshold for both providers and patients to engage in MRI diagnostics than in the rest of the modalities due to several reasons. For example, MRI services are the most expensive radiology services in terms of the provider's resources (i.e., marginal costs are highest). They also are most resource taking for the patients: patients have to spend time in the device and not all the patients can tolerate it. Furthermore, wait lines for MRI are longest (168-170). Therefore, MRI's high marginal costs might be a reason that MRI services were cut for both providers after the change in the reimbursement.

Table 4 in Paper 1 also illustrates that X-rays and CAT scans shifted in the market from private to public providers, while ultrasound, the cheapest of all the modalities and an established diagnostic, did not have a significant effect on the competition variables. With regard to ultrasound, the reimbursement price may still be larger than the marginal costs for this service because ultrasound does not require as many resources from the provider as the rest of the modalities. Although the price reduction was an equal percentage for all modalities, it might have not reached the marginal costs for ultrasound.

#### 5.3.1.2.3 Gatekeeping

Gatekeeping both saves on costs, preventing unnecessary public spending, and prevents the use of unnecessary specialist health services, thus preventing overtreatment.

Paper 1 studied gatekeeping only from the perspective of preventing unnecessary spending. To research overall overtreatment and undertreatment, we needed data on all the services, including private health insurance and out of pocket payments. Since the wait lines are long, there is a reason to believe that some of the patients from GP competitive areas might appeal to private health insurance or pay directly. Therefore, the overall conclusion is that although the change in the payment system for specialist providers might serve to ration and/or strengthen gatekeeping in the sense of the preventing unnecessary spending, it mostly affects the cases in which providers have hard budget constraints, services are highly supply sensitive ('grey zone') or marginal costs are high relative to price of the reimbursement. Although the study is inconclusive about overall undertreatment and overtreatment, the results suggests MRI overtreatment might have occurred before 2008.

#### 5.3.1.2.4 Other findings

The results of robustness check using weighting indicated that the competition indicators might provide different information depending on specification. During changes in weighting, we observed that the results were still valid for #Open, but the significance changed for #Open/capita, which should be considered.

The variation in significance indicated some heteroscedasticity, as well as that we might pay more attention to the results of the regression, where we used '#open' as competition indicator because it gave the same results across all the regression with and without weighting.

The distance results are not surprising: increased distance to the provider contributed to greater reduction in number of services by the provider. This finding supports earlier research that nearby providers are used more frequently than distant providers (31, 144-

147). I discuss the question of distances in more detail in Paper 2's discussion of the results.

### 5.3.2 Paper 2

*5.3.2.1 Results*

The second study contributed results on the geographical variation in the provision of radiology services after the 2008 reimbursement change.

After the change, private services were reduced from 9.59 to 8 services per 1000 inhabitants per municipality, while public services increased from 24.35 to 26.16 nationally. However, the stratified statistics before and after the change are of the most interest: the services changed unevenly in different centralities and different health regions. For example, after the reimbursement change, total services stayed basically the same in South East and North RHA, dropped by one in West RHA, and increased by 2.5 in Central RHA.

The regression analysis indicates that patients received fewer services from the private providers in 2008 through 2010 than in 2007 (in accordance with Hypothesis 1). First, in accordance to Hypothesis 2A the number of services was reduced more for negative values of *Time_difference* (where private providers are closer than public), with a diminishing reduction until *Time_difference* equalled 10 hours. Second, patients received more services at public providers along with an increase in *Time_difference* in accordance with Hypothesis 2B indicating that there were more patients switching to public providers than patients rationed from public providers. Third, total number of services reduced for the patients in the municipalities where *Time_difference* less than 40 minutes and increased along with *Time_difference* for municipalities characterized by *Time_difference* greater than 40 minutes. Thus, hypothesis 2C was partially supported, with the only difference in the threshold: I was expecting that the reduction would occur at negative *Time_difference*, while it lasted until *Time_difference* equalled 40 minutes.

Variation range in the number of services between different centralities (i.e., 'sizes of municipalities') was reduced by approximately 52% after 2008. The largest municipalities with the top centrality notably were not the greatest consumers of radiology services per capita as expected; instead, they are average. The greatest variation came from the small- and middle-sized municipalities. However, the variation range between different RHAs increased by approximately 20% after 2008. In the Central RHA, the total number of radiology services at both providers increased from 32 to 35, while in the West RHA, the number reduced from 31 to 30.

**Information box 5. Results of Paper 2**

I. After the 2008 reimbursement change, patients received fewer services at private providers and more services at public providers (Hypothesis 1).
    a. Private services reduced more for negative values of time difference, diminishing in reduction until *Time_difference* was around 10 hours (Hypothesis 2A),
    b. Public services increased with an increase in *Time_difference*. This result indicates that the stream of the patients switching from private to public providers is greater than the reduction in public services due to reimbursement change (Hypothesis 2B),

c. Total services reduced for *Time_difference* below 40 minutes and increased for *Time_difference* above 40 minutes (Hypothesis 2C).

II. Variation between different centralities reduced by 51.8% and between different RHAs increased by 19.5%.

*5.3.2.2 Discussion of the results*

**5.3.2.2.1 Effect of the distances**

The reimbursement change had different implications for the number of supplied services to the municipalities depending on the relative distance to the provider. When the 2008 reimbursement changes took effect, private providers offered fewer services, and many patients chose to switch to the relatively more accessible public providers. Patients who had private and public providers in similar proximity switched more frequently from private to public providers. Approximately 30% of municipalities had either both providers within the municipality itself or at an equally close distance; the total population of these municipalities was around 52% (124 municipalities with average populations of 19,500 people, ranging from 345 to 573,000 people) of the sample and included the largest cities, such as for example Oslo, Tromsø, Bergen.

In the municipalities where there were only private providers nearby, the patients did not have the same opportunity to switch to public providers to compensate for the private providers' reduced offers. Thus, those municipalities had the greatest reductions in the number of total services. It concerned not a large percent of population, just 5% of municipalities with 6% of the Norwegian population. However, this total still consists of approximately 280,000 people (21 municipalities with average populations of 13,000 people, ranging from 2500 to 45,000).

In areas where patients had public providers relatively close, the least change in the number of services after 2008 occurred. In addition, patients switched from private to public providers even more in these areas. The total population of this group is around 42% of the total Norwegian population.

#### 5.3.2.2.2 A need for further research about equity and equality

Some potential issues with regard to the effects of the reimbursement change should be investigated further. First, initially, private providers were supposed to help public providers share the patient load, but after the change, that role diminished, and public providers serviced patients previously served by the private sector. Thus, investigating the optimal workload for both types of providers would be useful because optimal distribution could contribute to the most efficient work for the public and private sectors, and thus shorter wait times.

Second, it would be useful to further examine what kind of patients were rationed in the areas with the greatest reductions in the total number of services and determine whether those were indeed the patients with the least expected benefit (with reference to Paper 1). In connection, we should discuss equity and equality for health care and social inequality. A study by Grasdal and Monstad (2011) distinguishes between inequality and inequity. 'While inequality simply refers to whether there is a correlation between a person's use of services and the person's ranking in the income distribution, inequity on the other hand takes into account individual need for treatment' (p 4 of 12 (171)). For example, smaller municipalities might have greater percent of elderly people compared to the municipalities with universities that attract younger people, and thus these municipalities would have different needs in radiology services.

Hence, it would be valuable to research whether the reform contributed to the general equity in healthcare access (i.e., whether it increased number of the services in areas with underused services and reduced the number of services in areas of overuse) (172). Therefore, to determine the type of patients who were rationed in the areas with the greatest reduction, we would need data on income distribution, individual need for treatment, age distribution, and number of services paid out of pocket or by insurance, mortality and emergency room visits at the municipality level, which we did not have.

Another limitation in our research was that we did not have patient level data on incomes and education levels of patients. Controlling for these variables would be useful since earlier research suggests that patients' use of health care is connected to their income (171), and research conducted by the Ministry of Health and Care Services indicates that social inequality correlates with differences in health status, life expectancy and place of residence (51).

#### 5.3.2.2.3 Regional variation

In addition to population characteristics, the variation between RHAs could arise from the difference in the composition of municipalities in each RHA with respect to the municipality's size, centrality and distribution of the providers, as well as supply side variation. Regional variation might origin from the demand and supply sides (173). Regional variation might come from the patient demand due to possible heterogeneity of the patients toward care. If the people who demand more treatments tend to live in the same areas, regional variation could occur (174-176). From the supply side, regional variation could be due to supplier induced demand, or overprescription of the treatment by physicians in order to gain more income. This variation could also arise as a response to organizational pressure to treat patients more intensively, especially for conditions with fewer guidelines (173, 177). Physicians clustering together, by working for the same clinic, for example, could create regional variation in beliefs (173). It is difficult to identify factors for regional differences (178), but some research indicates that half of differences are attributed to demand and half to supply (179). Cutler et al. (2019) suggests that although physician organizational factors matter, the most important factor is the physician believes about treatment, and demand side explains much less of total spending (173). In the supply side, financial considerations meant little, while pressure to accommodate either patient or the referring expectation to keep patients happy had a modest but significant relationship with physician beliefs about appropriate care. The greatest variation was due to physician's believes about efficacy of particular therapies (173). Thus to pinpoint the origins in the variation of radiology provision we would need to research further.

### 5.3.3 Paper 3

*5.3.3.1 Results*

The third study produced four types of results. First, Figure 4 (155) presents a scatter plot of GPs' proportions of DT2 patients, patient-list lengths (blue dots) and 95% interval curves (red lines), assuming patient allocation purely by chance. It indicates that patients were not allocated purely by chance (in accordance with expectation 1 in section 4.4). If they had been allocated randomly, 95% of the blue dots would have been positioned within the 95% confidence intervals (red lines). However, only 46.5% of the dots are positioned within these lines.

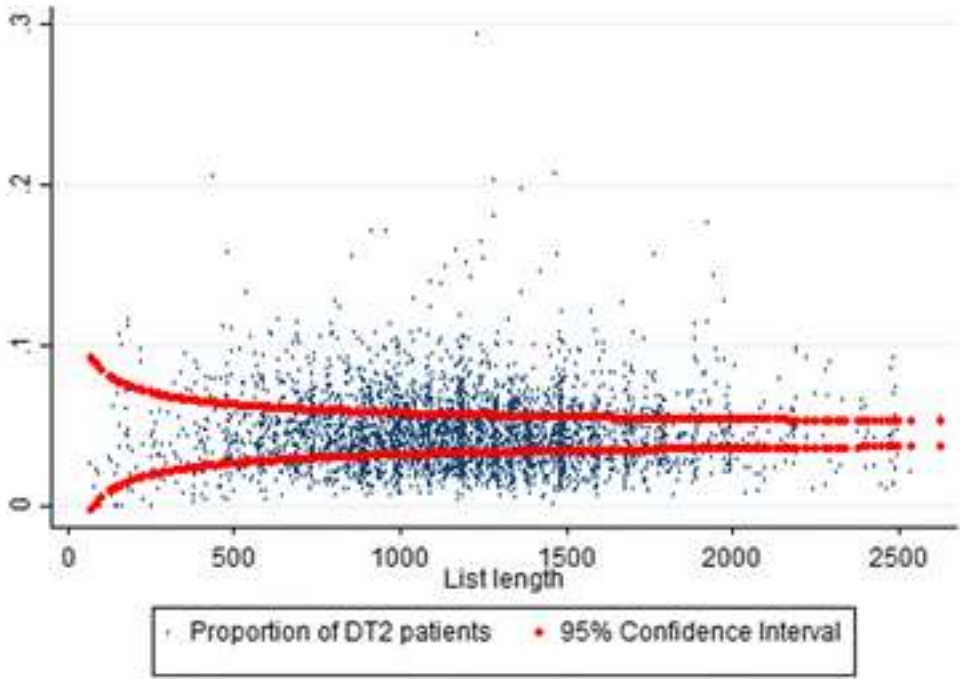


Figure 4. Scatter plot of GP proportion of DT2 patients and patient list length. Legend: Y-axis percent of DT2 patients, X-axis patient-list length. GP level, data for the first quarter of year 2009, $N = 3{,}965$, mean proportion of DT2 patients = 0.045, patient-list lengths of > 60 (Source: Figure 2 in Paper 3 (155)).

Second, regarding comorbidity, a large proportion of patients had at least two chronic conditions. For example, 13.5% of patients with DT2 and 28.7% of patients with schizophrenia had comorbid depression.

Third, the results provide information on correlations between variables. GPs' shares of patients with chronic diseases are positively correlated. This indicates that the majority of GPs have clusters of patients with chronic diseases (in accordance with expectation 1 in section 4.4). Shares of asthma, DT2, epilepsy and schizophrenia are negatively correlated with GP list length. Additionally, GP age and gender (male) were positively correlated with the seven chronic patient groups and negatively correlated with other patients.

Fourth, using logistic regressions, we found a pattern for patient GP disenrollment. Patients with chronic diseases who frequently used primary care (diagnosed with DT2, arthritis, asthma or depression) tended not to disenroll from GPs with large shares of patients with the same diagnosis. This tendency was not observed in patients who infrequently used primary care and frequently used secondary care (those diagnosed with DT1, schizophrenia or epilepsy). General practitioners with large shares of arthritis, asthma or depression patients were more popular in most patient groups (including patients without chronic diseases) (in accordance with expectation 2 in section 4.4). Patients without chronic diseases tended to be listed with GPs who had fewer patients with chronic diseases. This patient group contained a higher number of younger, male patients who used primary care less frequently than the group of patients with chronic diseases. These patients tended not to disenroll from younger GPs or those with specialist degrees in general medicine, longer patient lists or larger shares of arthritis patients. Older patients and patients who infrequently used primary care switch GPs less frequently than patients with chronic diseases.

All patients (with and without chronic diseases) tended to disenroll less from younger GPs or GPs with specialist degrees, longer patient lists or larger shares of arthritis patients (valid for the majority of chronic diagnoses) relative to other GPs. Moreover, men and older patients tended to disenroll less from their GPs. However, patients who visited their GPs frequently tended to disenroll more often.

**Information box 6. Results of Paper 3**

1. Patients with chronic diagnoses were not allocated to GPs purely by chance (Expectation 1).
2. Patients with chronic diseases who used primary care frequently (diagnosed with DT2, arthritis, asthma or depression) tended not to disenroll from GPs with large shares of patients with the same diagnosis.
3. General practitioners with large shares of arthritis, asthma or depression patients were more popular in most patient groups (including patients without chronic diseases) (Expectation 2)
4. Patients without chronic diseases tended to be listed with GPs who had fewer patients with chronic diseases.

*5.3.3.2 Discussion of the results*

**5.3.3.2.1 Quality indicators**

The results indicated that all patient groups tend to disenroll less frequent from GPs with larger shares of arthritis, asthma and depression patients than from other GPs. The fact that patients with arthritis, asthma and depression disenroll less from GPs with a high share of these patients might be due to particular characteristics of GPs who seems to specialize in those diseases. However, why other patient groups and patients without chronic diagnoses disenroll less from GPs with larger shares of arthritis, asthma and depression patients than from other GPs should be considered. In this and next subsection, I discuss the quality indicators and geographical clustering.

One reason patient preferences might align is unobservable qualities of GPs. Greater shares of patients with arthritis, asthma or depression may be indicators of more empathic GPs who are better communicators or diagnosticians, and thus more patients stay with them. We consider this possibility an indication of better quality GP care.

However, to validate the idea as a quality indicator, we would need to compare the results with existing quality indicators. There is extensive literature on quality indicators both in form of research articles and national guidelines.

Campbell et al. (2002) discusses research methods used in developing and applying quality indicators in primary care (180). A quality indicator is a measurable element of practice performance for which there is evidence or consensus that the element can be used to assess quality (180, 181). The researchers point out that when developing quality indicators, three issues are important. First is which stakeholder perspective the indicator is intended to reflect. Patient, caregivers, managers and professionals all have different perspectives that might not overlap (182-184). Health professionals often wish to follow guidelines, health outcomes and efficiency, while patients focus more on clinical performance, an understanding attitude and communication skills. In contrast, managers' pay more attention to data on efficiency, patient satisfaction, accessibility of care and outcomes. Second, the aspect of care, processes or outcomes, should be determined (185, 186). Outcomes such as mortality, morbidity, health status, health-related quality of life and patient satisfaction could be measured with indexes or with surveys (187), whereas structural indicators inform about practice organization, for example, personnel, availability of appointments or parking. Process indicators describe medical care (e.g., diagnoses, treatments, referrals, prescriptions). A few examples may illustrate: first, for a diabetic patient whose feet are at risk, such an indicator would be whether he (she) was referred to a chiropodist (188); second, for patients generally an indicator of good preventative care would be low number of emergency visits or hospital stays (189); third, number of health checks performed by physician for patients to reduce risk of life style diseases (190). The third issue is information on structure, process or outcome where indicators are underpinned by evidence (i.e., how the indicators work and are applied in practice (180)).

Similarly, the Norwegian Directorate of Health suggests a few quality indicators that patients can use when choosing a care provider, for example, to what extent the provider follows treatment guidelines, whether the patient rights are met and whether the users are satisfied (6). Like Campbell's, the directorate's indicators are divided into three groups: (1) structural (e.g., frames and resources, expertise, available equipment, records), (2) process (activities in the patient course, such as diagnostics and treatment), (3) performance indicators (e.g., survival, health benefits, satisfaction) (4, 6). These indicators should be still interpreted with care. For example, mortality could indicate a poor treatment site or a site with best experts and thus the most severely ill patients are referred there (6).

An interesting question is what indirect indicators could be used to underpin high quality. A study from 2018 about patients with DT2 found that GPs' specialization in General Practice, being graduate from Western Europe, being female were correlated with delivery of better care to DT2 patients by performing the recommended procedures more often and keeping better blood values (191).

Earlier research indicates that patients are more satisfied with physicians who have full lists and that patients switch less often from these physicians (124). Thus, Iversen and Lurås (2011) recommend making the number of switches per year available public information as a quality indicator (132). This would support our finding of the least disenrollment from the GPs with a greater share of arthritis, asthma and depression patients being a possible quality indicator.

Thus, a limitation of the study is our lack of data on other indicators for comparison and validation of our results. For example, checking the data to determine whether GPs performs regular controls for their chronically ill patients, or how many times patients ends up in hospital or emergency, would be useful to compare with our suggested indication of quality.

#### 5.3.3.2.2 Cluster and disenrollment patterns

Patient clustering could also indicate that a particular geographical area has a greater share of these groups of patients and the rest of the patients do not have other GP choices. Here, I continue the discussion started in the Section 5.3.2.2.3, Regional variation. The reasons for particular patients' clustering could be GP related, patient related or area related. First, GP-related reasons could be unobservable attributes of GPs, GPs' communication abilities, personal characteristics, specialization and diagnostics patterns. For example, GPs who specialize in a particular disease, such as DT2, would also diagnose more patients with DT2, thus increasing the share of DT2 patients on their own lists. In addition, the GPs would also have patients with several types of chronic diseases because DT2 patients often have comorbidities. Such GPs would probably have certain practice patterns.

Patient-related reasons could be personal choices, patients' socio-economic characteristics or effect from informal conversations. For example, patients with DT2 might take part in an organization for diabetes patients and receive particular information. They also might talk with each other, discuss the care they receive and recommend particular GPs. Patients' networks and informal conversations exert a stronger effect on disenrollment than that exerted by publicly available information (192). Earlier findings indicate that obese patients sought 'obese-friendly' GPs (193), which implies that patients seek GPs with particular personal and practice profiles and consider potential GP-patient relationships (156, 194). The patients might also have their own non-observable preferences. The choice might also be affected by their age, gender and socio-economic status. Some research indicates that patients often prefer GPs similar to themselves (130).

Area-related patient distribution could occur if patients with particular diseases cluster in specific geographic areas (173). For instance, cold and humid climates might contribute to the development of arthritis, and thus such patients might cluster in the areas with these climates (195).

#### 5.3.3.2.3 Other findings

Other important findings are that patients diagnosed with DT2, asthma, arthritis or depression use more primary care and switch GPs more frequently relative to other patients. In contrast to previous findings indicating that the duration and frequency of consultations did not affect GP switching (132), our results indicate patients who frequently visit their GPs tend to switch GPs frequently as well. Our findings suggest that these patients switch more often until they find a patient-GP relationship that works well for them, and then they stay with their GP. The patients with chronic diseases value continuity of care (196, 197) (continuity of care is measured as proportion of consultations made by the usual GP (198)). Continuity of care is essential for positive outcomes from the treatments (132, 199, 200).

The length of patient lists is negatively associated with disenrollment and shares of chronic patients. This finding supports the results of earlier research that greater accessibility was not always equal to higher quality, and that longer patient lists were associated with superior disease management (135).

There is a gap in the knowledge on patient list combination and patterns on how patients change GPs, such as patients changing within the same group of GPs. For example, DT2 patients may change GPs among GPs with a large share of DT2.

## 6 Concluding remarks

All three papers provide evidence on how Norwegian health care responds to policy instruments, both financial incentives and organizational constraints. Paper 1 demonstrated that the revenue system for specialist care providers has the potential to supplement GP gatekeeping in restricting access to specialist care when providers face hard budget constraints (29). Paper 2 demonstrated that the reimbursement change contributed to (1) a greater reduction of the number of services for population that has only private providers nearby, (2) a reallocation of patients from private to public providers and (3) a reduction in the difference between different centralities of municipalities in their consumption pattern but an increase in the difference between different RHA regions.

The further national policy development for radiology providers was as follows. The demand for services pressed the providers by increasing waiting lists, which in turn, coerced the authorities to make adjustments. Thus, the reduction was followed by an increase in reimbursement. From 2014 to 2015, there was a 14% increase in the reimbursement to private providers and a 16% increase in the reimbursement to public providers (201).

Results of the paper 3 are restricted to the health care systems with regular GP schemes where patients are allowed to change GPs. Paper 3 demonstrated that indicators of GP quality might be identified through patient actions, such as disenrollment of patients with chronic diseases, who appreciate continuity of care. Large shares of arthritis, asthma or depression patients might be indicators of better quality of primary care since those GPs were more popular in most patient groups (including patients without chronic diseases). However, further research examining objective quality measures is required to determine whether disenrollment patterns could function as quality indicators (155).

From a policy prospective, the thesis provided evidence on the outcomes of financial incentives and organizational structures and how those might help reach the health policy goals of increasing health care services' quality, accessibility balanced with cost containment and effective resource allocation.

# Appendix

## Table N1. Overview of the three studies completed for the dissertation: Aims and Hypotheses*

| Papers | Name | Type/Field of Journal / Target audience | Aim | Hypotheses |
|---|---|---|---|---|
| 1 | Supplementing gatekeeping with a revenue scheme for secondary care providers. Iversen, Mokienko, Int J Health Econ Manag, 2016. DOI 10.1007/s10754-016-9188-2. | Health economics / Economists and administrators | Paper 1 asks whether the revenue system for secondary care providers may supplement the gatekeeping mechanism in regulating utilization of secondary care. | (1) With less fee for service (FFS), we expect a reduction in the volume of radiology services performed by private providers.<br><br>(2) If post-2008 rationing occurred according to declining benefits, we would expect a greater reduction in number of examinations by private providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.<br><br>(3) We hypothesize an increase in the number of examinations performed by public providers and a greater increase in the number of examinations by public providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs.<br><br>(4) Because MRI examinations, to a greater extent than the other modalities, are located within the grey-area, we hypothesize a greater decline in the total number of MRI scans than for the other modalities and also a greater decline in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs (pp 12-14 in Paper 1 (29)) |

| | | | | |
|---|---|---|---|---|
| 2 | Effect of a funding change and travel times on delivery of private and public radiology services in Norway: Register-based longitudinal study of Norwegian claims data, Mokienko, Submitted to BMC Cost Effectiveness and Resource Allocation | Medicine / Health care professionals | Paper 2 examines how the change in the remuneration system for radiology providers can contribute to a change in the radiology supply in the different geographical regions, depending on the proximity of the providers. | I expect that:<br>(1) There will be a larger decrease in the number of private services than public services based on the differences in their budget constraints.<br>(2) The stream of patients who move between providers and the effect on the total number of services will be different depending on the difference in the proximity of private and public radiology providers.<br><br>The changes at private, public and both providers are expected to be the following:<br><br>2A) Patients use **private** radiology more when these providers are relatively closer (i.e., *Time_difference* ≤ *0)*, which means that, after 2008, the greatest reduction in the *Priv_Serv* will be in these areas. The reduction diminishes with an increase in *Time_difference*.<br><br>2B) The change for **public** providers consists of two effects:<br><br>First is a reduction in the original public service users. The greater usage was before 2008, the greater reduction in the number of services will be after 2008. In general, patients use public radiology more when these providers are closer (i.e., when *Time_difference* ≥ 0).<br><br>Second is an increase in the users switching from private radiology. These patients are more likely to switch if they live closer to a public provider compared to a private provider, that is, the greater the value of *Time_difference*. Depending on what effect is greater, the change will be positive, negative or equal to zero.<br><br>2C) Since private providers are more affected, the greatest reduction in the **total** number of services occurs in areas with negative *Time_difference*. This reduction will diminish with an increase in *Time_difference* because patients can more easily switch to a public provider. |
| 3 | Disenrollment from general practitioners among chronic patients: a register-based | Medicine / Health care professionals , economists and | Paper 3 aims to investigate disenrollment patterns among patients with chronic diseases because such | (1) If patients switch between GPs until their demands are met, we would expect these patients to be disproportionally distributed across GPs. Similar trends could be expected if the GPs intentionally specialize, formally or not, in a given patient group.<br><br>(2) If disenrollment patterns of special groups of patients align with other patients groups, then they might indicate better quality (155) |

| | | | | |
|---|---|---|---|---|
| | longitudinal study of Norwegian claims data. Mokienko, Wangen. BMC Family Practice, 2016. https://doi.org/10.1186/s12875-016-0571-3 | administrators | patterns could indicate otherwise unobserved quality | |

*Source: Papers 1, 2, 3 (29, 155)

**Table N2. Overview of the three studies completed for the dissertation: Data and Methods***

| Papers | Name | Data | Main variables | Methods |
|---|---|---|---|---|
| 1 | Supplementing gatekeeping with a revenue scheme for secondary care providers. Iversen, Mokienko, Int J Health Econ Manag, 2016. DOI 10.1007/s10754-016-9188-2 | 1. 176,709 monthly observations of 4486 self-employed GPs, covering the entire population of self-employed GPs who contract with municipalities in Norway.<br>2. Main data: Claims data to the NIS (Norwegian Insurance Scheme) from public and private radiology laboratories from 2007 to 2010 from the Norwegian Directorate of Health<br>• Number of examinations according to type of imaging (the modalities X-ray, ultrasound, magnetic resonance imaging (MRI) and computerized axial tomography (CAT scan)) and fees for patients covered by NIS;<br>• Each claim is assigned to the patient's regular GP through a patient ID number and aggregated to the number of claims during a month at the level of the GP;<br>• Merged with GP characteristics and patient list data;<br>• The distances between GP's municipality and municipality of | The dependent variables:<br>• The examination rates: total, private and public examinations per month per 1000 listed patients at the level of the individual GP.<br><br>Independent variables:<br>1. Competition indicators #Open and #Open/capita.<br>a. #Open = number of GPs in a municipality who accept additional patients,<br>b. #Open/capita adjusts for variations in populations across municipalities.<br>2. GP practice:<br>• Practice size<br>• The proportion of older people (above 70 years old) and the proportion of females in the practice,<br>• Age and gender of a GP,<br>• A dummy variable Short: whether a GP experiences a shortfall of | 1. Theory model with direct and indirect rationing<br>2. Empirical approach:<br>a. Model: Fixed effect<br>• Study effects of competition indicators,<br>• Clustered on the level of hospital catchment areas (21 clusters) due to contracts with radiology,<br>• To correct for regional variation: 11 dummies for months,<br>• To adjust for variation in the size of the municipality, use weighted regression with the municipality population as the weighted variable.<br>b. Specifications<br>• Aggregated numbers vs. modalities,<br>• Competition indicators: (1) no indicator, (2) #Open and (3) #Open/capita,<br>• For number of private, public and total services |

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| | | provider by Info Map. | patients on his (her) list of above 100 patients compared to the desired list size.<br>3. Travel time to the nearest private provider and travel time to the nearest public provider.<br><br>See Table 1 in Paper 1 for measurements and details (29) | c. To check robustness<br>• Cluster on municipality level due to GP contracts. The significance of the result does not change.<br>• Change the weights to patient-list size or drop weights. The significance of the result depends on the competition indicator. |
| 2 | Effect of a funding change and travel times on delivery of private and public radiology services in Norway: Register-based longitudinal study of Norwegian claims data, Mokienko, Submitted to BMC Cost Effectiveness and Resource Allocation | 1. 422 municipalities in 48 periods (monthly observations during 2007 to 2010), thus 19,867 observations.<br>2. Main data: Claim data to NIS from private and public radiology providers in Norway, obtained from the Norwegian Directorate of Health (data used for paper 1)<br>• Aggregated number of radiology services (CAT scans, MRIs, X-rays, and ultrasounds) to municipality level,<br>• Merged with travel times between GP's municipality and municipality of provider provided by InfoMap Norway | The dependent variable:<br>• A number of services performed at private (*Priv_Serv*), public (*Pub_Serv*) or both providers together (*Total_serv*) per month per 1,000 inhabitants in the municipality;<br>• If a patient from Municipality A goes to Municipality B for a radiology examination, that service is classified as a service delivered to Municipality A.<br><br>The independent variable:<br>• *Time_difference* = *Privtime* - *Pubtime* = the difference in travel time between the nearest private provider and nearest public provider in hours<br>✓ The travel times according to driving time by car between a patient's residential municipality (approximated by the municipality of the patient's GP) and the municipality of the public radiology | Empirical approach:<br><br>1. Stratified summary statistics (according to centralities and RHAs) for before and after the reimbursement change of 2008<br>2. Regression analysis:<br>• Model: Fixed effect model<br>• To study effect of *Time_difference*<br>• For private, public and both providers<br>• Quadratic function<br>✓ Different polynomial functions were checked but quadratic was chosen.<br>3. Measure of the change in numbers of radiology services before and after 2008 using values obtained from stratified summary statistics for (a) RHAs and (b) centralities |

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| | | | provider *(Pubtime)* or the private radiology provider *(Privtime)* in hours<br>✓ If the patient has the radiology provider in his (her) own municipality, then the travel time will be set to zero by definition in the data set.<br>• Centrality of the municipality (*Centrality 1-7*, dummy variables) is a variable from Statistics Norway and classifies every municipality in Norway according to one of seven categories, where 7 is most central (e.g., Oslo) and 1 is least central municipality<br>• *Region 1-4* are dummy variables describing whether the municipality belongs to South-East (1), West (2), Central (3), or North (4) Regional Health Authorities. | |
| 3 | Disenrollment from general practitioners among chronic patients: a register-based longitudinal study of Norwegian claims data. Mokienko, Wangen. *BMC Family Practice*, 2016. | Data:<br>1. Data from two national registers in Norway, administrated by the Norwegian Directorate of Health, from 2009 to 2011, six semiannual intervals, merged using the GPs' IDs.<br>• GP data: national register of regular GPs, which covers the entire GP population,<br>• Patient data: claims data obtained | Dependent variable:<br>• 'SwitchOut': measured whether a patient disenrolled from a GP from one semiannual period to the subsequent period.<br><br>Independent variables (see Table 1 in Paper 3):<br>• GPs' age, sex, specialization and list length, | 1. GP level data.<br>• Graphs to reveal whether the distribution of chronic patients seemed disproportionate across GPs. See Fig. 2 in Paper 3: proportion of patients with DT2<br>• Spearman's correlation coefficients for the various GP-related variables: the |

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| | https://doi.org/10.1186/s12875-016-0571-3 | from the KUHR registry (Kontroll og Utbetaling av HelseRefusjon), which covers the entire Norwegian patient population. The individual level of data included patient characteristics, their consumption of primary care and the GP with which they were enrolled.<br>2. Two samples of patients were selected among patients who visited a GP at least once from 2009 to 2011:<br>a. Sample 1: patients registered with one or more of the following seven diagnoses at least once during the period 2006 to 2011: DT1, DT2, asthma, arthritis, schizophrenia, depression and epilepsy.<br>b. Comparison group, Sample 2: entire birth year cohorts from 1940 and 1970, except patients already included in sample 1.<br>*3.* After certain exclusions to clean the data of irrelevant information, we had 313,659 patients in Sample 1 and 30,212 patients in Sample 2 (343,871 in total) (Fig. 1 in Paper 3) | • Patients' sex, birth year and number of visits,<br>• Number of patient's comorbidities (range between 0 and 6),<br>• Shares of the patients with certain diagnosis on the GP list | shares of patients with different diagnoses, the GP's age and sex.<br>2. Patient level data.<br>• Comorbidity: percent of patients with a chronic disease that have another chronic disease.<br>• Logistic regressions to model patients' disenrollment from their GP:<br>a. To study the effect of GP patient shares with certain diagnosis,<br>b. Subsamples for each patient diagnosis from Sample 1,<br>c. Comparison group from Sample 2,<br>d. Five effective observations for each patient. |

*Source: Papers 1, 2, 3 (29, 155)

**Table N3. Overview of the three studies completed for the dissertation: Results and policy implications***

| Papers | Name | Results | Policy implications |
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| 1 | Supplementing gatekeeping with a revenue scheme for secondary care providers. Iversen, Mokienko, Int J Health Econ Manag, 2016. DOI 10.1007/s10754-016-9188-2. | 1. Private providers conducted fewer examinations in 2008 to 2010 compared with 2007, and public providers conducted either the same volume or more (Hypotheses 1 and 3)<br>2. A greater reduction occurred in the number of examinations by private providers in municipalities with more competition for patients among GPs than in municipalities with less competition for patients among GPs. GPs who practice in municipalities with competition for patients also initiated a greater rate of examinations at private providers before 2008. => These results imply a greater absolute value of reductions at private providers for GPs who initially exhibited the greatest referral rate (Hypothesis 2). Some of the reduction in private labs is compensated for by an increase in the number of examinations at public labs. At the aggregate level, we are not able the reject that the total reduction in the number of investigations is unchanged irrespective of the level of competition.<br>3. From a disaggregated analysis, we find for MRIs that the absolute value of the reduction in the sum of private and public examinations increases with the level of competition => the rationing that occurs after 2008, in particular, is a disadvantage for patients in the grey area (which MRI is considered to be) with a low expected benefit (Hypothesis 4)<br>4. Other results:<br>• Distance to the nearest public provider, a shortage of patients, a high proportion of old people and the proportion of females have a positive effect on the number of services at private providers, whereas distance to the nearest private provider has a negative effect.<br>• Distances to the nearest private provider and a shortage of patients have a positive effect on the number of services at public providers, whereas the distance to the nearest public provider has a negative effect. | The revenue system for specialist care providers has the potential for supplementing GP gatekeeping in restricting access to specialist care when providers face hard budget constraints. |

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| 2 | Effect of a funding change and travel times on delivery of private and public radiology services in Norway: Register-based longitudinal study of Norwegian claims data, Mokienko, Submitted to BMC Cost Effectiveness and Resource Allocation | 1. After the 2008 reimbursement change, patients received fewer services at private providers and more services at public providers (Hypothesis 1). This result indicates that the stream of the patients that switched from private to public providers is greater than the reduction in the public services due to reimbursement change.<br>• Reduction in private services after 2008, but the reduction diminished along with *Time_difference* (Hypothesis 2A)<br>• Public services increased along with *Time_difference* (Hypothesis 2B)<br>• Total number of services decreased until *Time_difference* $\leq$ *40 min* and increased for *Time_difference* $\geq$ *40 min* (Hypothesis 2C)<br><br>2. Variation reduced between different centralities by 51.8% and increased between different RHA by 19.5%.<br>• The largest municipalities (highest centrality) are notably not the greatest consumers of radiology services per capita; they are just average.<br>• The variation comes from the small- and middle-sized municipalities. | The geographical distribution of the providers and how differently the providers react to reimbursement changes, affect the implications of the reimbursement change for publicly reimbursed providers in 2008.<br>Reimbursement change contributed to<br>1) a greater reduction of the number of services for population that has only private providers nearby,<br>2) a reallocation of the patients from private to public providers,<br>3) a reduction in the difference between different centralities of municipalities in their consumption pattern but increase in the difference between different RHA regions. |
| 3 | Disenrollment from general practitioners among chronic patients: a register-based longitudinal study of Norwegian claims data. Mokienko, | 1. The proportion of patients with DT2 varied substantially among GPs. If these patients had been allocated purely by chance, about 95% of the proportions would lie between the curves of confidence interval (Figure 2 in Paper 3), but this was not the case (Expectation 1).<br>a. Only 46.5% of the proportions were positioned within the red curves.<br>b. For the other diagnosis groups, the corresponding patient shares also seemed disproportionally distributed.<br>2. Patients usually have several comorbidities (Table 3 in Paper 3).<br>3. GPs' proportions of patients with different diagnosis:<br>a. The correlation coefficient of 'Asthm_share' and 'DT1_share' was 0.648, indicating | 1. Patients with chronic diseases are not allocated to GPs only by chance;<br><br>2. Chronic patients who use primary care intensively disenroll less often from GPs who have a high share of patients with the same diagnosis; |

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| | Wangen. *BMC Family Practice*, 2016. https://doi.org/10.1186/s12875-016-0571-3 | that GPs with a high proportion of patients with asthma also tended to have a high proportion of patients with DT1.<br>b. The proportion of patients with chronic diseases were all positively correlated and negatively correlated with the proportion of other patients (‘Other_Share’).<br>c. ‘Other_Share’ was negatively correlated with ‘GP_Age’ and ‘GP_Sex’, indicating that older GPs and male GPs tended to have fewer patients without the seven chronic diseases.<br>4. Estimations:<br>a. Main effects.<br>i. The ‘own share effect’: all patient groups tended to remain with GPs who had a high share of patients with the same diagnosis.<br>ii. The ‘cross share effect’: for instance, a high share of DT1 patients increased the switch-out for patients with arthritis (meaning, patients with arthritis were more likely to switch if their GPs had more patients with DT1).<br>iii. Most patient groups tended to remain with GPs with a greater share of arthritis, asthma and depression patients (Expectation 2)<br>b. Other results:<br>i. Patients tended to switch less often from GPs who had long patient lists or who were specialists in general medicine.<br>ii. Patients born more recently or who had more comorbidities tended to switch GPs more often.<br>iii. The 1% of patients who most frequently used primary care tended to switch less often than patients who had fewer visits. However, among the remaining 99% of patients, those with a higher number of primary care visits tended to switch more often. | 3. Most patient groups tend to remain with GPs with a greater share of arthritis, asthma and depression patients, which may indicate better quality care for these and other patient groups. |

*Source: Papers 1, 2, 3 (29, 155)

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II

**Effects of a reimbursement change and travel times on the delivery of private and public radiology services in Norway: A register-based longitudinal study of Norwegian claims data**

Anastasia Mokienko[1]

## Abstract

**Background**: This article studies the variation in the impact of the reimbursement change for radiology providers in Norway in 2008 depending on the travel times to private and public providers in different municipalities. The activity-based fund allocation for radiology providers was reduced from approximately 50% to 40%, which was compensated by an increased basic grant. The hypothesis is that Norwegian population would be affected by the reimbursement change unevenly depending on the distances to different types of the providers.

**Methods**: I used panel data at the municipality level with monthly observations for the period 2007–2010. I studied the effect of the reimbursement change and travel time difference between private and public radiology providers (*Time_difference*) on the number of the services using fixed-effects regressions.

**Results**: After the reimbursement change, the number of private services decreased more than public services. Private services declined after 2008, but the absolute value of the effect was

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smaller as the *Time_difference* became greater. The number of public services increased as the *Time_difference* grew. The total number of services decreased until the *Time_difference* was equal to 40 min, and increased for time differences greater than 40 min.

**Conclusions**: The messages for policymakers are as follows: Populations that only had private providers nearby were more affected by the reimbursement change in terms of a reduced number of services; The reimbursement change contributed to the reallocation of patients from private to public providers; The reimbursement change reduced the difference between different centralities of municipalities in their consumption patterns and increase the difference between different Regional Health Authorities.

**Trial Registration**: not applicable.

**Keywords**: radiology providers, reimbursement change, institutional settings, travel time to providers.

## Background

### Motivation

Radiology services are useful tools in the diagnostic process. When physicians suspect a particular diagnosis, they often send patients for further examination. Sometimes a diagnosis is confirmed, and sometimes not. Can we say that the service was unnecessary if the diagnosis was not confirmed? Some policymakers would say yes. However, a negative answer is still an answer when it comes to diagnostics. A big debate exists about efficiency, cost savings, and cutting unnecessary services. An extensive amount of literature supports the idea that rising costs do not necessarily translate into an increase in the quality and efficiency of health care (1-5). However, it is very difficult to assess the benefit of diagnostics and specialist services, which makes it easy to say that those services are overused (6). Diagnostics may save a significant amount of budgeted money by helping physicians to assess diagnoses more precisely. When the benefit of diagnostics is unclear, physician discretion is involved, and practice variation should be expected, which could result in patients being overtreated or undertreated.

In addition to practice differences, variation comes from regional differences in distribution of the providers. For instance, the number of radiology services in Norway varies in different regions and municipalities. Research on the accessibility of medical service providers has demonstrated that greater travel distances to providers lead to reduced utilisation of health-care services (7-10) and that patients consume more services from nearby providers (11). There is also a difference in the geographical tolerance of highly versus sparsely populated communities: Residents of closely settled areas are much less willing to travel to access a general practitioner (GP) than people in sparsely populated areas (12). Thus, people who live in remote areas travel to health-care institutions less frequently than those in populated areas, but they are willing to travel much longer distances than people residing in population centres.

Equal access to good quality care is one of the top priorities of health care in Norway (13, 14). Understanding how the variation in the provision of health care services works and how it affects the consequences of political and financial changes helps policymakers to take more thorough decisions. To be able to reach this goal, there is a need for evidence on what contributes to regional differences. The aim of this paper is to provide more evidence on what may add to regional differences in provision of health services using the example of the radiology services in Norway. It examines how the change in the remuneration system in 2008 for radiology providers contributed to a change in the radiology supply in the different geographical regions depending on the travel times to private and public providers.

This topic is important because Norway is a vast country with a small population, and it therefore has many remote municipalities. Not all municipalities have radiology providers, and from some municipalities, the travel time can reach several hours. Some municipalities (medium and large ones) have private and/or public providers, but others do not. When private and public providers react differently to financial changes, it could result in a variation in the supply to patients who have a particular kind of provider available.

**Public and private providers**

Norway has four regional health authorities (RHAs) named after their locations (Southeast, Central, North, and West). There are two types of radiology providers in Norway: private and public. Private providers operate as for-profit institutions that can have contracts with RHAs and deliver radiology services on public terms (Patients only pay the laboratory a patient co-payment, while the rest is paid by the state and the RHA.). Each RHA chooses a number of private radiology providers through a tendering process and by signing contracts with them for a specific number of services. This option is sometimes associated with wait times for patients. Private providers also deliver radiology services on private terms (when patients pay the full fee directly to the laboratory); this option is not associated with wait times for patients.

The contracts with RHAs specify the volume of and reimbursement for examinations, the maximum number of services, and the total costs. Some contracts specify only an aggregated budget for services (15). Other contracts are very detailed and specify the budget for each type of service, such as ultrasound imaging (UI), magnetic resonance imaging (MRI), computed body tomography (CBT or CAT scans), and radiography (X-rays) (16).

The provider’s revenue includes three components: the fee-for-service from the National Health Insurance (NHI) scheme, patient co-payments (the same for both private and public providers when received through NHI), and the invariable component (a basic allocation that is independent of the number of the services provided). ‘The size of the basic allocation [was] determined by a number of factors, including the number of inhabitants living in the region and the demographics of the population.’ (17)

Public providers are hospital radiology departments that deliver radiology services to the population on public terms; that is, they accept both patients from hospitals and outpatients referred to them by GPs and specialists. The revenue of public providers also includes three components equivalent to those of the private providers. Visits to a public or private laboratory require a referral from a general practitioner (GP) or a specialist to be covered by NHI (18). In theory, radiology laboratories can decline to make an appointment in general, but in practice, this does not happen often because GPs already act as gatekeepers, as illustrated in (19).

The RHA and NHI do not reimburse public radiology laboratories directly; instead, they reimburse the hospital affiliated with the laboratory. This implies that public outpatient providers are not as restricted by contracts as their private counterparts; thus, they have softer budget constraints than private providers do. Soft budget constraints are often related to a poor ability to balance budgets and providers with the tendency to increase activity or costs to a level above the one preferred by the principle stakeholder (20-22). In contrast, in the private sector, the number of services is controlled by hard budget constraints to maintain positive profits because contracts include specified volumes.

**The 2008 reimbursement change**

Reforms in the financing of specialist health care were carried out since 1997 and activity-based funding (ABF) was introduced to encourage the achievement of activity targets ((23), p 69). If these targets were not met, the RHAs lost income. If the activity levels were higher than targeted, then the costs would be only partially compensated. Hence, in short, ABF was not intended to cover marginal costs or to encourage activity beyond the target ((17), p. 13). In the period from 2005 to 2008, the proportions of activity-based and basic allocation were approximately equal. Figure 1 demonstrate that the prior to 2008 spending for private radiology continually increased.  The reimbursement change of 2008 has changed radiology funding accordingly: the ABF part decreased from 50% to 40%, and the basic allocation increased from 50% to 60% to compensate for it. The reimbursement scheme was changed to cut on spending and to harmonise the financial scheme of radiology providers with the general system for financing outpatient medical services in Norway (17, 24) ‘Somatic specialist care is financed partly through block grants (60%) and partly through activity-based financing from the central government to the RHAs (40%), with the latter component based on diagnosis-related groups (DRGs). The financing structure is aimed at both containing costs and giving providers sufficient flexibility to assure the best mix of services for patients.’ (23)

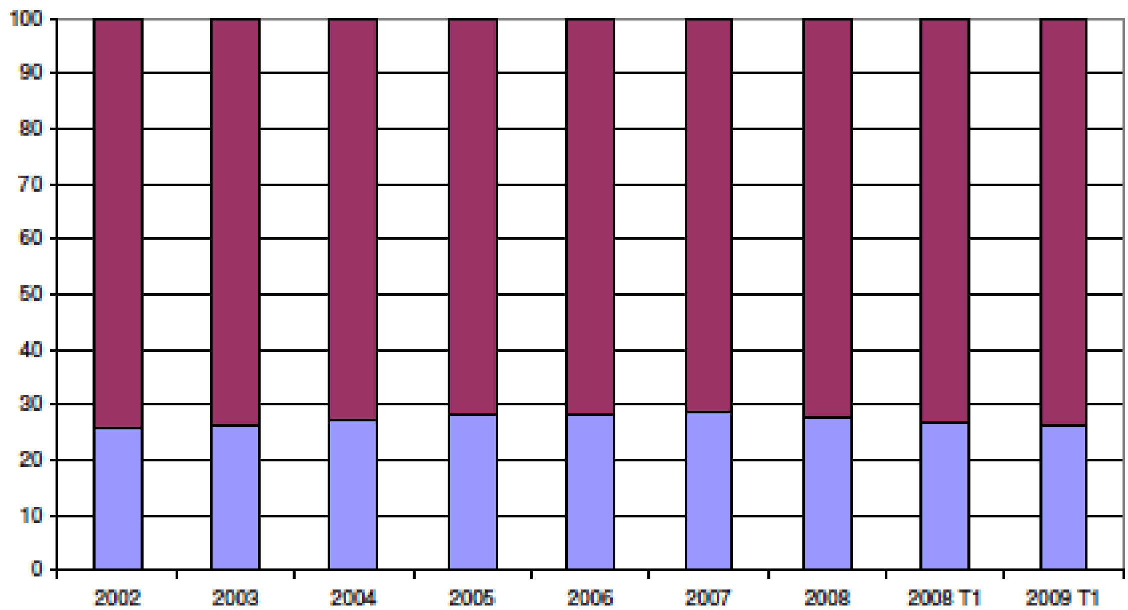


Figure 1 Market share in the costs between private (blue) and public (red) radiology providers in percent (Figure 3.4 in (25))

## Methods

### Data

I used claims data obtained from the Norwegian Directorate of Health. The dataset (aggregated at the municipality level) contained the number of radiology services (CAT scans, MRIs, X-rays, and ultrasounds) reimbursed per month by NHI from 2007 to 2010, the travel times from the municipality of the patient to the municipality with closest private or public provider, the number of inhabitants, the centrality of the municipalities, and the RHAs to which they belonged. I monitored 422 municipalities in 48 different periods (monthly observations from 2007 to 2010), for a total of 19,867 observations.

#### Variables

***Travel times***

Table 1 in Appendix contains an overview of the variables. The travel times were measured in hours according to driving time by car (provided by Info Map Norway [(26)]) between a patient's residential municipality (approximated by the municipality of the patient's GP) and the municipality of the public radiology provider (*Pubtime*) or the private radiology provider (*Privtime*). If patients have a radiology provider in their own municipality, then the travel time was set to zero by definition in the dataset. The difference in travel time between the nearest private provider and nearest public provider is represented by *Time_difference* = *Privtime* - *Pubtime*. The difference in travel time is included as the main independent variable because when deciding between two providers in the settings of unevenly distributed providers, patients often choose the more available provider in terms of proximity. Since private and public providers have different institutional settings, this choice affects outcome.

### *Centrality*

'*Centrality*' of the municipality (*Centrality* 1–7, dummy variables) is a variable from Statistics Norway that classifies every municipality in Norway according to one of seven categories, where 7 represents the most central type of municipality (e.g. Oslo), and 1 denotes the least central ones (e.g. small remote villages). '*Centrality*' indicates the location of municipalities in relation to urban settlements of various sizes (27, 28). It reflects the travel time from an urban settlement to a centre with well-developed infrastructure, including banks, post offices, and so forth, as well as the number of inhabitants and public services available (see (29, 30) for details). Since research indicates that residents of closely settled areas are much less willing to travel to access a health care provider than people in sparsely populated areas (12), '*Centrality*' might not only reflect type of municipality but as well be correlated with patients' willingness to travel.

### *Regional health authorities*

'*Region 1–4*' are dummy variables describing whether the municipality belongs to 1) South East, 2) West, 3) Central, or 4) North RHAs.

*Centrality* and '*Region 1–4*'are time invariant. They are part of the fixed effects and are therefore cancelled out in the model, but they are used for descriptive statistics.

### *Number of services*

The dependent variable is the number of services provided at private (*Priv_Serv*), Public (*Pub_Serv*), or both types of providers together (*Total_Serv*) per month. It was calculated by accumulating claims in every municipality. If a patient from municipality A goes to municipality B to receive a radiology examination, that service is classified as a service delivered to municipality A. The measurement of this variable reflects the number of services per 1,000 inhabitants in the municipality.

## Hypotheses

Patients who live in the centres have better access to both public and private providers, while those who live remotely have to travel up to several hours to reach a provider. I was interested in studying the interaction between patients' travel times and the reimbursement change of 2008 in terms of the number of services consumed. I expected that the Norwegian population would be affected by the reimbursement change unevenly depending on the distances to different types of the providers.

I based my hypotheses on two assumptions (A1 and A2). A1) There is stream of patients who need services, and if one source reduces the offer, the patients will switch to another more readily available source. Under availability, I considered both capacity and travel time to the provider. A2) As mentioned in the background section, public providers have softer budget constraints and can thus stretch their capacity outside of the limits set by budgets compared to private providers, which have hard budget constraints.

Thus, I formulated the following hypotheses.

***Hypothesis 1***

There will be a larger decrease in number of private services than public services based on the differences in their budget constraints.

***Hypothesis 2***

The stream of patients who move between providers and the effect on the total number of services will be different depending on the difference in the proximity of private and public radiology providers. The changes at private, public and both providers will be following:

2A) Patients use private radiology more when these providers are relatively closer (i.e. *Time_difference* is negative or equal to zero), which means that, after 2008, the greatest reduction in the *Priv_Serv* will be in these areas. The reduction diminishes with the increase in *Time_difference*.

2B) The change for public providers consists of two effects. The first involves a reduction in the original public service users. The greater usage was before 2008, the greater the reduction in the number of services will become after 2008. In general, patients use public radiology more when these providers are closer (that is, when *Time_difference* is zero or positive). The second effect relates to users switching from private radiology. These patients are more likely to switch the closer they live to a public provider compared to a private provider (i.e. the greater the value of *Time_difference*). Depending on what effect is greater, the change will be positive, negative, or equal to zero.

2C) Since private providers are more affected, the greatest reduction in the total number of services occurs in the areas with negative *Time_difference*. This reduction will diminish with an increase in *Time_difference* because patients can more easily switch to a public provider.

Figure 2 represents a visual explanation of the hypotheses in terms of *Time_difference*—how the consumption of services would change when we move on the scale of *Time_difference* from negative to positive values. Figure 2 makes use of three states: negative, equal to zero, and positive values of *Time_difference*. The text boxes indicate what I expected in each of the three states and why.

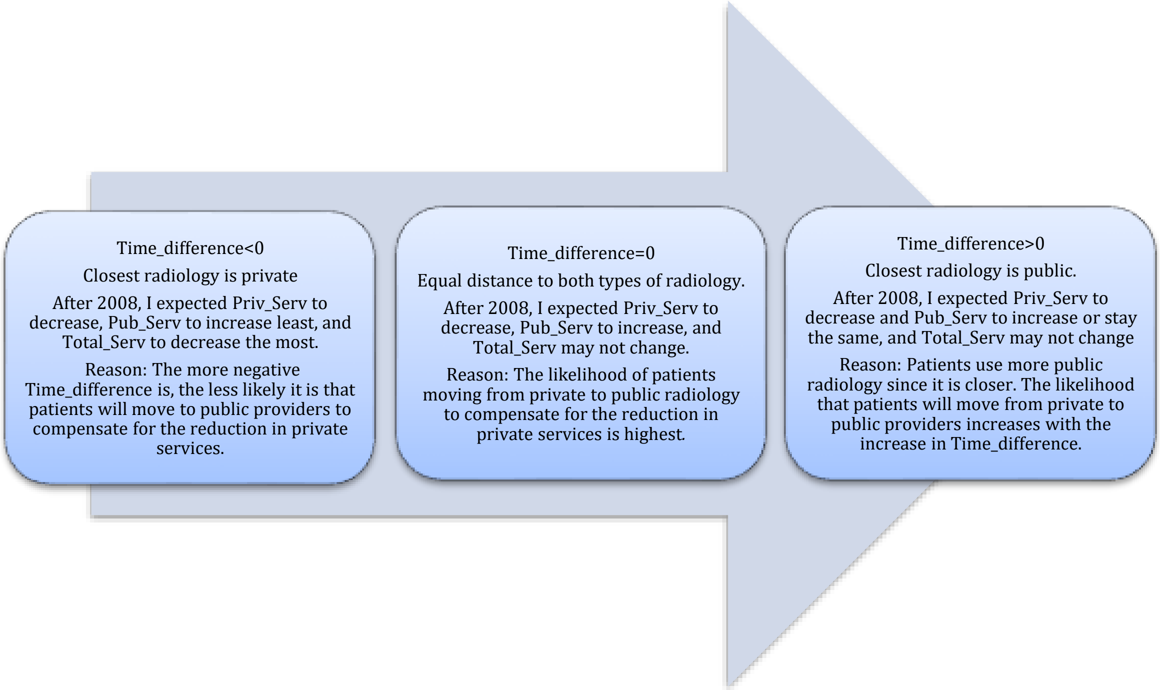


Figure 2 Three states on the axis of *Time_difference* (the difference in travel time between the nearest private provider and the nearest public provider) and the hypotheses regarding the consumption of radiology services

If we follow Figure 2, the first text box indicates that the closest radiology provider is private (*Time_difference* < 0). I expected the total number of services to decrease due to reduced offerings from private providers. Since there is a longer travel time to the public provider, fewer patients would move to the public provider due to time costs compared with the other two cases (when the public provider is closer or equally close). Therefore, more patients would rather not take the radiology examination at all or do it out of pocket. Thus, the total number of services would decrease more than if the closest radiology provider were public.

The second box indicates that the distance between private and public radiology providers is small (*Time_difference* → 0). In this situation, patients can change providers more easily. The likelihood that patients will switch from private to public radiology provider is higher. Thus, I expect a substantial drop in *Priv_Serv* and an increase in *Pub_Serv*, while the total number of the services may not even change.

In the third textbox, the closest radiology provider is public (*Time_difference* > 0). I expected that patients would use the public provider more than private ones. Since public providers have softer budget constraints, I predicted that the total number of services would be less affected by the reimbursement change. However, some patients who used private providers before 2008 would move to public providers due to the reduced offerings of private providers after 2008. Therefore, I expected that the total number of services would stay the same, public services would increase or stay the same, and private services would decrease or stay the same.

## Model

I estimated how *Time_difference* would affect number of services at private, public, and both providers after the reimbursement change. Using the panel data, we can control for time-invariant heterogeneity without observing it. I proceeded using a fixed effects model because it is more robust and needs fewer assumptions fulfilled compared to a random effects model. The fixed effects model is based on the assumption that the errors are uncorrelated with the independent variables and that the errors are conditionally homoscedastic and not serially correlated (31).

The model includes the differences in the time it takes for patients to reach a private provider minus time it takes for them to reach a public provider (*Time_difference* = *Privtime* - *Pubtime*). After trying several polynomial functions, I used a quadratic function because I expected that the relationship between number of the services and the *Time_difference* would not be completely linear. A regression model was estimated separately for each of the samples of private and public providers, as well as for the sample including both type of providers:

$$Y_{it} = B_0 + B_1\, post08_t + B_2\, post08_t \cdot Time\_difference_{it} + B_3\, post08_t \cdot Time\_difference_{it}^2 + e_i + u_{1it}$$

where $Y_{it}$ denotes the number of services (*Priv_Serv*, *Pub_Serv*, *Total_Serv*) to municipality $i$ ($i$=1,…,422) in period $t$ ($t$=1,…,48), $post08_t$ is a dummy equal to 0 prior to 2008 and 1 after

January 1, 2008, and $B_k$ (k=0…3) are the regression coefficients; $e_i$ is a provider specific fixed effect, and $u_{1it}$ is an error term.

*Pubtime*$_{it}$, *Privtime*$_{it}$ and *Time_difference*$_{it}$ do not vary much over time for the same municipalities, but I still used 'it'-indexes to indicate even a very small variation (although the variation is not enough to keep them as independent variables in the fixed-effects model without interaction effect with *post08*).

## Results

### Descriptive statistics

Tables 1A, 1B, and 1C in Appendix display descriptive statistics at different levels for the whole period of 4 years for the whole country: before and after the change for the whole country (Table 1A); before and after the change according to each level of centrality (Table 1B); and before and after the change for each RHA (Table 1C).

Average driving time to the nearest private provider is 3 h: It can be in the same municipality (as little as 0 h away) or in another region (up to 18 h away). The average driving time to the nearest public provider was a little over 1 h and had a smaller range than the driving time to a private provider, ranging from being in the same municipality to being almost 6.5 h away (see Table 1A).

Figure 3 illustrates the distribution of the variable *Time_difference*, which is continuous, concentrated around zero, and mostly to the right-hand side of zero. It has a long right tale and a left-sided truncation. There are many municipalities in which both types of providers were equally close (30%). In addition, in many municipalities, public providers were much closer than private providers (i.e. observations to the right of zero, 65%). In a few municipalities, private providers were closer than public providers (i.e. observations to the left of zero, 5%). The average *Time_difference* was about 1.5 h.

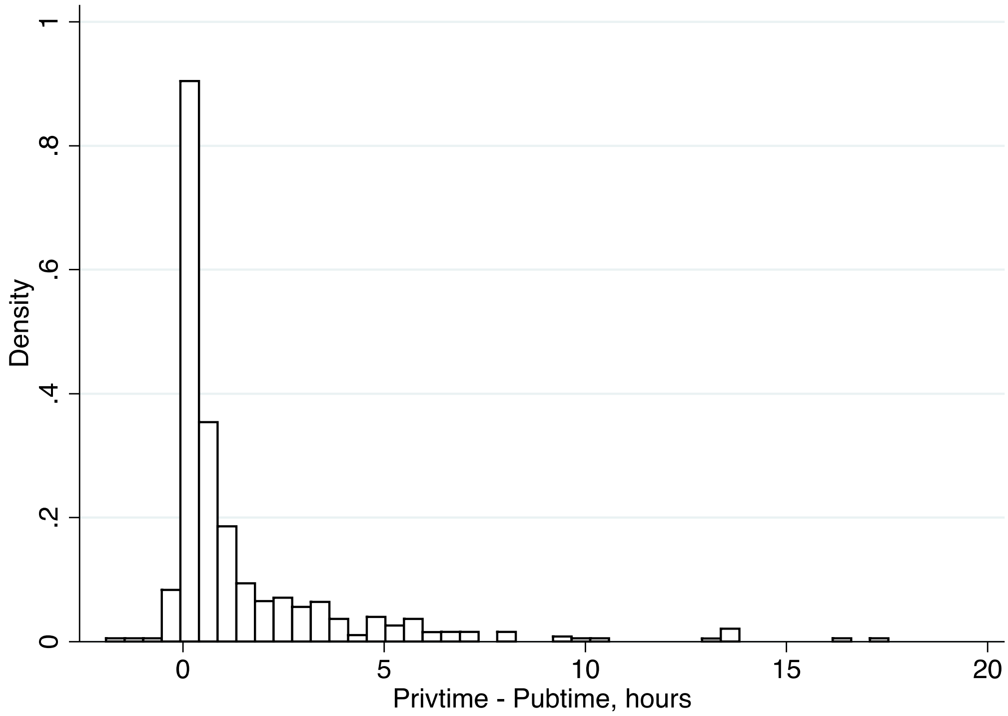


Figure 3 Distribution of *Time_difference* (the difference in travel time between the nearest private provider and nearest public provider) in hours

The summary statistics for the whole Norwegian population (Table 1A) indicates that the number of examinations per 1,000 inhabitants in the municipality conducted at private providers per month has decreased by 1.6 (from 9.6 to 8), while the corresponding number for public providers has increased by 1.8 (from 24.4 to 26.2) after the change.

Table 1B illustrates the stratified values of travel times according to the different centralities. It indicates that depending on the centrality of the municipality, patients may have both providers available in the same municipality or a short distance away, or they may have to drive at least 1 –2 h to the closest private or public provider. Table 1B demonstrates that the population in the least central places use most frequently public providers, while population in the most central locations use most frequently private providers. The most central municipalities saw a reduction in the number of private examinations by around four examinations per 1,000 inhabitants in the municipality (from 18.4 to 14.8); the reduction in the least central municipalities was a little less than 1 (from 6.2 to 5.6). A different picture emerged for examinations at public providers, with an increase of 3 at the least central locations (from 26.8 to 29.7) and 1.5 in the most central municipalities (from 17.2 to 18.9). In total, there was a slight increase in the numbers in the least central municipalities and a slight decrease in the most central municipalities.

Table 1C illustrating the summary statistics stratified by the RHA, demonstrates that private services (range 2–11 examinations/1,000 inhabitants x municipality after the reform) were most strongly represented in the South East, followed by the West and Central municipalities, with the smallest number located in the North. All of them decreased by 2, but in terms of the percentage of change from the original number, the largest and smallest reductions occurred in the North and the South East, respectively. Public services (range 22–32 examinations/1,000 inhabitants x municipality after the reform) were most strongly represented in the North, followed by the Central and South East areas, with the smallest number being located in the West. They increased by 1–3 services after the reform (Central, North, South East, and West, in descending order). The total number was more or less the same in the South East and the North, and it decreased by 1 in the West and increased by 2 in the Central RHA.

**Regressions**

The models were estimated using xtreg in Stata 13. To test the first hypothesis, I studied the coefficients next to '*post08*' in Table 2. I found that, after the reimbursement change, patients received fewer services at private providers (coefficient = -1.913) and more services at public providers (coefficient = 1.439) than before 2008. The total number of examinations has declined (coefficient = -0.474). The descriptive statistics in Tables 1A, 1B, and 1C complete the picture, especially the overviews stratified by *Centrality* and RHA.

Thus, hypothesis 1 is supported: The number of services offered by private providers has declined more than the number of services at public providers. Furthermore, *Pub_Serv* has increased, which indicates that the stream of the patients switching from private to public providers is greater than the reduction in public services due to the 2008 reimbursement change.

Table 2 Fixed-effects linear regression models for the number of private, public, and total services

| | Private | Public | Total |
|---|---|---|---|
| *Post08* | -1.913*** | 1.439*** | -0.474*** |
| | (0.070) | (0.141) | (0.164) |
| *Time_difference* x *post08* | 0.328*** | 0.348*** | 0.676*** |
| | (0.049) | (0.100) | (0.116) |
| $Time\_difference^2$ x *post08* | -0.016*** | -0.003 | -0.020** |
| | (0.004) | (0.008) | (0.010) |
| Cons | 9.579*** | 24.273*** | 33.852*** |
| | (0.048) | (0.097) | (0.113) |
| $R^2$ | 0.043 | 0.017 | 0.005 |

Coefficients (standard errors): * p < 0.10, ** p < 0.05, *** p < 0.01. n = 422, N = 19,867, n - number of municipalities, N - number of obs. (n = 422; N = 19,867). Xtreg procedure in Stata 13 was used for estimations.

To test the second hypothesis, I studied the combined coefficients for '*post08*' + '*Time_difference* x *post08*' + '$Time\_difference^2$ x *post08*' together (see Table 2). Figures 4A, 4B, 4C represent quadratic functions based on the coefficients in Table 2 after 2008 for easier understanding of the results. I created three separate graphs for 'private', 'public', and 'total number' of services. All the curves are described completely; however, the study's main interest is to look at the values within the minimum and maximum range of *Time_difference*, which are -1.92 and 17.53 hours, respectively. The curves describe the change in the number of services after 2008.

1) Private providers (Figure 4A). The curve is below 0. It indicates a reduction in services after 2008, but the reduction diminished along *Time_difference* until *Time_difference* = 10. Then, the reduction increased again in absolute value.

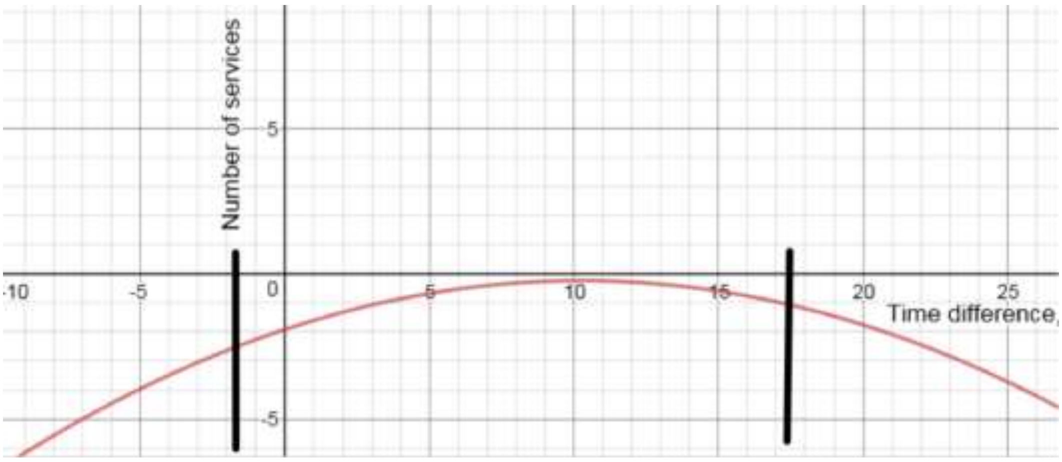


Figure 4A Curve representing the results for the number of services at private providers and the minimum and maximum *Time_difference* (black lines). The number of services was measured in services/1,000 inhabitants. The *Time_difference* was measured in hours

2) Public providers (Figure 4B). Within our minimum and maximum range of *Time_difference*, the curve is positive, increasing, and almost linear. It means that the public services increased in conjunction with *Time_difference* in our minimum and maximum ranges.

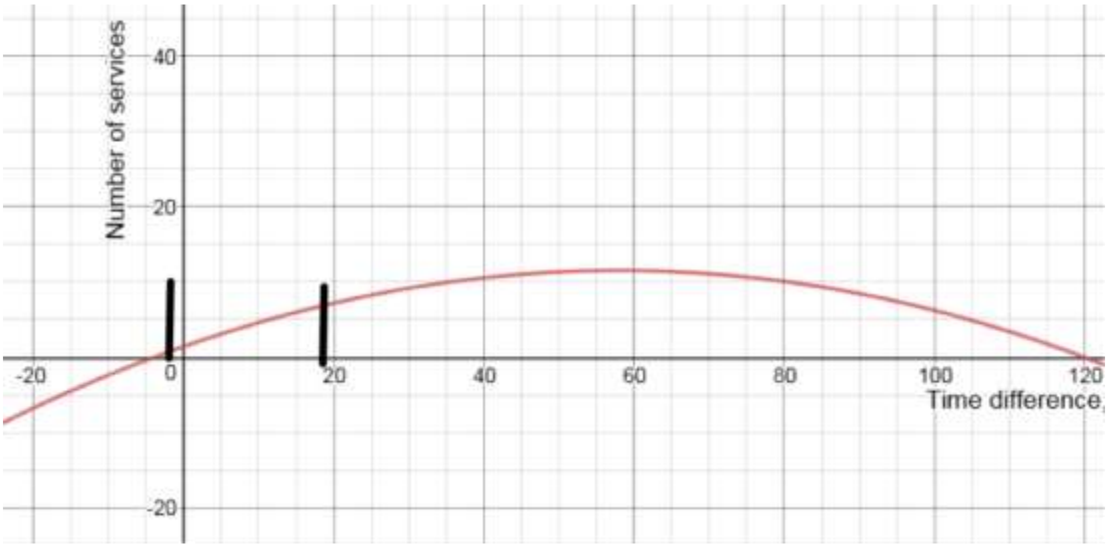


Figure 4B Curve representing the results for the number of services at public providers and the minimum and maximum *Time_difference* (black lines). The number of services was measured in services/1,000 inhabitants. The *Time_difference* was measured in hours

3) Total number of services (Figure 4C). Within our minimum and maximum range of *Time_difference*, for the values of *Time_difference* below 40 min, the curve is below the x-axis (i.e. there, the number of services decreases). For the values of *Time_difference* greater than 40 min, there was an increase in the services after 2008, and it increased along with *Time_difference*. If *Time_difference* equalled 40 min, then there was zero change in the number of total services after 2008.

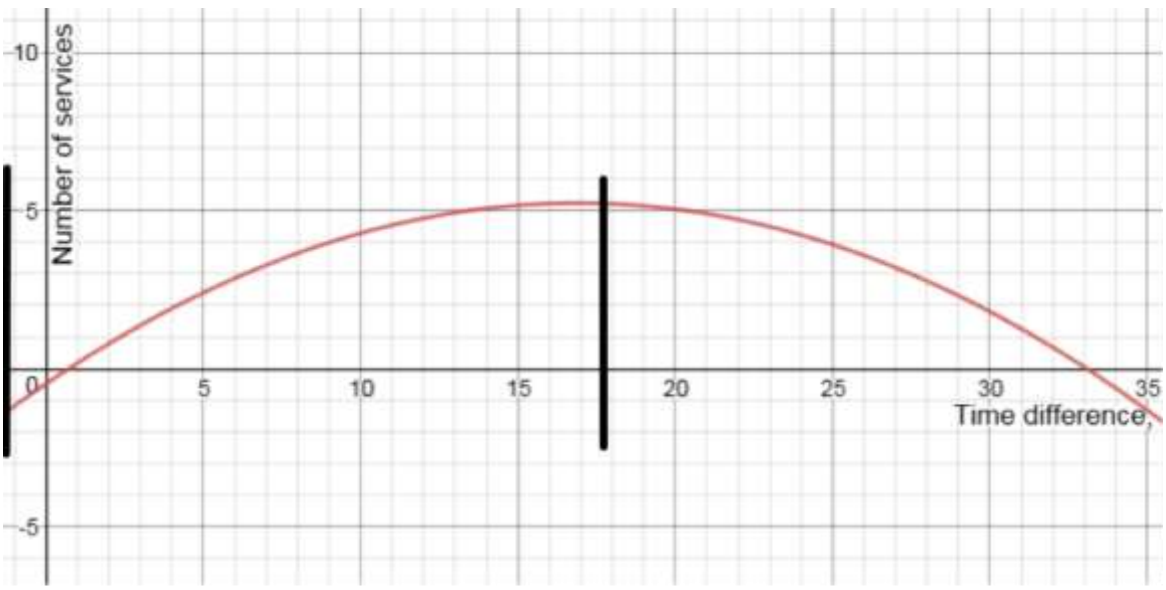

Figure 4C Curve representing the results for the total number of services, as well as the minimum and maximum *Time_difference* (black lines). The number of services was measured in services/1,000 inhabitants. The *Time_difference* was measured in hours

Here, we take a look at the curves when *Time_difference* = 0. This condition only leaves us with coefficients next to '*post08*' in Table 2. I expected that I would observe negative coefficients for private services but positive coefficients for public services with roughly equal numbers of each (i.e. patients would shift from the private to the public sector, and the number of total services would not change much). The results indicate that the coefficient for private providers was -1.913, the coefficient for public provider was 1.439, and the coefficient for the total number of services was -0.474. The coefficient for the total number was small (-0,474) but still different from 0. Therefore, even in areas with an equal distance to both types of providers, there was a small reduction in the total number of services. Hence, the effect of the reduction in private services was stronger than the compensation in public services in the municipalities with euqual distances to both types of providers.

To sum up, from the graphs, it appears that private services decreased, and they reduced more for negative values of *Time_difference*, with a diminishing reduction until *Time_difference* reached approximately 10 h. Public services increased along with *Time_difference*, and total services decreased until *Time-difference* equalled 40 min and increased for *Time_difference* values above 40 min. The hypotheses 2A, 2B, 2C about private and public services are supported by the results.

**Variation measure**

To elaborate and evaluate the results, I wanted to include a variation measure of the change based on the summary statistics results. The inspiration behind introducing a variation measure came from the inequality measure techniques, which were adapted to this particular case (32-34). I compared minimum and maximum values of means before and after 2008 for different centralities and RHAs for private, public, and both services together. The results are presented in Tables 3A and 3B in Appendix. The way I conducted it was as following. I looked on the summary statistics that are displayed in Tables 1B and 1C. For every line for private, public, and both services, I found minimum and maximum means before and after 2008 and transferred them to Tables 3A and 3B, respectively. Afterwards, I identified the difference between the minimal and maximal means (column 'Max-Min'). Then, I determined whether that difference increased or decreased after the reform and put the results in percentage form in the column 'Change, %'. For the purposes of the evaluation of the reform, the row with total number of services is of greatest interest.

After 2008, the range for the total numbers of services according to centralities has decreased from range [30.43–36.74] to range [32.46–35.50] (services per capita), indicating that less variation occurred between municipalities belonging to different centralities. It is interesting to note that the largest municipalities (highest centrality) are not the greatest consumers of radiology services per capita but are just average. The variation comes from the small and middle-sized municipalities. If we compare different RHAs, then we observe increased variation. The range has increased from [31.20 –36.34] before 2008 to [30.05 –36.19] after 2008 (services per capita).

The results reveal that variation has reduced between different centralities by 51.8% and increased between different RHAs by 19.5%. It is, however, curious that, for example, in the Central RHA, the total number has increased from 32 to 35, whereas in the West RHA, the number has decreased from 31 to 30. These findings do not paint very uniform picture of the consumption of radiology services according to location.

## Discussion

To explain the results for private providers, I wanted to look at the travel times and *Time_difference*. Distance to the health care providers is an important factor for patients (35). Demand for healthcare services changes amongst other factors due to variations in the travel time required to receive services, so service utilisation is inversely related to travel times (7-10, 36). Thus, the closest providers are used most frequently. Since private providers had harder budget constraints, they reduced their supply of services more after the reimbursement change. Thus, the patients who had private providers closer to them were affected by the change more than those who had public providers nearby. The number of the private services dropped by 15%–20% after 2008.

It is worth noting that only 5% of the municipalities had shorter distances to private providers than to public providers (21 municipalities with an average population of 13,000 people, ranging from 2,500 to 45,000). Most of the municipalities had equal distances to providers (124 municipalities with an average population 19,500 people, ranging from 345 to 573,000 people).

Next, we turn to an explanation of the results for public providers. Public providers had soft budget constraints, so they were not restricted by the 2008 change as much as their private-sector counterparts. Thus, first, when public providers were closer, patients would use more public services. Second, the smaller the distance between providers was, the easier it was for patients to 'transfer' to providers with more availability (i.e. to a public provider). In other words, patients tend to go to the provider where it is easiest to access services in terms of both travel times and availability. Thus, with the increase in *Time_difference* (i.e. a public provider becomes relatively closer than a private one), the number of the public services increases because it is easier for patients to transfer to the provider that is both available and relatively closer than a private provider. A report from the Norwegian Health Economics Administration

(25) supports these findings. The researchers reported a shift in the number of services towards public providers after the reimbursement change (see p. 27, Figure 5.1 in the report (25)). The report also indicates that refunds for private and public providers were 49%/51% in 2005–2007; after 2008, they became 46%/54%.

In general, the fact that in some areas many patients transferred from private to public providers is not nessesery efficient, because it indicates that patients that are rationed by private providers are now treated by public providers, shifting the market from private to public providers and implying that not only patients with the lowest expected benefit were rationed from private providers. If policy-makers want a coherent effect across providers, all providers should have hard budget constraints.

Thus, after uniting the outcomes for both types of providers, we observed that the smaller *Time_difference* becomes (i.e. a private provider is closer than a public provider), the greater the reduction in the number of total services is. Two causes brought about this change. First, patients used the closest provider (in this case, a private provider) more often, so proportionally the reduction became greater. Second, a possible transfer to a public provider is connected with time costs since private providers are not as far away. Therefore, more patients fall off, (i.e. they either chose not to have certain examinations, paid out of pocket, or used private health insurance). The total numbers depend on the composition of the private and public numbers. In areas where public providers dominate, the total numbers increased (i.e. centralities 1, 2, and 4). The opposite picture emerged in municipalities where private providers are more dominant; private services reduce and drag down the number of total services (*Centrality* 7) (see Table 1B).

Further research is required regarding whether the reduction in total services nationally was due to some of these services being unnecessary in the start (especially in areas where patients had providers close by) or whether people stopped waiting or paid for radiology examinations privately out of pocket (11, 19, 37). The number of patients using private health insurance went up 12 times from 2006 to 2016, and 30% of such plans were used for specialists and diagnostics (38). Thus, it would be valuable to investigate whether the reimbursement change added to the general equity in healthcare access: whether it increased offer of radiology services in areas with underused services and reduced that offer in areas of overuse taking in account individual need for services (39, 40). In the context of regional variation for radiology services, further examination to which degree the overuse and underuse of the services come from GP preferences (41), patients' specific characteristics (42-44) or purely from organizational structure (41, 45) would add clarity to understanding of the variation in radiology services. This study limits are missing data regarding wait times, examinations paid fully out of pocket, examinations covered by private health insurance, the number of dropped examinations, and provider capacities (i.e. the optimal work load for the providers in terms of efficiency).

It is also important to identify the criteria used to decide whether or not a service is necessary. In general, all diagnostics are necessary, and a negative answer is a great answer. However, from a health economics perspective, we should measure the marginal health benefits (improvement in health) gained from services received. However, diagnostics do not constitute a procedure to improve health but rather a step in order to know how to do achieve better health outcomes.

It would have been beneficial to have data for more years prior to the change in order to have more material with which to study the effects of the change. I have accomodated this limitation by including information on radiology development for 2002-2009 (Figure 1) to the present descriptional study. It would have been useful to control for life-expectancy, income level, variation in education in the municipalities. However, these characteristics were included in municipality fixed effects.

**Conclusion**

The geographical distribution of the providers and the different ways that providers react to changes in the reimbursement system affect the implications of the reimbursement change for publicly reimbursed providers in 2008. Policymakers can take away three messages from these findings: 1) Populations that only had private providers nearby were more affected than others by the reimbursement change in terms of the reduced number of services; 2) the reimbursement change contributed to the reallocation of patients from private to public providers; and 3) the reimbursement change reduced the difference between different centralities of municipalities in their consumption pattern and increased the difference between different RHA regions.

## Abbreviations

ABF – Activity-based funding

CBT or CAT scan – Computed body tomography

GP – General practitioner

HELFO – Norwegian Health Economics Administration

MRI – Magnetic resonance imaging

NHI – National Health Insurance

RHA – Regional Health Authority

UI – Ultrasound imaging

## Declarations

**Ethics approval and consent to participate**

The Norwegian Health Directorate has provided data and ethics approval.

**Consent for publication**

Not applicable.

**Availability of data and materials**

These data are sensitive without general access, so I applied for an exemption from the obligation to release the data publicly.

**Competing interests**

There are no competing interests.

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**Authors' contributions**

This is one-author paper; hence, all the work was completed by Anastasia Mokienko.

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# Appendix

**Table 1 Variables and Summary statistics: A) Nationally, B) stratified by centrality, C) stratified by Regional Health Authority before/after 2008 (*n* is the number of groups (i.e. municipalities), and *N* is the number of observations)**

**Table 1A Variables and summary statistics nationally before/after 2008**

| Variable | *Explanation of variables* | *Mean, N=19867 n=422* | *Std. Dev.* | *Min* | *Max* | *Mean before 2008 N=4944, n=415**** | *Std Dev.* | *Mean after 2008, N=14923, n=422**** | *Std. Dev* |
|---|---|---|---|---|---|---|---|---|---|
| *Priv_Serv* | Number of services per 1,000 inhabitants in the municipality done at private providers per month, services/1,000 inhabitants | 8.39 | 6.91 | 0 | 47.60 | 9.59 | 7.55 | 8.00 | 6.64 |
| *Pub_Serv* | Number of services per 1,000 inhabitants in the municipality done at public providers per month, services/1,000 inhabitants | 25.71 | 10.43 | 0 | 86.90 | 24.35 | 9.86 | 26.16 | 10.58 |
| *Total_Serv* | Total number of services per 1,000 inhabitants in the municipality per month, services/1,000 inhabitants x month | 34.11 | 9.98 | 1.39 | 96.86 | 33.94 | 9.88 | 34.16 | 10.01 |
| *Privtime* | The travel time from the municipality of the patient** to the nearest municipality with a private radiology provider in hours | 2.57 | 3.04 | 0 | 18.41 | 2.56 | 3.01 | 2.57 | 3.05 |
| *Pubtime* | The travel time from the municipality of the patient** to the nearest municipality with a public radiology provider in hours | 1.11 | 1.11 | 0 | 6.37 | 1.11 | 1.11 | 1.12 | 1.12 |
| *Time_difference* | *Privtime-Pubtime* in hours | 1.46 | 2.56 | -1.92 | 17.53 | 1.45 | 2.55 | 1.46 | 2.56 |
| *Centralities 1–7* | Dummies (1 is the least central municipality, 7 the most central) | | | 0 | 1 | | | | |
| *Centrality 1* | Least central: Centrality 0A* | 0.21 | 0.40 | 0 | 1 | 0.21 | 0.41 | 0.20 | 0.40 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Centrality 2* | Least central: Centrality 0B* | 0.13 | 0.34 | 0 | 1 | 0.13 | 0.33 | 0.13 | 0.34 |
| *Centrality 3* | Centrality 1A*, population from 1,000 to 15,000 | 0.16 | 0.36 | 0 | 1 | 0.15 | 0.36 | 0.16 | 0.36 |
| *Centrality 4* | Centrality 1B*, population from 1,000 to 15,000 | 0.17 | 0.38 | 0 | 1 | 0.17 | 0.38 | 0.17 | 0.38 |
| *Centrality 5* | Centrality 2A*, population from 15,000 to 50,000 | 0.19 | 0.39 | 0 | 1 | 0.19 | 0.39 | 0.19 | 0.39 |
| *Centrality 6* | Centrality 2B*, population from 15,000 to 50,000 | 0.07 | 0.26 | 0 | 1 | 0.07 | 0.26 | 0.07 | 0.25 |
| *Centrality 7* | Most central: Centrality 3*, population from 50,000 | 0.08 | 0.27 | 0 | 1 | 0.08 | 0.28 | 0.08 | 0.27 |
| *Region 1* | Dummy for the Regional Health Authority South East | 0.41 | 0.49 | 0 | 1 | 0.40 | 0.49 | 0.41 | 0.49 |
| *Region 2* | Dummy for the Regional Health Authority West | 0.20 | 0.40 | 0 | 1 | 0.20 | 0.40 | 0.20 | 0.40 |
| *Region 3* | Dummy for the Regional Health Authority Central | 0.19 | 0.39 | 0 | 1 | 0.19 | 0.39 | 0.19 | 0.39 |
| *Region 4* | Dummy for the Regional Health Authority North | 0.20 | 0.40 | 0 | 1 | 0.20 | 0.40 | 0.20 | 0.40 |

* Centralities classified by Statistics Norway.

** Municipality of the GP of the patient was used as a proxy of the municipality of the patient, as patients usually choose a GP in the same municipality, except in municipalities that are so small that the nearest GP is in another nearest municipality.

*** The difference in the number of municupalities in the data is due to structure of claims data. The total number of municipalities is 422.

**Table 1B Summary statistics stratified according to centrality and before/after 2008***

| Variable | *N*=1037, *n*=88 | N=3053, *n*=90 | *N*=624, *n*=52 | *N*=1937, *n*=55 | *N*=760, *n*=64 | *N*=2337, *n*=65 | *N*=843, *n*=71 | *N*=2559, *n*=72 | *N*=924, *n*=77 | *N*=2770, *n*=77 | *N*=348, *n*=29 | *N*=1043, *n*=29 | *N*=408, *n*=34 | *N*=1224, *n*=34 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 before | 1 after, | 2 before | 2 after | 3 before | 3 after | 4 before | 4 after | 5 before | 5 after | 6 before | 6 after | 7 before | 7 after |
| *Priv_Serv* | 6.23 (6.44) | 5.58 (5.79) | 8.28 (6.66) | 7.64 (6.29) | 11.00 (6.50) | 8.76 (5.64) | 6.60 (5.10) | 4.94 (4.43) | 13.91 (7.19) | 11.97 (6.48) | 4.08 (4.51) | 2.30 (3.86) | 18.43 (7.20) | 14.83 (6.55) |
| *Pub_Serv* | 26.77 (11.17) | 29.72 (11.28) | 22.15 (9.06) | 25.52 (9.55) | 23.13 (8.46) | 23.70 (9.31) | 27.28 (10.07) | 29.09 (10.33) | 22.83 (8.15) | 23.52 (10.26) | 28.98 (9.46) | 30.87 (8.28) | 17.21 (7.02) | 18.88 (8.20) |
| *Total_Serv* | 33.06 (11.70) | 35.30 (11.81) | 30,43 (9.97) | 33.15 (9.32) | 34.13 (8.78) | 32.46 (9.50) | 33.89 (10.05) | 34.03 (10.19) | 36.74 (8.80) | 35.50 (9.91) | 33.07 (9.54) | 33.84 (8.20) | 35,63 (6.06) | 33.70 (7.21) |
| *Privtime* | 3.52 (2.08) | 3.48 (2.10) | 2.26 (1.59) | 2.25 (1.58) | 1.51 (0.94) | 1.51 (0.93) | 4.14 (4.49) | 4.29 (4.60) | 0.66 (0.40) | 0.66 (0.40) | 6.35 (4.42) | 6.34 (4.40) | 0.38 (0.29) | 0.38 (0.29) |
| *Pubtime* | 1.78 (1.20) | 1.77 (1.19) | 1.22 (0.75) | 1.22 (0.74) | 0.94 (0.55) | 0.94 (0.54) | 1.44 (1.37) | 1.49 (1.45) | 0.35 (0.29) | 0.35 (0.29) | 1.49 (1.54) | 1.48 (1.54) | 0.27 (0.25) | 0.27 (0.25) |
| *Time_difference* | 1.74 (1.94) | 1.71 (1.93) | 1.04 (1.43) | 1.03 (1.42) | 0.57 (0.89) | 0.57 (0.88) | 2.71 (4.03) | 2.80 (4.06) | 0.30 (0.38) | 0.31 (0.38) | 4.86 (3.59) | 4.85 (3.59) | 0.11 (0.22) | 0.11 (0.22) |
| *Region 1* | 0.23 (0.42) | 0.24 (0.43) | 0.25 (0.43) | 0.26 (0.44) | 0.35 (0.48) | 0.35 (0.48) | 0.31 (0.46) | 0.31 (0.46) | 0.79 (0.41) | 0.79 (0.41) | 0.03 (0.18) | 0.03 (0.18) | 0.82 (0.38) | 0.82 (0.38) |
| *Region 2* | 0.18 (0.39) | 0.19 (0.39) | 0.31 (0.46) | 0.31 (0.46) | 0.36 (0.48) | 0.35 (0.48) | 0.19 (0.39) | 0.18 (0.38) | 0.14 (0.35) | 0.14 (0.35) | 0.03 (0.18) | 0.03 (0.18) | 0.06 (0.24) | 0.06 (0.24) |
| *Region 3* | 0.29 (0.45) | 0.29 (0.46) | 0.37 (0.48) | 0.35 (0.48) | 0.22 (0.42) | 0.23 (0.42) | 0.13 (0.33) | 0.13 (0.33) | 0.06 (0.25) | 0.06 (0.25) | 0.14 (0.34) | 0.13 (0.35) | 0.08 (0.28) | 0.09 (0.28) |
| *Region 4* | 0.30 (0.46) | 0.28 (0.45) | 0.08 (0.27) | 0.07 (0.26) | 0.06 (0.24) | 0.06 (0.24) | 0.37 (0.48) | 0.39 (0.49) | 0 | 0 | 0.79 (0.40) | 0.79 (0.41) | 0.03 (0.17) | 0.03 (0.17) |

*The first number is mean, the number in parenthesis is the standard deviation. *N* is number of observations, *n* is number of municipalities, and T is mean number of periods. T before=12, T after=36.

**Table 1C Summary statistics stratified by RHA***

| **Variable** | RHA1, before | RHA1 after | RHA2, before | RHA2 after | RHA3, before | RHA3 after | RHA4, before | RHA4 after |
|---|---|---|---|---|---|---|---|---|
| *Priv_Serv* | 12.66 (7.76) | 10.87 (6.80) | 10.08 (6.96) | 8.05 (6.13) | 8.08 (5.76) | 7.78 (5.79) | 4.44 (5.79) | 2.33 (2.70) |
| *Pub_Serv* | 23.67 (9.53) | 25.31 (10.64) | 21.12 (9.38) | 22.00 (9.60) | 24.11 (7.47) | 27.03 (8.93) | 29.04 (11.17) | 31.17 (10.71) |
| *Total_Serv* | 36.34 (9.62) | 36.19 (10.18) | 31.20 (8.91) | 30.05 (8.14) | 32.19 (7.82) | 34.81 (8.86) | 33.48 (11.75) | 33.50 (11.02) |
| *Privtime* | 1.23 (0.98) | 1.25 (0.99) | 1.91 (1.37) | 1.91 (1.36) | 1.78 (1.36) | 1.79 (1.37) | 6.56 (4.31) | 6.67 (4.40) |
| *Pubtime* | 0.79 (0.82) | 0.79 (0.82) | 0.83 (0.60) | 0.84 (0.60) | 1.04 (0.68) | 1.05 (0.70) | 2.08 (1.62) | 2.10 (1.37) |
| *Time_difference* | 0.44 (0.57) | 0.45 (0.58) | 1.08 (1.29) | 1.07 (1.29) | 0.74 (1.11) | 0.75 (1.13) | 4.48 (4.08) | 4.57 (4.10) |
| *Centrality 1* | 0.12 (0.32) | 0.12 (0.32) | 0.19 (0.40) | 0.19 (0.40) | 0.31 (0.46) | 0.31 (0.46) | 0.31 (0.46) | 0.29 (0.45) |
| *Centrality 2* | 0.08 (0.27) | 0.08 (0.27) | 0.20 (0.40) | 0.20 (0.40) | 0.24 (0.43) | 0.24 (0.43) | 0.05 (0.21) | 0.05 (0.21) |
| *Centrality 3* | 0.13 (0.34) | 0.13 (0.34) | 0.28 (0.45) | 0.28 (0.45) | 0.19 (0.39) | 0.18 (0.39) | 0.05 (0.21) | 0.05 (0.21) |
| *Centrality 4* | 0.13 (0.34) | 0.13 (0.34) | 0.16 (0.37) | 0.15 (0.36) | 0.11 (0.32) | 0.11 (0.32) | 0.31 (0.46) | 0.33 (0.47) |
| *Centrality 5* | 0.37 (0.48) | 0.36 (0.48) | 0.13 (0.34) | 0.13 (0.34) | 0.06 (0.24) | 0.06 (0.24) | 0 (0) | 0 (0) |
| *Centrality 6* | 0.01 (0.08) | 0.01 (0.08) | 0.01 (0.11) | 0.01 (0.11) | 0.05 (0.22) | 0.05 (0.22) | 0.27 (0.45) | 0.28 (0.45) |
| *Centrality 7* | 0.17 (0.38) | 0.17 (0.37) | 0.02 (0.15) | 0.02 (0.15) | 0.04 (0.19) | 0.04 (0.19) | 0.01 (0.11) | 0.01 (0.11) |
| | *N*=2002, *n*=168, *T*=11.92 | *N*=6078, *n*=170, *T*=35.75 | *N*=982, *n*=82, *T*=11.98 | *N*=2967, *n*=83, *T*=35.75 | *N*=949, *n*=80, *T*=11.86 | *N*=2878, *n*=82, *T*=35.1 | *N*=1011, *n*=85, *T*=11.89 | *N*=3000, *n*=87, *T*=37.48 |

*The first number is mean, the number in parenthesis is the standard deviation. *N* is number of observations, *n* is number of municipalities, and T is mean number of periods. T before=12, T after=36.

**Table 3 Minimum and maximum values of means before and after 2008 (services per capita) and their percentage change A) among centralities and B) among Regional Health Authorities**

**3A Minimum and maximum values of means before and after 2008 (services per capita) and their percentage change among centralities**

| | Before 2008 | | | After 2008 | | | |
|---|---|---|---|---|---|---|---|
| | Min mean | Max mean | Max-Min | Min mean | Max mean | Max-Min | Change, % |
| *Priv_Serv* | 4.08 | 18.43 | 14.35 | 2.30 | 14.83 | 12.53 | -12.7 |
| *Pub_Serv* | 17.21 | 28.98 | 11.77 | 18.88 | 30.87 | 11.99 | 1.9 |
| *Total_Serv* | 30.43 | 36.74 | 6.31 | 32.46 | 35.50 | 3.04 | -51.8 |

**3B Minimum and maximum values of means before and after 2008 (services per capita) and their percentage change among Regional Health Authorities**

| | Before 2008 | | | After 2008 | | | |
|---|---|---|---|---|---|---|---|
| | Min mean | Max mean | Max-Min | Min mean | Max mean | Max-Min | Change, % |
| *Priv_Serv* | 4.44 | 12.66 | 8.22 | 2.33 | 10.87 | 8.54 | 3.9 |
| *Pub_Serv* | 21.12 | 29.04 | 7.92 | 22.00 | 31.17 | 9.17 | 15.8 |
| *Total_Serv* | 31.20 | 36.34 | 5.14 | 30.05 | 36.19 | 6.14 | 19.5 |

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RESEARCH ARTICLE

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# Disenrollment from general practitioners among chronic patients: a register-based longitudinal study of Norwegian claims data

Anastasia Mokienko* and Knut Reidar Wangen

## Abstract

**Background:** Norwegian general practitioners (GPs) consult on a variety of conditions with a mix of patient types. Patients with chronic diseases benefit from appropriate continuity of care and generally visit their GPs more often than the average patient. Our aim was to study disenrollment patterns among patients with chronic diseases in Norway, because such patterns could indicate otherwise unobserved GP quality. For instance, higher quality GPs could have both a greater share of patients with chronic diseases and lower disenrollment rates.

**Methods:** Data on 384,947 chronic patients and 3,974 GPs for the years 2009–2011 were obtained from national registers, including patient and GP characteristics, disenrollment data, and patient list composition. The birth cohorts from 1940 and 1970 (146,906 patients) were included for comparison. Patient and GP characteristics, comorbidity, and patient list composition were analyzed using descriptive statistics. Patients' voluntary disenrollment was analyzed using logistic regression models.

**Results:** The GPs' proportion of patients with a given chronic disease varied more than expected when the allocation was purely random. The proportions of patients with different chronic diseases were positively correlated, partly due to comorbidity. Patients tended to have lower disenrollment rates from GPs who had higher shares of patients with the same chronic disease. Disenrollment rates were generally lower from GPs with higher shares of patients with arthritis or depression, and higher from GPs who had higher shares of patients with diabetes type 1 and schizophrenia. This was the same in the comparison group.

**Conclusion:** Patients with a chronic disease appeared to prefer GPs who have higher shares of patients with the same disease. High shares of patients with some diseases were also negatively associated with disenrollment for all patient groups, while other diseases were positively associated. These findings may reflect the GPs' general quality, but could alternatively result from the GPs' specialization in particular diseases. The supportive findings for the comparison group make it more plausible that high shares of chronic patients could indicate GP quality.

**Keywords:** Chronic patients, Switching, Primary health care, Schizophrenia, Epilepsy, Diabetes type 1, Diabetes type 2, Asthma, Arthritis, Depression

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## Background

The quality of care for people with chronic diseases often relies on appropriate primary care. Some such patients may need continuous, long-term follow-up and motivation in order to maintain a favorable lifestyle. Others, who experience a condition associated with social stigma, may need time to develop trust in their care providers. Early detection of the chronic disease and its subsequent routine monitoring is also very important to save patients from acute hospitalization and complications from the disease [1]. Comorbidity is a good reason for primary care providers to be better able to manage chronic diseases [2, 3].

Previous studies have found that long-term physician-patient relationships are beneficial for patients [4, 5] and that patients disenroll from their general practitioner (GP) when they are not satisfied with their GP-patient relationship [6–10]. Patients may also disenroll from their GP if they perceive insufficient quality of care. Accessibility factors, such as adequate time for consultations [11] and availability of appointments [12] are predictors of good quality. Booking intervals for consultations and duration of the consultations themselves are correlated with good management of chronic diseases; the effect was greater for patients with asthma than for those with diabetes or angina, possibly because primary care providers deal more with asthma than diabetes or angina [13].

When it comes to accessibility, earlier research shows that longer patient lists are associated with negative evaluations of accessibility and that the GP's age has a negative association with the evaluation of all aspects, except accessibility [14]. Longer patient lists are also associated with better illness detection [15], which may suggest that practices detecting a higher number of chronic conditions have greater demand from patients due to their systematic chronic disease management [15–18].

A strong connection between patient choice and higher quality of practice, as measured by studying the publicly available data on practice performance, has been reported [19]. A review study found that patients were weakly influenced by publicly available information about provider quality [20]. On the provider side, only hospitals seemed to improve quality as a response to quality indicators being made publicly available [21]. For GPs, patient shortage has been found to correlate with patient dissatisfaction, the GP's communication skills, and other GP characteristics [22–24].

Interaction between chronically ill patients and their GPs has not been given specific attention in previous literature, but a previous study of obese patients may contain clues for generalizable results: reportedly, obese patients avoided physicians they perceived as sources of stigma and searched for providers who were "obese friendly" [25].

If patients switch between GPs until their demands are met, we would expect these patients to be disproportionally distributed across GPs. Similar trends could be expected if the GPs intentionally specialize, formally or not, in a given patient group. However, neither of these mechanisms has obvious implications for the provider choices made by other groups of patients. For example, a GP who is popular among patients with diabetes type 2 (DT2) may also be popular among patients with depression, whereas patients without chronic diseases may be indifferent to this GP's motivational skills. Older patients and patients with chronic diseases have generally higher care continuity, whereas patients with lower care continuity are those living in rural areas, employed, with higher education, or with poorer mental health [26].

Our aim is to investigate patterns of chronic patient disenrollment. This type of study is required because there are no published indicators of GP quality, and therefore these indicators need to be identified through patient actions (such as disenrollment). Moreover, specialized patient choice patterns might suggest an extra argument for using more fee-for-service reimbursement or risk-adjusted capitation for GPs in order to compensate for varying expected workloads depending on their patient list composition. Primary care in Norway is publicly funded with a capitation and fee-for-service system, and patients have to consult their GPs in order to see a specialist. Each individual GP has a patient list and can decide the maximum number of patients that can be enrolled on their list. Patients can switch between available GPs up to three times a year, according to their own preference.

## Methods

### Data sources and study populations

This is a retrospective study using data from two national registers in Norway, administrated by the Norwegian Directorate of Health, from 2009–2011. Our GP data were obtained from the national register of regular GPs, which covers the entire GP population, and merged with patient data using the GPs' IDs. Our patient data were based on claims data obtained from the KUHR registry (Kontroll og Utbetaling av HelseRefusjon), which covers the entire Norwegian patient population. This registry records claims data continuously but for our analysis, the sample period 2009–2011 was divided into six semiannual intervals. The individual level data included patient characteristics, their consumption of primary care, and the GP with which they were enrolled.

Two samples of patients were selected among patients who visited a GP at least once from 2009–2011. Most of our analysis is based on sample 1, which consisted of patients registered with one or more of the following seven diagnoses at least once during the period 2006–2011:

DT1, DT2, asthma, arthritis, schizophrenia, depression, and epilepsy. These patient groups were chosen because they are known to vary substantially both in the number of patients in the population, and in the utilization of primary care services. For instance, patients with DT2 constitute almost 5% of the population and receive most of their health care from their GP, while patients with schizophrenia are fewer and receive more specialist care in a hospital setting.

Our analysis also included a comparison group, sample 2. This group consisted initially of the entire birth year cohorts from 1940 and 1970, but we excluded patients already included in sample 1. Obviously this selection yielded an age distribution different from that in sample 1, but the selection of one elderly and one younger birth year cohort should provide a good basis for comparison.

Initially, the two samples combined contained 988,483 patients (Fig. 1). We excluded 34,189 cases where the disenrollment was likely to be due to causes not relevant for our purpose; that is, when patients moved to another municipality, or when a GP moved, retired, or died. For the logistic regressions, we excluded patients living in municipalities with less than 50,000 inhabitants in order to focus on patients who could choose from several GPs. This left us with 316,636 patients in sample 1 and 32,311 patients in sample 2 (348,947 in total). Finally, we excluded patients with irregular medical records, mainly missing birth year or sex, yielding 313,659 patients in sample 1 and 30,212 patients in Sample 2 (343,871 in total).

### Measures

Our main outcome variable, 'SwitchOut', measured whether a patient disenrolled from a GP from one semi-annual period to the subsequent period. Definitions of independent variables are summarized in Table 1. Information about the GPs' age, sex, specialization, and list length, and patients' sex, birth year, and number of visits was obtained directly from the data registries. The variable 'Pat_comorb' was given the value 0 for patients in sample 2, while for each patient in sample 1 we counted the number of registered diseases (1–7) and subtracted 1 from this number. This yielded a variable with a range between 0 and 6. The variables 'Diab2_share' and 'Epil_share' measure a GP's share of patients with the respective chronic disease, but with a slight adjustment: if shares were calculated straightforwardly, they could potentially be influenced by the health status of a single patient, because some chronic diseases are relatively rare and some GPs had fewer patients (shorter lists). To illustrate, consider a GP who has 100 patients, of which one has epilepsy. If we take the perspective of the GP, the share of patients with epilepsy is slightly above average (Table 1). However, this measure is of little relevance if we take the perspective of the patient with epilepsy: the GP has no other patients with epilepsy. To avoid interpretational ambiguity, we chose to take the patients' perspective. For each patient-GP pair, we excluded the patient from the calculation of the GP's share. Thus, the share variables mostly showed the variation between GPs but also some variation within a GP practice.

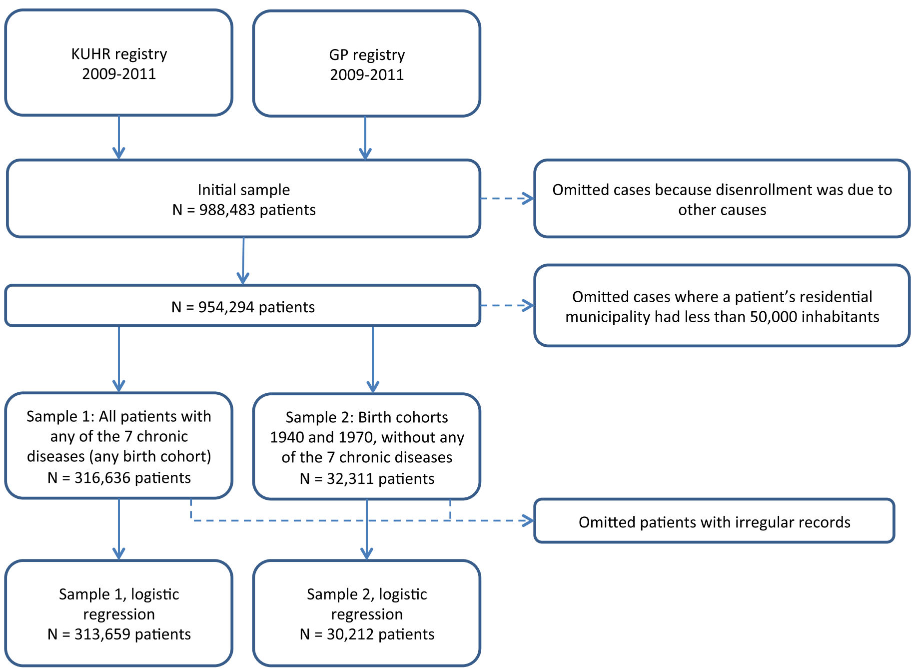


**Fig. 1** Flow diagram of sample selection

**Table 1** Variable definitions and descriptive statistics on the patient level[1]

| Variable | Definition | Sample 1 (*N* = 313,659) | | | Sample 2 (*N* = 30,212) | | |
|---|---|---|---|---|---|---|---|
| | | Median | Mean | St.dev | Median | Mean | St.dev |
| DT1_share | The share of a GP's patients with diabetes type 1 | 0.005 | 0.007 | 0.006 | 0.005 | 0.006 | 0.005 |
| DT2_share | The share of a GP's patients with diabetes type 2 | 0.042 | 0.046 | 0.027 | 0.036 | 0.040 | 0.021 |
| Arth_share | The share of a GP's patients with arthritis | 0.014 | 0.016 | 0.010 | 0.013 | 0.015 | 0.009 |
| Asthm_share | The share of a GP's patients with asthma | 0.020 | 0.023 | 0.015 | 0.018 | 0.020 | 0.013 |
| Depr_share | The share of a GP's patients with depression | 0.107 | 0.112 | 0.042 | 0.094 | 0.100 | 0.038 |
| Schi_share | The share of a GP's patients with schizophrenia | 0.004 | 0.005 | 0.003 | 0.004 | 0.005 | 0.003 |
| Epil_share | The share of a GP's patients with epilepsy | 0.008 | 0.009 | 0.004 | 0.008 | 0.008 | 0.004 |
| ListLength | The number of patients on a GP's list | 1423 | 1444.0 | 367.8 | 1439 | 1453.4 | 367.8 |
| Ln_ListLength | The natural logarithm of Listlength | 7.261 | 7.240 | 0.277 | 7.272 | 7.248 | 0.270 |
| GP_Age | The GP's age | 52 | 50.358 | 9.120 | 51 | 49.744 | 8.989 |
| GP_Sex | =1 if the GP is male, =0 otherwise | 1 | 0.706 | 0.455 | 1 | 0.673 | 0.469 |
| GP_age · GP_Sex | The product of GP_Age and GP_Sex | 48 | 36.473 | 24.718 | 45 | 34.266 | 25.016 |
| GP_Specialist | =1 if the GP has a specialist degree in general medicine; =0 otherwise | 1 | 0.707 | 0.455 | 1 | 0.702 | 0.457 |
| Pat_Sex | =1 if the patient is male; =0 otherwise | 0 | 0.426 | 0.494 | 0 | 0.494 | 0.500 |
| Pat_BirthYear | The patient's year of birth | 1959 | 1958.6 | 19.1 | 1970 | 1961.5 | 13.5 |
| Pat_Comorb | Sample 1: No. of chronic diseases minus one. Sample 2: Not defined | 0 | 0.148 | 0.405 | - | | |
| Pat_Visits | The patient's number of visits to primary care | 3 | 4.662 | 5.268 | 1 | 2.227 | 3.369 |
| Pat_Visits_win | Winsorized Pat_Visits at 99$^{th}$ percentile (max = 23) | 3 | 4.570 | 4.626 | 1 | 2.205 | 3.107 |
| Pat_Visits_dum | =1 if Pat_Visit >23, =0 otherwise | 0 | 0.10 | 0.98 | 0 | 0.002 | 0.047 |

[1]Municipalities over 50 000. First half of 2009

In order to avoid highly influential outliers, we transformed two variables. The distribution of GPs' list length was skewed so we transformed the variable using the natural logarithm. The distribution of patients' number of visits to primary care was also skewed, and for this variable, we winsorized the distribution at the 99$^{th}$ percentile (23 visits per period) and included a dummy variable for observations that exceeded this limit.

### Statistical analyses

We inspected the data numerically and graphically at both the patient and GP levels. This included graphs intended to reveal whether the distribution of chronic patients seemed disproportionate across GPs. On the GP level, the mean proportion of patients with DT2 was 4.5% in the first half of 2009. If patients were allocated by pure chance, a randomly selected GP's share of patients with DT2 would have the expected value of about 4.5%, and be approximately normally distributed for a sufficiently long patient list (>60 patients). For data at the GP level, we calculated Spearman's correlation coefficients for the various GP-related variables, including the shares of patients with different diagnoses, the GP's age and sex. We defined sub-samples of patients from sample 1 based on the seven chronic diseases. These sub-samples partly overlapped due to comorbidity. For each sub-sample, the shares of patients with 1 of the other six diseases were calculated.

We then used logistic regressions to model patients' disenrollment from their GP. The modeling was performed for each patient category separately: on the sub-samples from sample 1, as defined above, and sample 2. Because the dependent variable (SwitchOut) was based on observations from two consecutive periods, we had up to five effective observations for each patient. For the independent variables, we used observations from the first five periods. The set of independent variables included those from Table 1, and an interaction term between GPs' age and sex. We incorporated the longitudinal data structure by including patient-specific effects (intercepts) in the models. Patient-specific effects can account for unobserved factors, such as ethnicity or educational background, as long as these factors remain constant throughout the sample period. The models were estimated using xtlogit in Stata 13, under the standard assumptions that the patient-specific effects were normally distributed and did not correlate with the independent variables. Fixed effect models, which allow the patient-specific effects to be non-normally distributed or correlated with the independent variables, were also considered. However, in fixed effect models the time-invariant patient variables for sex and birth year would, by construction, be excluded from the estimations.

## Results

### Descriptive statistics

According to Table 1 and Fig. 2, the proportion of patients with DT2 varied substantially among GPs. If these patients had been allocated purely by chance, about 95% of the proportions would lie between the red curves in Fig. 2, but this was not the case. In fact, only 46.5% of the proportions were positioned within the red curves. For the other diagnosis groups, the corresponding patient shares also seemed disproportionally distributed.

Overall, 4.5% of chronic patients disenrolled from their GP from one period to the next, but the share varied from 3.7% among patients with DT2 to 6.2% among patients with schizophrenia (Table 2). Among patients in sample 2, the share that disenrolled was 3.7%.

Descriptive statistics for the independent variables used in the logistic regressions are reported in Table 1, separately for samples 1 and 2. Due to the sample selection procedure, the average GP characteristics differ somewhat from those obtained for the full GP population, where 66% were men, the average age was 48 years, and the average patient list length was 1200 ($N = 3940$).

The distribution of the variable 'ListLength' appeared continuous but was somewhat skewed to the right. The distribution of 'Pat_visits' was markedly right-skewed, and the distribution's tail was rather scattered: for sample 2, the 75th, 95$^{th}$, and 99th percentiles were 6, 14, and 23, respectively, but the maximum value was as high as 219.

Table 3 presents the sizes of the sub-samples defined for the seven chronic diseases. The most frequent of the diseases was depression ($N = 488,686$), while schizophrenia

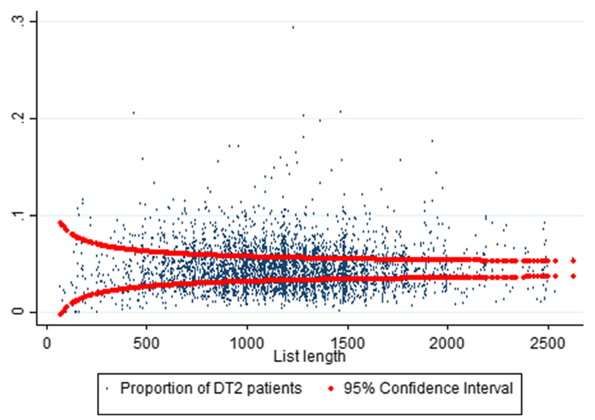


**Fig. 2** Scatter plot of GP proportion of DT2 patients and patient list length. Legend: Y-axis percent of DT2 patients, X-axis patient-list length. GP level, data for the first quarter of year 2009, $N = 3,965$, mean proportion of DT2 patients = 0.045, patient-list lengths of >60

**Table 2** Share of patients who voluntarily disenrolled from their GPs, between the 1$^{st}$ and 2$^{nd}$ halves of 2009.[1]

| Sample | Sub set | N | % |
|---|---|---|---|
| Sample 1 | Full sample | 313,659 | 4.52 |
| | DT1 | 11,292 | 4.99 |
| | DT2 | 74,473 | 3.75 |
| | Schizo | 8,316 | 6.29 |
| | Depr | 186,415 | 5.00 |
| | Arthr | 27,157 | 4.00 |
| | Asthm | 37,110 | 4.16 |
| | Epil | 15,403 | 4.86 |
| Sample 2 | Full sample | 30,212 | 3.76 |

[1]Municipalities over 50 000

was the least frequent ($N = 21,368$). In the sub-sample of patients with depression (third column from the left), 1.3% also suffered from schizophrenia. Among patients with schizophrenia (rightmost column), 28.7% also suffered from depression. A substantial number of patients were recorded with both DT1 and DT2, likely due to registration errors or diagnostic uncertainty.

We calculated Spearman's rank correlation coefficients for the GP proportion of patients with a given chronic disease and other patient proportions and GP characteristics, as shown in Table 4. The correlation coefficient of 'Asthm_share' and 'DT1_share' was 0.648, indicating that GPs with a high proportion of patients with asthma also tended to have a high proportion of patients with DT1. All variables related to the GPs' proportions of patients were significantly different from zero. The proportion of patients with chronic diseases were all positively correlated, and negatively correlated with the proportion of other patients ('Other_Share'). 'Other_Share' was negatively correlated with 'GP_Age' and 'GP_Sex', indicating that older GPs and male GPs tended to have fewer patients without our seven chronic diseases.

### Logistic regression analysis

Table 5 shows the estimated parameters of the logistic regressions where 'SwitchOut' is the dependent variable, the independent variables are those listed in Table 1, and Sigma_u denotes the standard deviation of the patient-specific intercepts. The first seven columns show results based on sample 1 according to patient diagnosis group; the last column is based on sample 2. In logistic regressions, the coefficients can be used to compare the difference in log-odds ratios between groups, so that a patient sex coefficient of −0.188 (arthritis patients) represents the difference in log-odds ratios between male and female patients. The corresponding difference in odds ratios is obtained by taking the anti-log, $\exp(-0.188) = 0.829$.

**Table 3** Percent of patients with a chronic disease (column) that have another chronic disease (row)

| | Arthritis | Asthma | Depression | DT2 | DT1 | Epilepsy | Schizophrenia |
|---|---|---|---|---|---|---|---|
| Arthritis | | 4.4 | 2.7 | 3.9 | 4.0 | 2.0 | 1.3 |
| Asthma | 6.1 | | 4.5 | 6.7 | 5.8 | 3.6 | 6.0 |
| Depression | 14.5 | 17.6 | | 13.5 | 15.2 | 15.8 | 28.7 |
| Diabetes type 2 | 10.0 | 12.4 | 6.4 | | 77.8 | 5.7 | 12.0 |
| Diabetes type 1 | 1.6 | 1.7 | 1.1 | 12.0 | | 1.3 | 1.9 |
| Epilepsy | 1.0 | 1.3 | 1.5 | 1.1 | 1.6 | | 3.1 |
| Schizophrenia | 0.3 | 1.0 | 1.3 | 1.1 | 1.1 | 1.4 | |
| N | 90,095 | 124,776 | 488,686 | 232,383 | 35,887 | 46,145 | 21,368 |

[3]First half year of 2009. Patient level data. Sample 1 without restrictions (neither on municipality size, data irregularity or moving). N is the number of patients with the chronic disease

The statistical inference for this type of model is based on large-sample theory and coefficient estimates are approximately normally distributed. Thus, to simplify the presentation, we do not report *p*-values as they can be derived from the estimated standard errors.

Some of the estimated effects of the patient share variables were relatively robust across patient groups. For 'Arth_share', all coefficients were significantly negative, implying that all patient groups tended to have lower disenrollment from GPs with relatively high shares of patients with arthritis. For 'Asthm_share' and 'Depr_share', all of the significant coefficients were also negative. In contrast, for 'DT1_share', 'Epil_share' and 'Schi_share', almost all significant effects were positive.

We can distinguish two main effects. First, the "own share effect," namely, all patient groups tended to remain with GPs who had a high share of patients with the same diagnosis. Second, the "cross share effect," where, for

**Table 4** GP characteristics. Spearman's correlation coefficients with two-sided *p*-values.[2]

| | Arth_ share | Asthm_ share | Depr_ share | DT1_ share | DT2_ share | Epil_ share | Schi_ share | Other_ share | GP_ age | GP_ sex | List Length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Asthm_share | **0.488** | | | | | | | | | | |
| | 0.000 | | | | | | | | | | |
| Depr_share | **0.195** | **0.264** | | | | | | | | | |
| | 0.000 | 0.000 | | | | | | | | | |
| DT1_share | **0.519** | **0.648** | **0.221** | | | | | | | | |
| | 0.000 | 0.000 | 0.000 | | | | | | | | |
| DT2_share | **0.232** | **0.310** | **0.121** | **0.332** | | | | | | | |
| | 0.000 | 0.000 | 0.000 | 0.000 | | | | | | | |
| Epil_share | **0.270** | **0.298** | **0.205** | **0.335** | **0.177** | | | | | | |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | | | |
| Schi_share | **0.045** | **0.175** | **0.227** | **0.135** | **0.183** | **0.162** | | | | | |
| | 0.005 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | | |
| Other_share | **−0.562** | **−0.683** | **−0.762** | **−0.712** | **−0.362** | **−0.406** | **−0.285** | | | | |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | |
| GP_Age | **0.203** | **0.137** | **0.064** | **0.213** | **−0.047** | **0.091** | −0.028 | **−0.174** | | | |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.077 | 0.000 | | | |
| GP_Sex | **0.181** | **0.293** | **0.077** | **0.318** | **0.101** | **0.205** | **0.135** | **−0.265** | **0.249** | | |
| | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| ListLength | −0.020 | **−0.069** | 0.041 | −0.032 | **−0.145** | −0.040 | −0.033 | 0.035 | **0.166** | **0.172** | |
| | 0.205 | 0.000 | 0.010 | 0.046 | 0.000 | 0.011 | 0.038 | 0.026 | 0.000 | 0.000 | |
| GP_Specialist | 0.008 | 0.017 | 0.030 | 0.037 | **−0.133** | **0.067** | −0.003 | −0.018 | **0.365** | **0.098** | **0.226** |
| | 0.618 | 0.275 | 0.063 | 0.020 | 0.000 | 0.000 | 0.860 | 0.250 | 0.000 | 0.000 | 0.000 |

[2]GP level data for first quarter of 2009, $N = 3974$. Correlation coefficients with two-sided *p*-values less than 1% are in boldface

**Table 5** Logistic regression for patients' voluntary disenrollment from GPs, separate for patient groups.[4]Estimated parameters (standard errors)

| | Arthritis | Asthma | Depression | Diabetes type 2 | Diabetes type 1 | Epilepsy | Schizophrenia | Others |
|---|---|---|---|---|---|---|---|---|
| Arth_share | **−15.032** | **−10.550** | **−16.792** | **−9.506** | **−16.905** | **−16.495** | **−20.113** | **−15.310** |
| | (1.611) | (1.597) | (0.815) | (1.194) | (3.116) | (2.836) | (3.925) | (2.185) |
| Asthm_share | **−4.381** | **−10.406** | **−2.117** | 1.883 | −1.624 | −0.188 | −3.895 | 0.093 |
| | (1.598) | (1.309) | (0.636) | (0.934) | (2.494) | (2.262) | (2.922) | (1.799) |
| Depr_share | **−1.915** | **−2.343** | **−5.377** | **−2.781** | −0.484 | **−2.029** | −1.095 | −0.220 |
| | (0.445) | (0.392) | (0.165) | (0.278) | (0.648) | (0.590) | (0.752) | (0.457) |
| DT2_share | −0.875 | 1.260 | −0.534 | **−4.117** | −0.499 | −0.886 | 2.397 | 0.112 |
| | (0.855) | (0.738) | (0.349) | (0.459) | (1.347) | (1.207) | (1.524) | (0.986) |
| DT1_share | **16.725** | **11.661** | **15.525** | **7.841** | **−20.177** | **15.491** | 10.100 | **15.962** |
| | (3.049) | (2.576) | (1.147) | (1.691) | (4.069) | (4.042) | (5.592) | (3.473) |
| Epil_share | 9.578 | **11.917** | **4.069** | 4.048 | −9.185 | **−13.955** | −1.462 | −0.165 |
| | (4.637) | (3.910) | (1.695) | (2.815) | (6.681) | (5.882) | (7.709) | (4.754) |
| Schi_share | **23.551** | **28.298** | **37.453** | **39.029** | **21.821** | **39.502** | 1.307 | **29.586** |
| | (5.265) | (4.248) | (1.810) | (3.082) | (7.191) | (6.259) | (7.663) | (5.136) |
| Ln_ListLength | **−0.702** | **−0.631** | **−0.405** | **−0.658** | **−0.346** | **−0.489** | −0.205 | **−0.623** |
| | (0.053) | (0.047) | (0.019) | (0.033) | (0.076) | (0.069) | (0.090) | (0.052) |
| GP_Age | **0.032** | **0.029** | **0.033** | **0.035** | **0.032** | **0.033** | **0.033** | **0.033** |
| | (0.003) | (0.003) | (0.001) | (0.002) | (0.005) | (0.004) | (0.006) | (0.003) |
| GP_Sex | −0.367 | **−0.512** | **−0.202** | −0.234 | −0.138 | −0.108 | −0.390 | −0.317 |
| | (0.189) | (0.166) | (0.065) | (0.118) | (0.265) | (0.235) | (0.306) | (0.175) |
| GP Age [a]Sex | **0.010** | **0.013** | **0.006** | **0.007** | 0.009 | 0.004 | 0.010 | 0.008 |
| | (0.004) | (0.003) | (0.001) | (0.002) | (0.005) | (0.005) | (0.006) | (0.004) |
| GP_Specialist | **−1.148** | **−1.271** | **−1.145** | **−1.288** | **−1.119** | **−1.236** | **−1.189** | **−1.242** |
| | (0.035) | (0.030) | (0.012) | (0.021) | (0.050) | (0.044) | (0.056) | (0.033) |
| Pat_Sex | **−0.188** | **−0.090** | **−0.100** | **−0.082** | **−0.133** | 0.015 | **−0.163** | 0.040 |
| | (0.035) | (0.028) | (0.012) | (0.020) | (0.047) | (0.041) | (0.055) | (0.032) |
| Pat_BirthYear [a] | **0.007** | **0.007** | **0.012** | **0.007** | **0.003** | **0.007** | **0.012** | **0.195** |
| | (0.001) | (0.001) | (0.000) | (0.001) | (0.001) | (0.001) | (0.002) | (0.036) |
| Pat_Comorb | **0.135** | **0.103** | **0.096** | **0.162** | **0.169** | **0.193** | **0.214** | |
| | (0.027) | (0.022) | (0.013) | (0.016) | (0.034) | (0.035) | (0.038) | |
| Pat_Visits_win | **0.042** | **0.046** | **0.049** | **0.041** | **0.035** | **0.049** | **0.046** | **0.057** |
| | (0.003) | (0.003) | (0.001) | (0.002) | (0.005) | (0.004) | (0.005) | (0.004) |
| Pat_Visits_dum | 0.046 | **−0.208** | **−0.270** | **−0.327** | −0.141 | −0.157 | −0.212 | **−1.019** |
| | (0.116) | (0.087) | (0.046) | (0.083) | (0.158) | (0.134) | (0.143) | (0.333) |
| Cons | **−12.977** | **−13.367** | **−25.141** | **−13.052** | **−7.795** | **−14.111** | **−26.068** | −0.306 |
| | (1.863) | (1.736) | (0.738) | (1.283) | (2.508) | (2.090) | (3.519) | (0.402) |
| Sigma_u | **0.718** | **0.784** | **0.773** | **0.747** | **0.755** | **0.809** | **0.922** | **0.662** |
| | (0.040) | (0.032) | (0.013) | (0.024) | (0.051) | (0.043) | (0.049) | (0.042) |
| No. obs | 130,690 | 175,010 | 890,215 | 357,153 | 53,206 | 73,419 | 39,535 | 146,906 |
| No. patients | 27,157 | 37,110 | 186,415 | 74,473 | 11,292 | 15,403 | 8,316 | 30,212 |

[4]Dependent variable: 'SwitchOut'. Only patients living in cities with more than 50,000 inhabitants were included. The seven left columns are from sample 1, the far right column is from sample 2. [a]For '*Others*', '*Pat_BirthYear*' was replaced with a dummy variable equal to 0 for patients born in 1940 and equal to 1 for patients born in 1970. Each patient was observed up to five times. Sigma_u denotes the estimated standard deviation of the random patient-specific constant terms. Stata 13, the xtlogit procedure, was used in the estimations. Estimates with two-sided *p*-values < 1% are in boldface

instance, a high share of DT1 patients increased the switch-out for patients with arthritis (meaning, patients with arthritis were more likely to switch-out if their GPs had more patients with DT1). The cross share effect was not generally symmetric as a high share of patients with arthritis reduced the switch-out for patients with DT1.

For all GP and patient characteristics, the significant coefficients had the same sign across all patient groups. Patients tended to switch less often from GPs who had long patient lists ('Ln_ListLength') or who were specialists in general medicine ('GP_Specialist'). For older, female GPs, patients tended to switch out more often ('GP_Age'). This effect was even stronger for male GPs, for which the full effect of age is obtained by adding the coefficients of 'GP_age' and the interaction between a GP's age and sex ('GP_Age*GP_Sex').

Patients born more recently (i.e., lower 'Pat_BirthYear') or who had more comorbidities ('Pat_Comorb') tended to switch GPs more often. The 1% of patients who most frequently used primary care (i.e., 'Pat_Visits_dum' = 1) tended to switch less often than patients who had fewer visits. However, among the remaining 99% of patients, those with a higher number of primary care visits ('Pat_visits_win') tended to switch more often.

The patient-specific effects are assumed to be normally distributed, with a zero mean and an estimated standard deviation, Sigma_u. For patients with arthritis, the value of Sigma_u can be interpreted as the difference in log-odds between a patient who has a patient-specific intercept one standard deviation from the mean (0.718) and a patient with an intercept equal to the mean value (zero). This is about four times the numerical value of the coefficient for patient sex, and it corresponds to a difference in odds ratio equal to 2.050. In all patient groups, the estimated value for Sigma_u indicates that the unobserved patient characteristics have a comparably large influence on disenrollment.

## Discussion

Our data indicate that patients with chronic diseases are not allocated to GPs by chance alone (Fig. 2). One explanation could be that some GPs informally specialize, for example in DT2, and thus are able to establish and maintain a "stock" of such patients. In so doing, the patient comorbidity shown in Table 3 would imply a tendency for these GPs to also have relatively higher shares of patients with arthritis and asthma. Moreover, patients with chronic diseases tend to have comorbidities, contributing to their GPs having shares of patients with different diagnoses. This could partly explain why the proportions of chronic disease types are all positively correlated, as shown in Table 4.

The coefficients in Table 5 suggest that chronic patients disenroll less often from GPs who have a high share of patients with the same diagnosis; for instance, 'Arth_share' has a negative effect (−15.032) for patients with arthritis, and 'Asthm_share' has a negative effect (−10.406) for patients with asthma. Again, this may be the result of GPs informally specializing in certain types of patients with chronic diseases. It may also result from the GPs' general qualities such as organizational skills, communication abilities, or empathic attitudes. It has been suggested that such patterns may result from patients' negative interactions with healthcare providers, so that, for instance, obese patients search for "obese friendly" physicians [25]. Patients could also make use of informal conversations (word-of-mouth) with family, friends, or colleagues that recommend one GP or another, which seems to have a greater effect on the choice of GP than public information disclosure [20]. The relationship between the GP and patient could also be a factor in patient choice, since chronic patients spend more time in primary care and would change their GP if they were not satisfied [3, 4]. We can assume that GPs who have high numbers of patients with a particular disease might have a particular practice style, which also attracts these patients, but these mechanisms may be complex, for instance for patients with schizophrenia. In Table 5, the only exception from the general pattern is for patients with schizophrenia, for which the effect of '*Schi_share*' is insignificant. However, all other patient groups tend to disenroll more from GPs with high shares of patients with schizophrenia, potentially suggesting that these GPs are less popular in general, and this may perhaps counter the "own share effect" among patients with schizophrenia.

We find that all or most patient groups tend to disenroll less from GPs who have high shares of patients with arthritis, depression, and asthma. We assume that this disenrollment pattern happens due to qualities of GPs that attract most patients, such as good communication and care coordination skills. For chronic patients who are intensive users of primary care it is important to find a GP that fits their needs, so they might change until they find the right match. Patients in the comparison group have, per se, no obvious reason to prefer GPs who specialize in any chronic disease, but it is likely they have preferences regarding GP qualities. Thus, our finding that in some cases the preferences of the comparison group and of the patients with chronic diseases align suggests that GPs' shares of chronic patients reveals information about these GPs' general qualities.

A puzzling finding is that all or most patient groups tend to disenroll more from GPs who have high shares of patients with DT1 and schizophrenia. According to Norwegian guidelines, these two patient groups' follow-up happens in secondary care, in contrast to our other patient groups. Patients who receive follow-up in secondary care could perhaps be more indifferent to which GP they visit for other acute illnesses. If so, they may be satisfied with GPs who have a practice style favoring patients who can be treated expediently over patients who need long-term follow-up. With this interpretation, the high disenrollment among patients with schizophrenia (Table 2) can be interpreted not necessarily as a search for a GP who is well-suited for handling issues related to schizophrenia but perhaps as an expression of other, shorter-term considerations.

GP specialization in general medicine has a negative relationship with disenrollment, suggesting that patients prefer to stay with specialized GPs. List length also has a negative relationship with disenrollment for all patient groups, except for patients with schizophrenia. Previous studies have found that non-chronic patients stay with GPs with shorter patient lists, meaning that they value accessibility [10–12], in contrast to chronic patients who value long patient lists, which is associated with higher disease detection [13]. GP's age is positively related with disenrollment for all patient groups, suggesting that patients in general may prefer younger GPs. This effect of age is supported by earlier findings [12]. For patients with arthritis, asthma, depression or DT2, this tendency is stronger for male than female GPs, perhaps because there are fewer women among older GPs than among younger GPs. In most patient groups, disenrollment was not significantly associated with GP sex, except patients with asthma and depression, who tend to less often disenroll from male GPs.

In all groups of patients with chronic disease, disenrollment increased with the number of comorbidities. This is consistent with the discussion above, given that management of patients with comorbidities is challenging for primary care providers [27]. Our selection of patient groups was not, however, designed to investigate the effect of comorbidities in particular. Future studies should consider including other diagnoses, such as cardiovascular disease and cancer. A higher number of visits to primary care also tended to increase disenrollment, but the negative coefficients for the dummy variable, identifying patients who had more than 23 visits in a six month period, may indicate that the relationship between disenrollment and the number of visits is not linear. Younger patients generally disenroll more often and, except for patients with epilepsy and other patients (sample 2), male patients disenroll less often.

This study has three main imitations: first, although the majority of the numerical data seemed reliable, we found that as many as 77.8% of patients with DT1 were also registered as having DT2. Such “double diabetes” cases are not uncommon [28, 29], but it is likely that most of the cases in our data are due to diagnostic uncertainty or registration errors. This may affect both the results related to the share of patients with diabetes (‘DT1_share’ and ‘DT2_share’), and the results for subsamples defined for patients with DT1 and DT2. Second, our data did not include potentially relevant patient variables such as cultural background, native language, income, educational background, or marital status. Disease severity and proper control of symptoms could also influence disenrollment behavior. To an extent, our random effect logistic regressions can account for time-invariant patient variables, but future studies should consider including more variables in order to assess their influence. Additional information about the GPs, such as cultural background, length of time in practice, and professional interests would also have been of interest. Third, the age distribution differs between our selected comparison group, sample 2, and our main sample of interest, sample 1. Sample 2's age distribution also differs from the age distribution across all groups in the full population without our specified chronic diseases. This means that the estimates for sample 2 in Tables 2 and 5 are likely to be biased, if interpreted as estimates for the full population. We believe that the qualitative aspects of these results would not be very different in the full population, but this is of course a conjecture. Future register-based studies should consider obtaining a comparison group with similar age distribution as the sample of main interest, for instance by drawing patients randomly from the entire population.

The data sets used in our logistic regressions were restricted with respect to municipality size. In smaller municipalities, patient options for disenrollment will be more limited by the fact that there are fewer local GPs to choose from. It is likely that including patients irrespective of municipality size would yield estimated effects less pronounced than those reported here – that is, compared to the full population, our result are likely to be biased away from zero. We also excluded observations where observed disenrollment seemed to be due to causes other than patients' preferences for GPs. Patients and GPs who move, or GPs who retire or die, are likely to have demographic characteristics (e.g., age) that differ systematically from the distributions in the full patient and GP populations. It is more difficult to predict how including these observations would have influenced our results, but it would at least have complicated the interpretations.

## Conclusions

The following conclusions can be drawn from our findings: 1) patients with chronic diseases are not allocated to GPs only by chance; 2) chronic patients that use primary care intensively disenroll less often from GPs who have a high share of patients with the same diagnosis; and 3) most patient groups tend to remain with GPs with a greater share of arthritis, asthma, and depression patients, which can indicate better quality care for these and other patient groups. These conclusions are distinct from the findings in the literature.

To investigate this further, more objective quality measurements should be obtained, such as adherence to treatment guidelines, surveillance of treatment outcomes for chronic patients, and user satisfaction in general. If objective quality differences are found, further assessments could be warranted, for instance, whether the current reimbursement system has an appropriate balance between capitation and fee-for service, or whether capitation should be risk-adjusted based on shares of patient types.

### Abbreviations
DT1: Type 1 diabetes; DT2: Type 2 diabetes; GP: General practitioner; KUHR: Control and payment of reimbursements to health service providers (Kontroll og Utbetaling av HelseRefusjon)

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### Availability of data and materials
The datasets analyzed during the current study were obtained from the Norwegian Directorate of Health. Due to legal restrictions we are prevented from making the data publicly available or otherwise sharing individual level data. For access to such data for research purposes, please contact the Norwegian Directorate of Health directly.

### Authors' contributions
AM conceived the study, prepared the data and performed the statistical calculations. Both AM and KRW participated in the study design, interpretation of results, and writing of the manuscript. The final manuscript has been read and approved by both AM and KRW.

### Competing interests
There author declare that there have no competing interests.

### Consent for publication
The patient data were obtained from public registers and patient consent for publication was not required.

### Ethics approval and consent to participate
The patient data were obtained from public registers and patient consent to participate was not required. The project has been approved by the Regional Committees for Medical and Health Research Ethics (REC South East), project no. 2011/1708.

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