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Evaluating health system effects of emerging digital primary care services in Sweden

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Jens Wilkens

DOCTORAL DISSERTATION

Doctoral dissertation for the degree of Doctor of Philosophy (PhD) at the Faculty of Medicine at Lund University to be publicly defended on June 17th at 13.00 in Agardhsalen, Department of Clinical Sciences, Malmö

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Abstract:

Digital contacts in primary health care have increased in Sweden over the last decade. From 2016, digital-only providers expanded publicly funded services, providing the opportunity for patients to meet primarily physicians online. The development improved access to care in several ways and digital services are indeed an attractive alternative for many. They are also potentially provided at lower cost than traditional services. However, digital primary care services have been criticised for obstructing a needs-based health care provision and catering for a demand that should not be met in a publicly funded health system.

The changing landscape of care seeking and service provision in digital formats is likely to continue and have fundamental health system effects. But the evidence base to support governance in this field is weak. The overall aim of this thesis is to evaluate health system performance effects of emerging digital primary care in the Swedish context, in relation to traditional-office based primary care.

The thesis consists of four specific studies addressing both clinical and distributional effects of digital primary care in Sweden, including: Investigating by whom and for which conditions these digital services are utilised; Developing a study protocol for comprehensive health systems evaluation of this new field of services; Estimating the effects on antibiotic prescription as a key indicator of quality, using regression analysis methods from the potential outcomes framework to mitigate probable biased sampling effects in the observational data, and; Evaluating distributional effects in service utilization from a socio-economic and health care need perspective, by applying concentration index analysis and regression methods to adjust for need.

The results add new evidence to the field by pointing to effects that were not documented earlier. It is shown how digital primary care services focus on mild infections and younger, urban patients. Further, that antibiotic prescription is less prevalent in digital primary care as compared to office-based provision, but with variation between diagnoses and associated with specific demographic factors. The results also demonstrate that, unlike in traditional primary care, utilization of digital primary care is relatively higher among high income patients.

The studies included in this thesis provide guidance to development and regulation of digital primary care services. But as digital services develop in their functionality and ability, new governing policies and studies of how they affect the health system are warranted, for which guidance is provided in the thesis.

Key words: Primary care, Digital care, Utlization, Equality, Equity, Antibiotic prescription, Health service transformation, Sweden

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MADE IN SWEDEN

How long is a piece of string?

It depends.

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Abstract

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Populärvetenskaplig sammanfattning

De digitala tjänsterna för patienter som vill ha kontakt med vården ökar snabbt i antal och form, är uppskattade i stora delar av befolkningen, och kan potentiellt spara resurser i vården. Samtidigt är förhoppningarna stora på att en utvecklad primärvård ska möta de ständigt ökande kraven på sjukvården. När digitala vårdmöten tog fart för några år sedan drevs nya plattformar fram medan traditionella vårdcentraler i ökande grad också utvecklade sina digitala kanaler. Men åsikterna går isär om huruvida digitala möten är medicinskt effektiva och om de lever upp till den prioriteringsordning för vården som riksdagen har slagit fast. Debatten är dock ofta baserad på svaga kunskapsunderlag.

Det övergripande syftet med den här avhandlingen är att utvärdera om Sveriges primärvård presterar bättre med den framväxande digitala primärvården. Avhandlingen ämnar svara på nyckelfrågor om i vilka avseenden digital primärvård bidrar till vårdens många målsättningar, i relation till traditionell primärvård. Den inkluderar publikationer med följande specifika studiesyften:

Beskriva vem som använder digitala tjänster och vilka medicinska problem som tas omhand; Presentera ett studieprotokoll som beskriver vilka dimensioner som behöver utvärderas, med vilka metoder, för att skapa en enhetlig och fullständig bild av hur digital vård bidrar till ett högre presterande vårdsystem; Utvärdera hur kvalitén och medicinska effekter skiljer sig från traditionell primärvård, med en specifik studie som svarar på om digital primärvård förskriver mer antibiotika, en högprofilerad fråga i svensk primärvård; Svara på huruvida utnyttjandet av digital primärvård fördelar sig mellan patienter som önskat, eller om det finns skillnader mellan digital och traditionell primärvård vad gäller förmågan att fördela vårdkonsumtionen efter behov utan att betalningsförmåga påverkar.

Resultaten bidrar till kunskap om digital primärvård, både genom att bekräfta vissa aspekter i den litteratur som finns med mer robust data och metodik, samt genom att visa på effekter som inte dokumenterats tidigare. Att digitala tjänster har vunnit gehör och mött en efterfrågan för främst milda infektioner bland yngre, urbana patienter är tydligt. Studien av antibiotikaförskrivning visar att den är lägre i digitala tjänster, men med betydande variation mellan diagnoser. Det är också tydligt att digital primärvård används i större utsträckning av höginkomsttagare, till skillnad från traditionell primärvård.

Den här avhandlingen skapar underlag för en mer initierad debatt och kunskap om i vilka delar digital primärvård kan förbättra den svenska vården. Denna nya vårdform, liksom all användning av ny teknik i komplex verksamhet som hittar en efterfrågan, kan bidra till ett bättre hälso- och sjukvårdssystem samtidigt som den ställer nya krav på vårdens reglering och styrning.

This thesis is based on the following four papers referred to in the text by Roman numerals.

List of Papers

Paper I

Ekman, B., Thulesius, H., Wilkens, J., Lindgren, A., Cronberg, O., & Arvidsson, E. (2019). Utilization of digital primary care in Sweden: Descriptive analysis of claims data on demographics, socioeconomics, and diagnoses. International Journal of Medical Informatics, 127, 134-140. https://doi.org/10.1016/j.ijmedinf.2019.04.016

Paper II

Wilkens, J., Thulesius, H., Arvidsson, E., Lindgren, A., & Ekman, B. (2020). Study protocol : effects, costs and distributional impact of digital primary care for infectious diseases - an observational, registry-based study in Sweden. BMJ Open, 10(8). https://doi.org/10.1136/bmjopen-2020-038618

Paper III

Wilkens, J., Thulesius, H., Arvidsson, E., & Ekman, B. (2023). Evaluating the effect of digital primary care on antibiotic prescription: Evidence using Swedish register data. DIGITAL HEALTH. https://doi.org/10.1177/20552076231156213

Paper IV

Wilkens, J., Thulesius, H., & Ekman, B. (2024). From office to digital primary care services: Analysing income-related inequalities in utilization. International Journal for Equity in Health. https://doi.org/10.1186/s12939-024-02184-6

Introduction

This thesis took shape within a research project that responded to a new phenomenon in health care service delivery; The digital forms of primary health care services, predominantly contacts between patients and medical professionals managed in a digital format. Since then, the magnitude has increased and although the idea of contacting and consulting patients remotely is not new, in the last decade, this form of care has developed into a standard alternative for a series of care services. Notable is of course the behaviour transition that took place with the COVID pandemic.

A parallel development is the revitalisation of primary health care in public policy. The strive for increasing these services in scope and scale, for accessible comprehensive first-line services, often with a preventive focus and aim to coordinate other care interventions, is globally seen as a means to both enhance patient responsiveness and outcomes, and the efficiency of a health system. Sweden is no exception, and strengthening primary health care is high on the public policy agenda.

The effects of increasingly using digital tools in delivering primary health care are largely unknown. The evidence base to support governance in this field is therefore also weak, even if care seeking behaviour and service provision will continue to change. The thesis builds on the premise that digital services change the structure and way of working of the health care system and thus affect how the health system performs, in many different ways. Many of these effects, with few facts on the table, are intensively discussed in media, among health professionals, and by policy makers.

In addition to affecting multiple performance aspects, there is also an almost endless number of digital tools implemented in health care, and they are applied in many different ways. In primary health care, many of them are disease-specific (e.g. for diabetes management) and many focus on a particular part of the care continuum for this disease (e.g. monitoring a set of medical parameters), others provide a general platform for the patient meeting. The challenge in answering what value they bring is multifaceted, and trying to be comprehensive in an evaluation is challenging.

The aim of the thesis

The overall aim of this thesis is to respond to the question of to what extent digital primary care services contribute to the attainment of health system objectives, as described in the Swedish legislation and related policy documents.

Because these objectives are multifaceted and complex, each one of the thesis's four publications builds up towards a broad coverage of various performance aspects. In particular, each paper frames a set of specific study aims. Paper I aims at explaining how digital primary care services are provided, how and by whom they are utilized, and for what medical conditions. Paper II aims to present a comprehensive evaluation approach, including data and methods, in the form of a study protocol, to answer to what extent this new field of primary care services is a plausible alternative relative to defined objectives. Some of the suggested studies are conducted within this thesis and presented in the subsequent publications. Paper III aims to evaluate a key clinical quality aspect in primary care, namely antibiotic prescription. Finally, Paper IV addresses distributional effects in primary care utilization, a performance area of high prominence in Swedish health policy, primarily by investigating if there is a risk that utilization relates to patients' ability-to-pay. All studies relate and evaluate digital primary care vis-à-vis the main alternative; traditional office-based primary care.

Key terminology and definitions

In this thesis, I define digital primary care services as remote interactions between the patient and a medical professional by means of some digital platform, typically a web-based chat or video application on a computer or a mobile device, such as a smartphone or tablet. From this follows that it includes text, sound, and images, and these can be delivered both synchronously (in real time) and asynchronously (store and forward). The terms e-visits, online, and virtual visits, are not used in the thesis but fall within the same definition in most literature.

The definition is narrower than what is typically used in definitions including the word health, such as eHealth, telehealth or mHealth, as the focus is the care provided through a consultation, which excludes applications aiming at education, information sharing, and patient monitoring. The definition is also narrower than most conventional definitions of telemedicine, as patient self-care as well as clinical decision support and communication for medical professionals are not within its boundaries. However, for cited articles I strive to replicate the wording of the author. For a useful framing of these topics and associated terminology, I recommend the OECD working paper *Bringing health care to the patient: an overview of the use of telemedicine in OECD countries* (Hashiguchi, 2020).

I have chosen to use the term *primary care* as opposed to *primary health care* all through the thesis, except in places where I purposefully use the latter term (notably in the Introduction and Discussion chapters). Although often used interchangeably, *primary care* denotes a narrower concept of the services provided by physicians and nurses specialised in family medicine, i.e., general practitioners and district nurses (by Swedish conventional terminology), while P*rimary health care* is a broader term, which also includes population-level interventions (Muldoon et al., 2006).

Outline

Following this *Introduction*, the *Background* chapter describes the growing importance of primary care in policy and strategy documents, and how digital primary care services have developed in the last decade. It describes the debate about digital services' advantages and shortfalls, which in many ways identified the need for research to produce evidence in the field. Further, the pandemic and how remote services have become part of standard care is discussed in the perspective of this thesis.

The next chapter, *Framing the topic of evaluating system effects of digital primary care*, provides the motivation to the different studies by elaborating on their aims. It takes a starting point in health systems thinking and explains the various performance dimensions evaluated within this thesis (notably antibiotic prescription and distribution of utilization), as well as some relevant dimensions that are not covered by specific studies (notably cost and cost-effectiveness). The particular difficulties in evaluating primary care are also discussed.

In the *Data and Methods* chapter, the database built and used for the thesis work is described. The analytical methods applied, and the particular challenges in drawing conclusions from analyses based on observational data, are discussed in relation to and with references to the studies conducted. The *Study results* chapter summarises the findings of the four papers by underlining the most critical findings and implications for both further research and policy application.

The *Discussion* chapter problematises both methods and results. It discusses how well the empirical studies meet the aims from the framing chapter, what should be developed further, and how the object of study, digital primary care, is developing currently and the challenges that brings. Towards the end, it has a forward-looking view on how digital primary care services are likely to develop in the near future and how that challenges research, policy and regulation. The final chapter, *Implications and further work*, includes separate sections for suggestions for policy development and for research.

Background

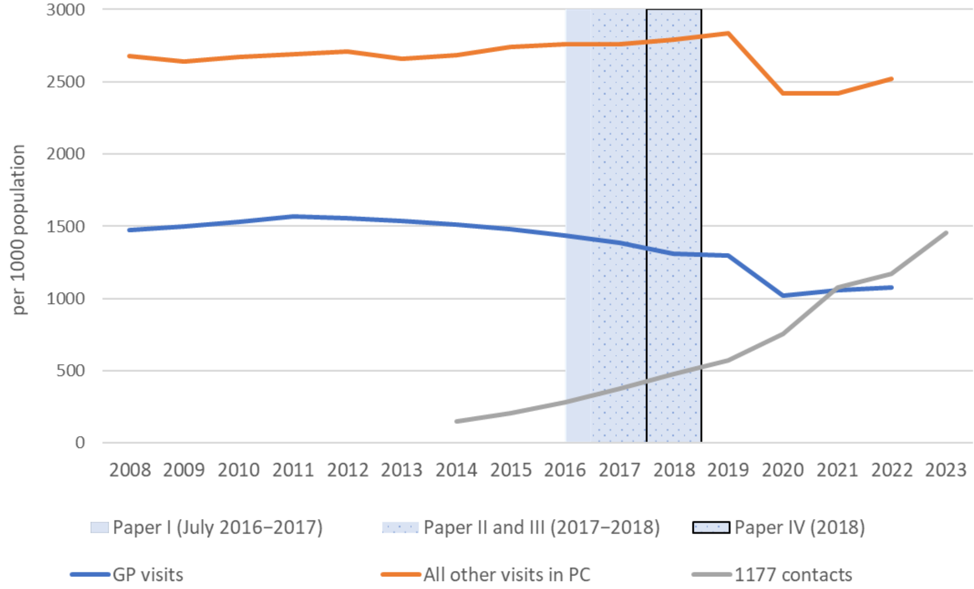
Primary care grows in importance but declines in physical visits

While Swedish health policy formulation has a strong focus on making use of the untapped potential in more comprehensive and effective primary health care, utilization measured as physical physician-patient visits has been declining for many years. Whether utilization of primary health care services broadly is declining is somewhat difficult to answer, as it ultimately depends on the definition.

Primary care physician visits had started to decline prior to most of the alternatives we now call digital care services had appeared (figure 1). At the same time, meetings with other staff categories increased, primarily with specialised nurses but also several other professions such as psychologists and physiotherapists, all working in the typically team-based Swedish primary health care.

A similar development can be observed in many countries. Although comparisons have to be made carefully as the definition of different types of care and professions vary, it’s still clear that primary care service utilization declines, especially in relative terms, in many countries (Ganguli et al., 2019). This is while primary health care has been revitalised in several ways and the list of reports pointing to primary health care as a key tool in providing universal health coverage efficiently is long. The Alma-Ata declaration from 1978, as well as recent years’ invigorated versions are referred to in many of them (WHO, 2019).

Figure 1. Visits to primary care clinics and phone calls to medical support service 1177 in the recent 15 years, and time frame of data for papers



Source: Verksamhetsstatistik from the Swedish Association of Local Authorities and Regions (skr.se)

In Sweden, a national primary care reform called *God och Nära Vård* (SOU 2019:29) took shape with a series of government reports. These discuss and suggest several policies to how primary care can increase its role as first choice of contact, ability to coordinate care, and disease preventive work. They also attempt to operationalise an earlier enquiry for more efficient use of resources in Swedish health care (SOU 2016:2), which among many other aspects pointed to how digital provision can be used more effectively. For example, it suggested shifting the legislated guarantees of waiting time from meeting a primary care physician within a defined time frame, to receiving an appointment (in any type of encounter) within a given time frame. This, it was argued, supports innovation as it does not lock in providers and patients into a specific format of care, but can still meet the ambition of promising access in reasonable time. The initiative *God och Nära Vård* has transformed into a large, national government funded, development program led by the Swedish Association of Local Authorities and Regions, including several work streams.

Digital primary care is driven by multiple factors

In Swedish primary care, private for-profit, digital-only providers started offering consultations nation-wide in 2016. The uptake of digital services for contacting a physician increased fast in the early phase of implementation. As described in Paper I, the number of digital contacts increased by approximately 20% per month from July 2016 to December 2017 and continued at a similar pace the year after. Soon thereafter the COVID pandemic induced an even faster development (see below). However, in absolute numbers, still after the COVID pandemic utilization was low compared with traditional contacts (Dahlgren et al., 2021).

Comparisons of types of contacts are difficult. As shown in Paper I, the medical content provided is not directly comparable. In addition, digital consultations provided by traditional primary health care clinics to their own listed population is growing and gradually integrating with face-to-face options, which is imprecisely captured in data collection (see the *Discussion* chapter).

The steady increase in digital services has probably been driven by several factors. Generally, for patients, the ease of access by means of digital platforms reduces barriers in the form of travel and waiting time, but also more subtle factors like the ability to be, or feel, more anonymous. Stakeholders responsible for health budgets, such as purchasers of services accountable to outputs and outcomes from spending, are all attracted by potential efficiency gains and savings on healthcare spending.

Swedish market features accelerated digital physician-patient contacts

The emerging digital services driven by digital-only providers is one of several organisational innovations in Swedish primary health care. It can be argued the regulation of the Swedish health system, and in particular primary care, has favourable market conditions for commercially driven innovation (Avby et al., 2019) and a conducive reimbursement system for the largely private new digital providers (Ellegård, Kjellsson et al. 2021).

Sweden has a long tradition of policy initiatives aiming at strengthening the patient's choice, within the publicly funded system. A fundamental step was the 2009 legislation *Vårdvalsreformen*, which enforced otherwise independent regional administrations nation-wide to introduce free establishment of primary care clinics, conditional on relatively basic medical capacity requirements (SFS 2008:962). The next decisive regulatory step increasing patient choice was a new patient rights legislation in January 2015 (SFS 2014:821), in which the choice of provider was made national, a fundamental shift in the regionalised Swedish health care system.

Important aspects for the private digital-only services that established soon after are that visit costs are covered by the patient's home region, while each region still decide about co-payment and referral rules. Also, the legislation is neutral to technique or form of contact, even though the opportunities in remote digital provision had another horizon when these legislations were prepared compared to only a few years later. In combination this has led to the opportunity for digital providers to formally establish their provision in regions where its most favourable for the patient, even if both the physician and the patient, in this publicly funded system, can still reside anywhere in the country.

Certainly, in combination with the free-choice reforms, there is one specific market feature, which was very effectively used by the digital-only providers at the onset of development. The old fee-for-service payment system for consultations outside the patient's home region, originally designed as an inter-regional billing system to cater for relatively rare visits, was used to charge a payment for each digital visit. As there were no objections to start with, volumes were very small, this became the ruling practice. However, when the future potential budget impact of the fee, with the cost estimate based on a physical visit, was realised, the Swedish Association of Local Authorities and Regions introduced a lower rate for remote contacts and the rate was subsequently reduced in several steps (SOU 2019:42).

Digital primary care meets the accessibility challenge

A key underlying factor driving the digital primary care development in Sweden may be the chronically low access to timely appointments with primary care services. The variation is large across the country in how responsive primary care clinics are, but it's not uncommon to have one week's wait or more, which in a European perspective is long, and arguably not conducive to an effective primary care and an overall efficient health system. The many ways in which accessibility to care improves with digital options are appreciated among Swedish patients (Gabrielsson-Järhult et al., 2021). However, as discussed in this thesis and elsewhere, this doesn't necessarily apply among older people (Nymberg et al., 2019) and expected gains have different weights for older and younger patients (Lu and Tsai-Lin, 2024).

It's also documented that, as compared to peer countries in Europe, access to primary care outside office hours is particularly poor in Sweden (Doty et al., 2020, Anell et al., 2012). One result of Paper I is the description of early digital services complementing office-based services in terms of time of the day.

The digital primary care development may also be supported by underlying factors outside the health system

A societal factor often referred to is that digital entrepreneurship is strong, with new service providers in many sectors, and an advanced digital society (Dahlstrand and Farrokhnia 2023). Indeed, internet infrastructure, digital maturity and eGovernence are relatively developed, which is evident in public statistics comparing European countries. Sweden has scored among the top four countries in the European Union's

Digital Economy and Society Index (Digital Economy and Society Index 2022) all years since the start of publication in 2017.

In interviews with 24 Swedish stakeholders among digital care practitioners and thought leaders in 2021, a set of conducive technical comparative advantages were specifically mentioned to be important for digital health service development, including effective broadband being widely available across the country, uptake of computers and smartphones, and widely used national systems for secure digital identification (Ekman et al., 2022a).

The COVID pandemic and sharp increase in digital services

In early 2020, approximately one year after commencement of this thesis work, a virus infection took the whole world with surprise, caused a spike in morbidity and mortality, and forced governments to impose limitations to individuals' freedom of movement on an unprecedented scale. Initially primary care provision was severely affected, but it also lead to a very sudden focus on opportunities in contacting patients remotely (Thulesius, 2020). This disrupted the scale and scope of digital utilization by new ways in which technology was applied. It would be difficult to leave the pandemic aspect out of this thesis, even though its key articles build on data from the time just prior to it. Utilization of office-based outpatient services generally fell globally, an immediate effect of restrictions in the public space and people simply opting to stay at home in fear of a pandemic we knew little about. Digital service provision at the same time expanded rapidly, in response to the limitations in travel and physical meetings, documented in almost an endless number of articles.

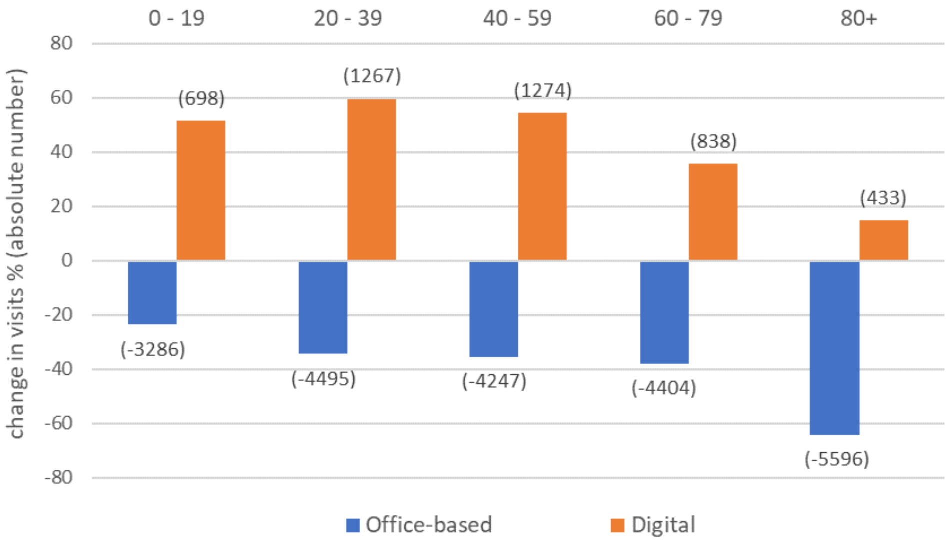
Sweden was no exception, and probably relatively well equipped for the response, at least in primary care broadly, for the reasons discussed above. There are a few aspects of particular importance for the theme of this thesis. Overall utilization, as measured in number of primary care consultations, fell sharply in spring 2020 but both traditional office-based visits and remote digital contacts were back to their respective long-term trends already after the summer. The former picked up close to pre-pandemic levels, but continued to decrease in line with the earlier trend. The latter, which increased sharply in spring 2020, in fact fell back quickly after a few months and has then continued to grow in line with the long-term trend (Ekman et al., 2021).

Demographic aspects are key to this thesis, as they have been extensively used as explanatory factors, in particular the variables age and sex. During the pandemic, men and women seem to have shifted their primary care seeking behaviour between office-based and digital services in a similar way (Ekman et al., 2021).

However, the response in utilization across age differed. Data from one Swedish region (Kalmar, population 247 000 in 2020) show that all age groups compensated the fall in physical office-based utilization with digital contacts to some degree from first half year 2019 to the same time period 2020 when the pandemic started (figure 2). Note that no age group fully replaced the change in physical office-based utilization (absolute number of consultations in brackets). The decrease in physical visits is most notable among elderly. Still, this group's utilization of digital services increased the least. This may be intuitive given authorities' recommendations for elderly to isolate and their lower digital literacy, but also demonstrates how disruptive technology changes, in this case triggered by an external chock, is picked up differently across the population.

Figure 2. Older patients did not compensate the loss of office-based utlization as much as younger patients during the COVID pandemic

Change in office-based and digital PC contacts by age groups from 1st half of 2019 to 1st half of 2020, Kalmar region, Sweden



Source: Claims data, Region Kalmar, 2020. From the presentation Digital care and the Covid-19 pandemic in Sweden: Preliminary findings using aggregate data, by Jens Wilkens at an online conference 13 November 2020, organized by the Swedish Collaboration on Digital Care Research (digitalcareresearch.se)

Governing bodies across the world were indeed fast in responding with new regulations to allow for more services to be provided remotely (Keesara et al., 2020). Also funding schemes were modified at an unprecedented speed. Primary care providers relying largely on fee-for-service or generally activity-based reimbursement met a fall in revenues, which risked to lead to redundant medical staff and closed provider capacity. In countries where this form of reimbursement is dominant, the response was designed in different ways. Some provided block grant funding support to passively sustain capacity, others saw the opportunity to ensure digital consultation were reimbursed at rates that incentivised providers to move over to this form of care (OECD, 2021). Sweden faced lower risk of this, as capitation is the lion share of revenue for primary care providers and restrictions on individuals were less sever.

The debate about digital primary care services' shortcomings

The debate has been fierce about the effects and at times even usefulness of digital primary services. One of the criticisms has been that they have moved utilization of care from meeting a medical need to an unjustified demand. With the ambition to strengthen patients' decision power (see the description of Swedish patient choice reform above) the separation of demand and need is particularly challenging. As digital services are in many ways more accessible, this balancing act between a needs-based allocation and patient responsiveness may well have been tilted towards relatively more demand as opposed to need. Early studies of digital care utilization showed that these contacts were largely additional in the sense that digital users did not contact traditional office-based primary care less often (Ellegård and Kjellsson, 2019a, Shi et al., 2018). However, these digital services may have met previously underserved patient groups.

Another criticism has been that new digital-only providers made coordination and continuity in primary care more difficult, by interrupting the traditional care seeking pattern and adding a provider that was not necessarily well integrated. Coordination and continuity are essential for effective primary care (Car et al., 2021, Starfield et al., 2005). It has also been noted by many that the fee-for-service payment used by digital-only providers (see description above) is not aligned with the capitation system and does not support integration with office-based primary care (Lindgren, 2019).

But strictly speaking, most of the research conducted so far assesses effects from single contacts. Hence the studies concern primarily 'the first contact', including Paper III in this thesis, and do not attempt to assess effects of a patient's episode or case. This limitation follows most studies on the topic, although some studies on Swedish digital primary care have embarked on defining or identifying a more comprehensive intervention (Ekman et al., 2022b, Ellegård et al., 2021).

What the debate has missed in large parts, is to differentiate between the technical platform as a mode of service delivery, from the market or organisation of this service, as implemented in Sweden and elsewhere. The digital format per se, with its superior information management opportunities, ought to be particularly well suited to function better than office-based settings with regards to coordination and continuity.

The fragmentation of primary care and the evident risk of discontinuity in care, in combination with the criticism that many appointments were made for conditions that did not lead to a physician consultation at all prior to digital services were available, meet in the area of pharmaceutical prescription and antibiotics. Especially among physicians, concerns were voiced about the risk that hard earned gains in lowered prescriptions rates would be lost. This concern was expressed also in other countries where these services were introduced on large scale (Iacobucci, 2019). This discussion directly shaped one of the studies in this thesis (Paper III).

What is new in terms of services, really?

In Sweden, the narrative is often that digital primary care started with the digital-only, commercially driven, providers that increased the service volume of web-based video and chat consultations from 2016 onwards. The volume of consultations and the increasing resources spent on these services, indeed warrants the increased attention to this type of provision. But one also has to recognize that the remote forms of consultation, and most of the technology we see in the market so far, are not new. In Sweden there are examples of innovations in tele-based consultations with hard-to-reach patient groups all the way back to services by Gothenburg's Sahlgrenska hospital in the 1920s (Olsson and Jarlman, 2004).

Closer in time, when the opportunities with internet emerged, a service that increased fast was searching for information by using internet. In 2002, 33.5% of the Swedish population used internet to search for health-related information (Spadaro, 2003). But also consultations, not very dissimilar from what is common now, have been around for some time. A descriptive analysis of 1998 to 2002 utilization of the Swedish asynchronous text service *Ask the doctor* was evaluated by similar aspects as in this thesis's Paper I: Distribution of age; Sex; In- and outside office-hours; Medical conditions, and; Utilization by population density. Most results pointed in the same direction as Paper I and similar descriptive studies in recent years, i.e. users of the text service were younger, more were urban, more women than men used the service and most of the utilization occurred outside office-hours. However, the spectrum of diagnoses seems to have been wider for the *Ask the doctor service* than current digital services (Umefjord et al., 2008).

Geographic distance is intuitively an obvious factor driving remote service development, and indeed video consultations have been applied for many years in northern Sweden, although often these telemedicine services have developed for the communication between medical professionals rather than the patient meeting (Sjögren et al., 1999). The fact that the increase of new digital primary care services, at least to this point, have been faster in urban areas runs opposite to how the opportunities in digital services were discussed earlier but also shows that the driving forces are complex and effects are difficult to predict.

That digital medical services as such are not new is also reflected in the data and analytical difficulties of separating what is a new technology and what is a new application and market of the same when evaluating digital primary care. The latter may for example be a scale-up of utilization or a shift of medical conditions and treatments. If we are not careful, effects are attributed to a technology change while what has changed is how and by whom its used (see further elaboration in the *Discussion* chapter below).

The research response

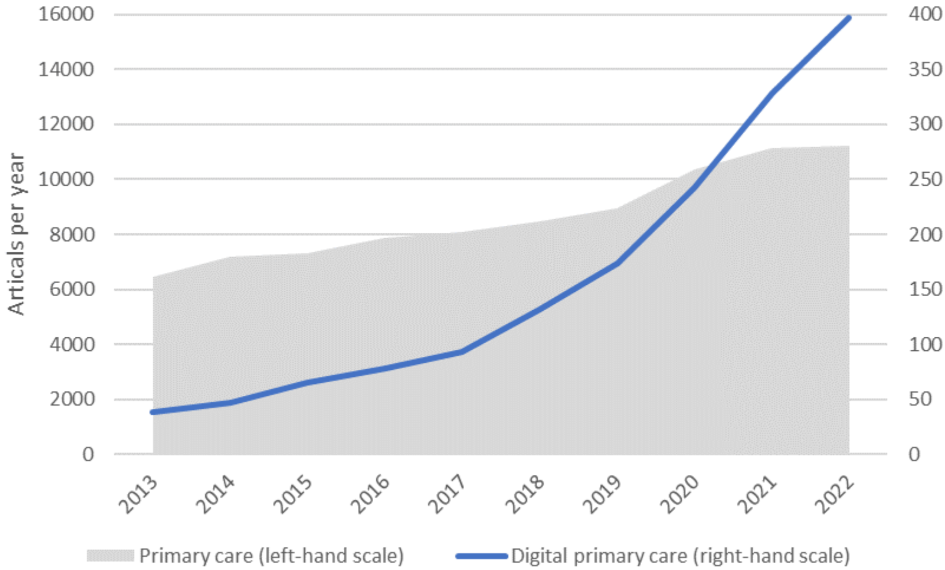
There are several challenges to this project linked specifically to a changing study object and context, which have developed in both scale and scope since commencement. At first, the scale aspect was most visible, i.e., the mere volume of service utilization. The fast increase and anticipated escalation in use of this service was an underlying primary motivation of the thesis, and is also documented and assessed in Paper I. In a longer perspective, the scope of the technology and medical content of digital primary care services will change fundamentally (see the *Discussion* chapter).

Evaluations of clinical quality and effectiveness, as well as objectives such as patient centeredness and equity in utilization, are arguably still lagging behind implementation of new digital tools. Evaluating fast developing technical progress, which transforms the entire sector during implementation are difficult to evaluate with its complexity, as interventions are constantly developing during implementation (Gomes et al., 2022). They seldom allow themselves to randomised trails and affect multiple outcomes, many of which are not anticipated and difficult to identify until time has passed. Indeed, theories of adoptive complexity seem appropriate for studying effects in digital health, but are in practice difficult to apply in evaluating concrete services (McNamee et al., 2016).

In clinical service development, hence where patients are involved, implementation of new technology without due evaluation of at least medical safety and efficacy is questionable. Still, it is very common to scale up digital technology in clinical settings, bypassing traditional market entry hurdles set up by regulators or purchasers (WHO, 2016). This challenge is also recognised by the Swedish regulatory authority (The Swedish Medical Products Agency) in a recent guideline on using artificial intelligence in health care (page 5): ”Finding the right balance between access to innovative technique and the need for thorough clinical validation will probably be a challenge in the foreseeable future” (Läkemedelsverket, 2023).

Logically, the sharp increase in digital services offered and increasingly utilized has been met by an increase in research on the topic. The volume of research on digital primary care has increased exponentially, much faster than the otherwise also growing number of scientific publications each year (figure 3). The most notable upward shift came with the COVID pandemic, although most research on digital care was not responding to the disease itself, but rather how providers and patients met in new ways (Hollander and Carr, 2020, Greenhalgh et al., 2020).

Figure 3. The number of publications on digital primary care increases much faster than on primary care generally



Source: https://pubmed.ncbi.nlm.nih.gov, accessed 18/04/2024. Search queries: Left-hand scale: (primary care) Right-hand scale: ((digital) OR (ehealth)) AND (primary care), [Title/Abstract] for all terms

The increase in effort to establish evidence about how to apply digital primary care services does not mean the evidence is more conclusive than earlier, as the field evolves continuously. A 2021 literature review concludes what is stated by many; There is lack of evidence about what works in scaling up digital contacts, which can support or justify the global efforts and enthusiasm about the opportunities in video consultation services (James et al., 2021). Also Swedish based researchers express the same lack of evidence (Hägglund et al., 2023b). These statements are likely to be valid for a very long time, as implementation of the digitalisation in health care is only at its infancy.

Framing the topic of evaluating system effects of digital primary care

Health systems thinking

From the onset this thesis had the ambition to cover multiple potential effects, hence the overall aim about digital primary care services' contribution to the attainment of health system objectives. These objectives can be defined somewhat differently, but most recognized frameworks are versions of how they were formulated in the World Health Report 2000 (WHO, 2000). A landmark aspect of that report is that the health sector has multiple objectives, which are broader than only patients' health outcomes (Frenk, 2010). The report has been widely criticized and debated for, among other limitations, missing out on essential goals (Nord, 2002) and overly simplifying complex contexts (Deber, 2004), but has after all gained recognition and a lot of practical use (McIntyre, 2010).

The links between a new policy or a new medical technology, like digitally provided primary care, and ultimate health system outcomes are difficult to evaluate. Often, it's more useful to work with intermediate objectives, which are easier to attribute to a policy or medical intervention. This can be for example the objective to improve access to services, either generally or for a specific population group identified to be undersupplied or have an unmet need. This objective is then intermediate because it is not the access per se that the system aims for but it's a performance aspect that can be assumed to have, or has proven to have, effect towards one or more final objectives.

To the complexity of health systems analysis belongs that often, but not always, health system objectives (intermediate or final) are competing, e.g. concentrating service provision can be a policy to increase efficient use of resources but it may also lead to inequalities in access to the same. Early on in large scale implementation of digital primary health care services, it was argued that specific services can be proven effective in some aspect, or save resources somewhere in the system, but still not be rational to implement, or vice versa (Atherton and Ziebland, 2016).

Describing a new technology in primary care, its initial effects, and how it can be evaluated (aims of papers I and II)

At the onset of this thesis, digital primary care had expanded over a short period of time, and raised a heated debate about its possible contributions to the Swedish health system and how well it performs. Few articles were available that summarised the emerging technical shift and hence, a study contributing to a broader understanding of digital care as currently under development in several countries across Europe and beyond was warranted. The purpose of Paper I was to present a descriptive review of digital primary care as it developed, by comprehensively presenting relevant aspects of who used it and for what purpose.

Paper I also served the purpose of fine-tuning the definition of the study object of this thesis, which is important not least because of the many different types of remote based digital services that are applied in the health sector. Digital care was narrowly defined as a primary care physician consultation over a digital platform in the format of text chat or video conversation. Reducing primary care to the physician's role is not optimal, but was initially a matter of data availability and desire to be stringent in comparisons. The subsequent studies of this thesis have shown that this limitation helps to separate evaluations by the specific functions of a particular digital tool. The suggestions for further work (see final section) includes a recognition that 'digital primary care' can mean very different things and then assessing it against multiple health systems objectives requires a very narrowly defined intervention. Hence, a further separation of chat and video had probably been useful, especially in informing the policy debate where the distinction is often not made.

Paper II, which is a study protocol, aims to present a comprehensive approach to evaluation of this new field of services. It describes the ambition of the wider research project this thesis is part of in three areas of investigation: clinical effects; costs; and distributional aspects. Each one of them is described in terms of suggested methods and expected outputs. Although each of these areas is broad and can be defined in several alternative ways, the health system approach helps to frame how different evaluations complements one another. As stated in the publication, the suggested set of evaluations also intend to merit for a health system approach to other emerging services, which claims to provide primary care either as an alternative or as a complement to traditional office-based care. An illustrative example of such is the global phenomenon to redefine the provider function of pharmacies from pharmaceutical dispensing units to primary health care providers.

Evaluating clinical effects of digital primary care (aim of paper III)

To meet the ambition in the thesis plan to evaluate selected relevant aspects of clinical effects following the introduction of digital primary care services, the starting point of formulating research aims for Paper III was effectiveness of care. Evaluating effectiveness in a service area like primary health care is complex and difficult. The care area is intended to provide health promotion and illness prevention and typically constitutes a wide range of contributors, and is often combined with many other service areas (Ryan et al., 2016). Hence both the nature of the intervention and the outcomes as such are difficult to crystallise, and include a large range of multiple associations, which effects are difficult to evaluate (Skivington et al., 2021, Craig et al., 2008).

A common starting point is to look at intermediary effects with regards to chronic conditions such as for example hypertension, diabetes and asthma. They represent a large share of the burden of disease managed in primary care and when managed effectively in this setting, do not require further interventions and thereby save costs and keep the patient at close to full health and a fully functional life. Therefore, a common evaluation dimension is how effective primary care is in attainment of intermediary objectives like decreasing specialist care, or avoiding hospitalisation, for these often called *primary* or *ambulatory care sensitive conditions* or *diagnoses* (Gibbons et al., 2012, Lamberti-Castronuovo et al., 2022)

Commencing the thesis work, I did indeed review evaluations of digital chronic care management in the literature. However, these are characterised by evaluating disease specific digital applications, or specific settings like home care (McFarland et al., 2021), or a particular part of the care continuum (Odeh et al., 2015). A few studies covered multiple effects but for one specific condition, for example virtual visits by patients diagnosed with hypertension (Levine et al., 2018). These disease- and tool-specific interventions can very well be effective as such and they hold a lot of promise for the future if they can be scaled up (Corbett et al., 2020). But for effects of general practitioners' or primary care offices' services broadly, research was and still is both difficult and scarce (Chambers and Schmid, 2018).

Finally, classical primary care effectiveness evaluations, like hospital admission rates for chronic conditions, obviously require a study population with these diagnoses. These conditions are however not what digital primary services have been used for in the Swedish context, and particularly not at the onset of these services. Chronic conditions were simply not observable at any large scale in the type of symptoms and diagnoses for which people were seeking contact with digital providers when the data collection for my thesis started. In addition, chronic conditions all have in common that the intervention is multifaceted and complex, often provided by many organisational entities, many of them at play simultaneously. This challenged the ability to evaluate clinical effects, as the outcome's attributability to type of interventions was difficult. Therefore, early in the project design, I concluded that assessing traditional overall indicators of effective primary care such as hospitalization rates for common chronic conditions, would generate severe attribution and effect measurement difficulties.

Antibiotic prescription as an indicator of effective primary care

In a health systems framework, quality and safety aspects can be seen as intermediate objectives to medical effectiveness, as they don't automatically give an answer to whether an intervention leads to improved outcomes. The ability to manage antibiotic medicines wisely and prudently is a rather specific quality aspect, but inhabits several characteristics, which makes it purposeful to evaluate in the frame of this thesis: It is a global challenge in which Swedish health care claims to manage well; It is of high relevance for trust in digital primary care development; And it lends itself to relatively reliable comparison between different providers.

Antimicrobial resistance is a large and growing public health problem, causing 33 000 deaths per year in the European Union countries alone (Cassini et al., 2019). The problem receives substantial attention by Swedish health authorities and professional organisations and their efforts to curb consumption of antibiotics have contributed to among the lowest levels of antibiotic use internationally, both in the human and animal sectors. In Swedish primary care, prudent prescription is encouraged financially and development of, and adherence to, treatment protocols has greatly improved over the last two decades (Mölstad et al., 2017).

As described in Paper III, fears of losing the battle against careless antibiotic prescription and use was one of the more common criticisms to digital primary care services in its early days, particularly in the Swedish specialised medical press *Dagens Medicin* and *Läkartidningen*. Conceptually, these fears were logically backed up by the digital provision's lower barriers to a prescribing physician by easier patient access online and a more anonymous patient-physician relationship.

The objective to estimate differences in antibiotic prescription rates between traditional office-based and digital contacts was therefore both a highly responsive choice vis-à-vis the policy debate, and an effect that lends itself to a relatively stringent analysis of a new technology in first-line consultations of non-acute patients. The specific analyses of how possible differences varied between groups of diagnoses depending on the availability of information for the prescribing physician was designed to build and test a hypothesis about what affects prescribing in the remote digital format. Similarly, investigating to what extent differences were associated with socio-demographic patient characteristics advanced the build-up of new evidence on this particular quality performance dimension.

Evaluating distributional effects in utilization (aim of paper IV)

A starting point in the objectives as expressed in Swedish legislation

The Swedish Health and Medical Services Act states health utilization shall be based on need, and more specifically, the individual with the largest need shall have priority (Hälso- och sjukvårdslag 2017:30). This has been a corner stone of the Swedish health system since at least the 1982 health legislation, which stated health and health care on equal terms as a key objective (Hälso- och sjukvårdslag 1982:763), but was not operationalised until 1997 with the so-called ethical platform for priorities in health care (1996/97:SoU14). The platform explicitly states that all individuals have equal rights to care. The second explicit criterion is that the medical need shall guide resource allocation. A cost-effectiveness criterion is ranked thereafter, but in practice only for prioritising between interventions for the same condition.

A key aspect for practical implementation of the Swedish health legislation is that it's s a framework for governance, not a rights-based legislation. Hence, health care responsible authorities on all administrative levels are guided by the legislation and operationalise it in different ways to the best of their abilities, balancing competing objectives and making judgements about how to best attain the stated ambitions in the legislation. Even though there is no concrete accountability mechanism for compliance to the legislation and the ethical platform (Sandman and Tinghög, 2011) one implication, among others, is that individual ability to pay must not be decisive in deciding who uses any particular health service.

Innovations and distribution of health care

For any health system to attain the highest possible benefits from innovation, the system has to ensure that care utilization and health gains are distributed broadly and across societal needs. Innovative disruptive changes in a health care system, in particular technical, seldom emerge from planned interventions by health authorities. In addition, they are often aiming for other objectives than equal or any form of needs-based distribution, but rather for example quality or efficiency gains. This is a challenge to local and platform specific innovation, as immediate expansion or integration with other services may not necessarily be an ambition of creators, and don't always meet conducive incentives to do so. Therefore, innovation to the benefit of many, especially designed to correlate with the need of the specific innovation, often doesn't come automatically in the health sector (Nolte, 2018).

The choice of measurement in evaluating how utilization of a new service is distributed

Evaluating attainment of the needs-based ambitions as expressed in the legislation requires a choice among many specific measures. The overall purpose with Paper IV in this thesis was to study to what extent digital primary care services could contribute to the needs-based ambition of health care provision in Sweden. The approach used in evaluating this, horizontal equity, meaning that individuals with equal need are provided equal (or at least the same amount of) treatment irrespective of socio-economic characteristics, was applied. This is probably the most commonly used approach in applied research on equity.

As discussed in Paper IV, different aspects of need can be considered. Because the definition of equity in utilization is based on a value judgement about services consumed relative to need, everybody should not necessarily be entitled to the same level of health care, not even if they have the same medical need. For example, if the ability to benefit differs between two individuals with the same need, it may be considered more equitable to provide them different amounts of care, so they attain the same level of health. Or a difference in intervention is required to attain the same level of health relative to their individual full potential, which may be different (Culyer, 1995, Acheson, 1978). The various ways to define equity are almost endless (Ma et al., 2023).

As equity, more so than equality, is dependent on a value judgement and the options vary, in practice, they represent a variety of objectives, which differ from each other and may even be competing. In Paper IV, I argue that if there had been a perfect measurement of care need, utilization distributed evenly across this need could be defined equitable. Computationally it had been simple and socio-economic indicators could have been left out of the analysis. But this approach would not explain if any socio-economic gradient was at play.

Ultimately the choice of approach is inevitably dependent on the data available. The alternatives in terms of source of data are also almost endless in equity analyses: survey or administrative; self- or professionally assessed health status; income, consumption or wealth measures as indicator of ability-to-pay, and more.

Cost, efficiency and cost-effectiveness

Hopes of cost savings in the form of efficiency gains, at least at a preserved quality of care, is an underlying notion in much argumentation about the benefits of digital care. Indeed, studies have shown that digital primary care services are most often provided at lower cost, and most certainly at lower cost per single contact (Rastogi et al., 2020, Ekman, 2018). Although this thesis does not include empirical evaluations of cost and cost-effectiveness dimensions, this section follows up on the study protocol (Paper II), which describes the approach to a cost comparison of office-based visits and digital contacts.

To know if digital provision is actually leading to lower cost than office-based care when transitioning over to digital means for a particular type of care, we would need to know more about how the single digital contact is used in clinical practice, as the intervention's cost is dependent on the complete episode of contacts for any one case. Only then the technology is comparable with the alternative. Also at the time this thesis was taking shape, clinical practitioners raised this challenge, e.g. as expressed in an editorial letter in the Swedish Medical Association's journal Läkartidningen, titled "Dangerous hopes of massive savings" (Akner, 2017).

Some studies have tried to frame the problem that any same specific medical condition might lead to different number of encounters by estimating how much one digital contact substitutes an office-based contact (Ashwood et al., 2017, Ellegård and Kjellsson, 2019b, Ekman et al., 2022b). With this knowledge in combination with the cost per contact, the provider intervention costs of the two alternatives are comparable. However, these studies on substitution effects primarily aim at an assessment of the budget impact (or fiscal implications) of digital service, not the cost of an intervention. This steams from the suspicions, or hypotheses, that digital services are either provided on an indication of lower severity and/or each contact is less effective in solving the medical problem and the patient therefore needs an additional contact for the intervention to have the same effect as a traditional contact. If previously unmet needs are now met by digital services, or this new service is less effective per contact, more contacts will be consumed and this leads to larger health care expenditure.

For traditional economic evaluation of a service or medical technology, a cost-effectiveness or cost-utility analysis, the intervention's cost is compared with the clinical effect or the health outcome respectively. In evaluating primary care, this is challenging for several reasons. The tool studied is intended for multiple conditions and in principle for any part of the care continuum. The outcomes of the service also range across a very wide spectrum. Another is that the attribution of the outcome to a specific intervention is seldom clear as its dependent on many other interventions (Bergmo, 2015, Gomes et al., 2022). When the clinical effect is reduced to further care consumption, evaluating single-condition digital tools is relatively more manageable, as intervention costs can be compared with avoided costs of complications, for example digital platforms for weight monitoring of heart failure patients (Haynes et al., 2020) or diabetes prevention (Sweet et al., 2020) to prevent unnecessary care utilization.

For mild infections, which represented the absolute lion share of digital primary care contacts under scrutiny in this thesis, one can argue that neither effectiveness in terms of lower further care utilization such as the Heynes and Sweet et al examples above, nor utility effects measured as standard quality adjusted life years, are relevant. Instead, Paper III on antibiotic prescription rates evaluates whether mild infections are over-treated with antibiotics. This does not mean treatment is effective, only that one of the potentially unfavourable effects of digital services is avoided. In the *Discussion* chapter, the implications of a cost-effectiveness approach to digital services are further elaborated, as future studies need to address this fundamental question of how digital tools can be developed, implemented and evaluated.

Data and Methods

A purposefully built database

To obtain a traditional primary care comparison with digital contacts for Paper I, data from one region (Kronoberg) in southern Sweden with a 200,000 population were collected. Hence, the data material used for Paper I on the one hand and Papers III and IV on the other, are collected in very different ways. Collecting data on primary care in Sweden is a challenge, which is further elaborated in the first section of the *Discussion* chapter below.

In response to the difficulties with applying nationally representative data sets that can compare the two types of contact, a broader data collection commenced to create a database that could claim to represent the country, as opposed to the many region-specific data collections in Swedish studies. The ambition to have a nationally representative data set and the variables included are described in Paper II. Data were collected from seven regions (Jämtland-Härjedalen, Stockholm, Örebro, Östergötland, Kronoberg, Halland and Jönköping), which can be argued constitute a fair representation of Swedish regions in terms of demographics, socioeconomic distribution, and rural and urban aspects. These data were then used in Paper III and IV.

An additional obvious missing piece in the data set for Paper I was that it does not enable linking socio-economic data to the individual utilization data points. In contrast to the fragmented health information system, Sweden has a national personal identification number and a consolidated and robust data collection system for socio-economic data, which gives vast analytical prospects.

Selection of diagnoses

The selection of diagnoses was based on the observations described in Paper I, i.e. the fact that three groups of mild infections were dominating among patients seeking digital primary care at the onset. To ensure a balanced and relevant comparison of the two types of encounters, the data selection was based specifically on all patient contacts who were given one of these most prevalent diagnoses: upper respiratory tract infection, lower urinary tract infection and skin and soft-tissue infection during the study period of 1 January 2017 to 31 December 2018. The concentration of conditions is a limitation in the subsequent studies, but probably supported homogeneity in the data and mitigated the risk of bias in estimations.

Data comparability across regions

A challenge in applying the uniquely created database was the variation in data quality across regions. Differences in data terminology, definitions, and coverage between regions created limitations to some of the analyses. After digital care was defined as physician consultations on a digital platform in Paper I, the data collection asked also for contacts with other professional groups. However, differences in definitions between regional health information systems across the country made purposeful grouping of professional categories difficult, as the number and types of values this variable could take varied. For the same reason, data on out-of-hours consultations with a national perspective in primary care was not possible to compile. The ambition to evaluate whether antibiotic prescription was a broad-spectrum antibiotic or not (by defined types of antibiotics) and if appropriate streptococcal testing was performed (see Paper II) was not possible due to the regions varying ability to respond with reliable data. In addition, the general impression is that even the fundamental diagnose coding varies by local tradition and individual practitioner.

Capturing individual level morbidity in the data material

We measured morbidity by a Charlson comorbidity index. The index is constructed by means of the diagnoses data from specialised care (outpatient and inpatient) from the Patient register at the National Board of Health and Welfare. The diagnoses are grouped with a validated method to construct an index value for each patient (Charlson et al., 1987). Originally designed to predict mortality, later versions of the Charlson index are extensively used for predicting utilization and thereby for example cost estimates (Charlson, Charlson et al. 2008), and as in Paper IV, as a co-variate for adjusting utilization (Ludvigsson et al., 2021).

Applying the Charlson comorbidity index with diagnoses from the Patient register is a weakness in that patients who are only diagnosed in primary care are defined as being at full health in our database (table 1 in Paper IV). The data thereby capture less people with a condition than overall in society. For the same reason, a set of binary variables for presence of chronic conditions, similar to what has been done earlier in Swedish equity studies (Gerdtham, 1998), was not possible.

The overall picture with lower disease burden among digital patients in our data is however in line with what is observed in the literature generally (Ashwood et al., 2017, Gordon et al., 2017, Hertzog et al., 2019, Ray et al., 2019, Shi et al., 2018). Well aware of this challenge, one of the sensitivity analyses conducted for paper IV showed that the inclusion of the co-morbidity index only had a marginal effect for regression results in the indirect standardization.

Differences in application of the project database between Paper III and IV

Because Paper III (similar to Paper I) measured unique patient contacts and Paper IV the volume of visits per patient, the database was transformed from a so called 'long-format' (one row per contact) to a 'wide format' (one row per patient) for Paper IV. When shifting from the long to wide format, some variables fall out of the sample, as only variables that are the same for each individual (e.g. age and sex) are kept while those that may vary by contact for the same individual are omitted. Consequently, to count the number of contacts per person, specific diagnoses were not possible to separate in the analysis, as some patients have multiple contacts with the same diagnosis, others multiple contacts with a variation in codes.

Analytical methods

Paper I applies descriptive analysis of the utilization of digital care by sex, age, place of residence, socioeconomic status, and most common diagnoses. In addition, we compared utilization with out-of-hours care and non-emergency telephone consultations. This angle has received little attention in assessing the role of digital services, especially in the Swedish context where primary care supply is relatively concentrated to the ordinary office-hours of the day. This aspect is also relevant for understanding the specific effect studies in this thesis (Paper III and IV), as out-of-hours primary care has a different antibiotic prescription pattern (Cronberg et al., 2020), and socio-economic distribution of patients (Jansen et al., 2020).

An obvious shortcoming of Paper I is the use of national data on digital care and only a single-region sample (Kronoberg) for office-based primary care. However, the data sample from one region made comparisons of specific aspects manageable, which due to varying definitions and data collection systems across regions would otherwise be difficult. The same approach was taken in a later article with similar aims, where a similar national sample was compared with region Skåne (Dahlstrand and Farrokhnia, 2023).

The sampling problem

With the registry (or observational) data comes the statistical problem that our binary intervention (or treatment) variable (an office-based visit or a digital contact) may be endogenous. This is even likely to be the case, as there are most probably unobserved variables of importance, which correlate with outcomes that we were interested in. This situation risks that estimates of any dependent outcome are biased and inconsistent. Data with randomised assignment of treatment is seldom available in studies of societal, wide-spread, phenomena. With the exception of studies on digital single-disease platforms, typically in their early stage of development, I have found no study on the effects of digitalisation in primary care with such data collection in the literature.

Measuring clinical quality and effectiveness with observational data

Paper III includes a discussion, which attempts to explain possible reasons for why differences in antibiotic prescriptions can appear, and in which direction various effects would steer. A fundamental difficulty described in the paper is that quantitative data from registers hardly differentiate between levels of severity within a diagnose, i.e. we may have unobservable confounders. We believe the new technology under study has lowered the access barriers to meeting the prescribing physician (see Introduction). This means we might find ourselves in the situation where the denominator in the share of visits leading to a prescription is simply much larger because a new contingent of patients with milder conditions have arrived, who would not have sought care at all if the easier access option had not been available. This logic and problem is very seldom mentioned in studies of digital primary care, but has been pointed out earlier (Iacobucci, 2019). As discussed in Paper III, surprisingly few published studies at all attempt to deal with the selection problem, except simply stratifying data by known confounders such as age and sex.

Quasi-experimental techniques

The strive for causal inference in non-randomized studies has challenged my thesis work throughout the entire process. A first-choice strategy (i.e. after a randomised data collection) would have been to identify the casual effect by applying a quasi-experimental technique. One such alternative had been to identify an instrumental variable, a variable that is random and can be assumed to affect the treatment variable X but not the outcome Y (more than through X). One such could for example be the distance of each patient to the office-based treatment alternative. This could have been assumed to affect the choice of provider type (a patient is more likely to opt for a digital contact if the distance to a physical clinic is long), but not have any direct effect on our outcome of study, such as for example antibiotic prescription in Paper III. Another plausible quasi-experimental method is a difference-in-difference model, typically applied when an intervention is implemented in pilot phases, e.g. first in a selected geographical area. Under certain assumptions, the difference in the change of prescription between the area where the alternative treatment is introduced and where it is not, can be interpreted as a causal effect. For the purpose of this thesis, data did not allow for any of these estimation techniques.

Carefully studying individual medical records could mitigate the selection problem, for example stratifying the observations by a classification of severity (Entezarjou et al., 2021). But this approach obviously comes with other challenges like data access to individual clinical records and a limited volume of observations, depending on study resources available. However, the latter can be solved with large language models in the very near future, if not already, when manual reading and assessment of such data is not necessary.

The potential outcomes techniques applied for Paper III

A common strategy to reduce the confounding problem in observational data is to apply a matching technique. Matching is a phrase representing a group of rather different methods, all building on matching of observations by means of variables available in the data material, so that 'intervention' and 'control' groups are created that are more useful for drawing conclusions about their relationship. In the simplest form, this means direct matching on covariates, either with one-to-one observations from the control and intervention groups, or to increase the sample size, one-to-several observations. The matching can also differ in exact matches (e.g. on age) or the nearest observation available on some defined scale.

For the study in Paper III, I used two propensity score techniques in the potential outcomes' framework family (StataCorp., 2021), which all build on finding the counterfactual intervention alternative for each observation. The methods build on that every observation has two *potential outcomes* (in the case the outcome is binary), one observed (factual) and one unobserved (counterfactual) and a conditional exchangeability of observations, based on observed covariates. In Paper III these co-variates were the socio-demographic background variables available in the database.

Both techniques used in Paper III work with the premiss to find a comparable propensity to choose one or the other type of contact, and then estimate the different effect on the outcome between the two interventions. The propensity score matching attempts to match patients so they have the same probability to be assigned (or in this case choose) either intervention (type of primary care consultation). The estimation is made in two steps, one to estimate the propensity to choose one or the other treatment, the next matches the observations based on this propensity. The inverse probability weighting instead creates a parallel 'pseudo' sample by replicating observations. Instead of matching, each observation is given weights, which are the inverse of the propensity score.

The use of an ordinary logistic regression model, a 'naïve' modelling of the association between intervention (choice of consultation) and effect (prescription) directly using only the background variables as adjustors, gave additional information for interpreting the results (see table 2 in *Study results* below).

Grouping diagnoses to detect differences in effect

In addition to using the propensity score techniques to meet a selection problem, Paper III also separated the diagnoses in groups that reflect key differences in case management. The approach is related to self-selection by severity, as this problem may play out differently depending on how the health care service can respond. I hypothesised that for some of the conditions, the prescribing physician had the same information in the two types of encounters (urinary tract infections), while for other conditions (throat and skin), the remote digital format has larger implications for what information the physician has, which might lead to another effect. Of course, the design cannot answer directly to the hypothesis, but only confirm whether there are differences or not. Although the grouping of diagnoses was based on national medical guidelines, the differences in information may not always be present in practice. The results indeed showed a variation between diagnosis groups, as prescription differences for urinary tract infection were lower than for the other diagnosis groups.

Challenges with index analysis in Paper IV

Measuring inequality and equity by concentration index methodology

The concentration index applied in Paper IV measures the accumulated utilization of the service across the population ranked from lowest to highest income. This results in an index value running from -1 to 1, with a value zero if individuals, regardless of income, have the same utilization. This is illustrated graphically with accumulated utilization on the y-axis and the income rank on the x-axis. This simple and intuitive measurement and illustration of inequality combines the advantages of a purely graphical illustration, like a bar chart in income deciles, and a composite index. The former can be illustrative and provides information about how inequalities vary across the income scale but doesn't necessarily give a conclusive estimate that lends itself to a decisive binary result. Sometimes decile or quantile comparisons are used to compare the highest and lowest, but that ignores the lion-part middle share of the sample. The index number and a graphical illustration based on a continues income scale gives both an exact composite number based on all data and can indicate if the distribution of the outcome variable changes across income.

A common critique of the concentration index is that the ranking of income does not inform about the scale of income inequalities, i.e. two different populations with the same index value may have large differences in income, but the individuals are ranked the same (Erreygers and Van Ourti, 2011). This relative measure of income related health or utilization inequality also means that if everyone receives an equal absolute increase in income, the index does not change. In this perspective, not only "equity" requires a value judgement about what is the right measurement, also something as simple as "equal" incorporates a value-based element of choice.

In the literature there is a debate about the difference between relative and absolute inequality, for example about whether the former is a problem when the outcome is utilization as in Paper IV, simply because it is not necessarily better with more than less health care utilization (Kjellsson et al., 2015, Pulok et al., 2020). This has implications for interpreting the results of Paper IV. Assuming the distribution across income of the two types of encounters stays the same over time, while digital utilization increases and office-based stagnates, the absolute inequalities would increase.

Income as the decisive socio-economic indicator

Income is used in relation to utilization in Paper IV, which is convention for good reasons, but not the only choice. We want to ensure that ability-to-pay is not decisive for who consumes care, as it would risk both equal and equitable utilization. But it's not obvious that income should be on the x-axes, neither in a simple index on equality in utilization nor in any measurement claiming to measure equity. First, the distribution of utilization across the distribution of another variable is not an absolute necessity. The analysis could have been simply along utilization, hence an index on the accumulation in one variable (like a classical Gini coefficient on income equality). As argued in Paper IV, if this variable was adjusted for need, this could then have been denoted an equity analysis. Further, the second variable applied could have been something else, for example education. Again, also for seemingly simple equality indexes, there are value judgements about what is 'equal' (Wagstaff et al., 1991, Wagstaff and van Doorslaer, 2000).

The ability-to-pay expression may be unfortunate, depending on interpretation. One could argue Sweden has mitigated individual or household ability-to-pay barriers with its publicly funded system. Residency in Sweden is both de jure and de facto a governing criterion for entitlement to publicly funded services. Except for some service exclusion for undocumented migrant groups, population and service coverage is very comprehensive. Rationing of resources comes through other mechanisms, probably waiting time being important. However, it's not obvious that we have no financial barriers to health services. First, co-payments apply in all regions, to a varying extent. And although these have nationally regulated ceiling amounts (separate for services, prescribed pharmaceuticals and transport), they add up and constitute financial hardship for some low-income groups (Glenngård AH, 2019). Second, these co-payments are there partly to govern utilization, hence they are by design intended to use individual's ability-to-pay as a factor in utilization.

The causality question, again

Finally, on causality and the concentration index. The index as such is obviously only descriptive. Then the decomposition method used in Paper IV, based on Wagstaff and colleagues' conventional approach from 2003, couples the concentration index with a simple regression method in which other variables' relation to the concentration of utilization is separated. However, the method is described as "factors of contribution", a use of language that gives a notion of a causal relationship. As referred to in Paper IV, there are alternative methods, proposed by Heckley and colleagues, which claim to solve this problem.

Study results

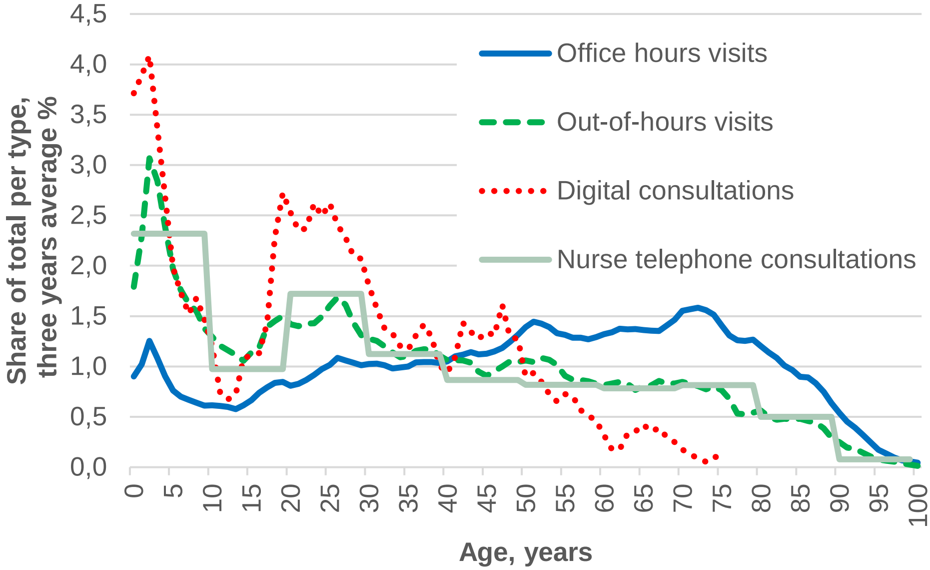
Digital contacts differed in several ways from traditional primary care (paper I)

From the perspective of this thesis, the results of Paper I purposefully describes both the situation at the time of its data collection and guides the design of which studies should come. The main results were framed around patterns of how the two types of primary care encounters differed. Digital primary care in Sweden increased rapidly over the 1,5 years covered by the data. Still, these contacts represented only two percent of all physician-led primary care. The low prevalence of these visits, the early days of applying this form of meeting patients, as well as the general lack of experimental studies, leads to that conclusions should be conservative and more viewed as hypotheses building rather than evidence of effect.

Digital patients were younger and sought contact for different conditions

A critical pattern of the study in Paper I was that digital care contrasted monumentally from traditional office-based primary care in age and diagnoses, but in many ways showed similar patterns as out-of-hours and non-emergency nurse phone contacts. With the exception of infants, young people generally utilized physical health services sparsely. This is true not only for primary care but also for narrow specialist outpatient and hospital services. Digital services as a new health care opportunity in Study I presented itself as more common among young patients, even more so than consultative phone services by nurses, and with a very low absolute number of encounters among older patients (figure 4). This naturally confirmed and raised concerns about how well the service meets needs-principles in utilization.

Figure 4. Visits and consultations by age and sex, office hours physician visits



Source: Figure 3 in Paper I

A decisive result guiding further studies, and the data collection for these, was the clear patterns of diagnoses coming out of Study I. Among small children and adolescents, mild skin conditions and upper respiratory infections were common, although skin conditions were the top group among both young boys and girls (table 1). However, the most substantial difference across diagnoses were in the wide group of young adults and middle-aged, which had relatively low office-based utilization, but constituted the bulk of digital contacts. For these patients, infection diagnoses were most prevalent in digital contacts while the traditional chronic non-infection diagnoses like depression, hypertension and myalgia were met in office-based visits. This documented the anecdotal and in other studies observed claims that digital services met a previously not managed disease burden, which still give raise to criticism about potentially unnecessary care utilization.

Table 1. Comparison of the most common diagnoses, by age groups and type of primary care: Total digital care; Total office-based visits; and Total out-of-hours visits, 2017.

Age groups	All	Women	Men
Total digital care, Sweden			
0-9	Non-specific skin condition	Non-specific skin condition	Non-specific skin condition
10-19	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
20-39	Acute URI, non-specified	Acute UTI	Acute URI, non-specified
40-59	Acute URI, non-specified	Acute UTI	Acute URI, non-specified
60-	Acute UTI	Acute UTI	Erectile dysfunction
Traditional, office-based visits, Kronoberg Region			
0-9	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
10-19	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
20-39	Depression	Depression	Depression
40-59	Hypertension	Myalgia	Hypertension
60-	Hypertension	Hypertension	Hypertension
Out-of-hours visits, Kronoberg Region			
0-9	Acute URI, non-specified	Acute URI, non-specified	Acute media otitis
10-19	Superficial wound	Acute tonsillitis	Superficial wound
20-39	Acute tonsillitis	Acute UTI	Superficial wound
40-59	Acute UTI	Acute UTI	Wound
60-	Acute UTI	Acute UTI	Wound

Notes: URI – upper respiratory infection; UTI – urinary tract infection. Source: Table 1 in Paper I

The data about which conditions were met by the growing digital services guided the subsequent data collection, and thereby the content and profile of the studies (see Paper II). Follow up based on the diagnoses pattern has however proven difficult. Similar results are confirmed in government reports (Vårdanalys, 2022), but national representation is still difficult to achieve in comparing office-based and digital primary care.

Inequalities already prevailing seemed to increase with digital services

Two factors commonly associated with relatively high health care utilization, urban residency and high income, were associated with [even] more use of digital services in Paper I. As measured in contacts per capita, Stockholm had almost twice as many visits as the second highest region (Skåne) and four times more than the rural regions Blekinge, Västerbotten and Norrbotten. As discussed in the paper, the commercial digital-only marketing efforts in large cities may have contributed to that high population regions had higher utilization.

The study related income to utilization on aggregated average municipal levels and illustrated that residents in high-income areas made more use of digital services (figure 5). This pattern is in line with overall health care resources utilization but contrary to how primary care is generally consumed, and thereby risks being contrary to the ambition of needs-based utilization. These findings, in themselves confirming some of the anecdotal evidence that flourished at the time, were then followed by an in-depth study using individual level data in Paper IV.

Figure 5. Per capita use of digital care (2017) and socioeconomic status by municipality (2016).

Source: Figure 5 in Paper I

The role of the digital primary care format

The results of Paper I also guided the understanding of which role digital care played relative to out-of-hours services and phone-based medical care support. These findings can guide both analytical work and discussions of what care function the digital format provides in primary care. Both the Introduction and Discussion chapters of this thesis include discussions of what is actually new in digital primary care, as they functionally and technically overlap with other means of communication, such as for example phone and email. A case in point is that Paper I showed how digital contacts, just like any form of care, had the most consultations on Mondays and the least on Saturdays. However, with more contacts in mornings and evenings the digital services mirrored utilization of (already) available phone services with respect to time of the day. The resemblance to phone contacts was also noticeable with regards to age, sex and conditions met.

Digital services did not compromise prudent antibiotic prescription (paper III)

The main result coming out of the study on differences in antibiotic prescription is that in digital primary care, a considerably lower share of the contacts led to a prescription. Hence, Sweden's many years of work with rational and prudent antibiotic use in the outpatient sector does not seem to be at risk because of emerging digital services. This result holds regardless of estimation model and group of diagnoses. Table 2 shows the crude difference in prescriptions and the results from a logistic regression model and the two propensity score models.

Table 2. Difference in prescribing probability between office-based and digital contacts, by groups of diagnoses and by estimation model [95% confidence interval].

	Crude differences in shares of prescription	Descriptive logistic regression	Regression by propensity score matching	Regression by inverse probability weighting
Total sample	31.5	.28 [.27, .30]	.33 [.29, .36]	.33 [.33, .34]
Group 1: Lower Urinary Tract Infections	41.2	.34 [.31, .37]	.41 [.28, .54]	.41 [.38, .43]
Group 2: Throat infections	52.3	.52 [.49, .55]	.52 [.49, .57]	.53 [.50, .56]
Group 3: Skin Infections	59.4	.50 [.44, .56]	.62 [.59, .65]	.60 [.57, .64]

Source: Summary of tables 2 and 3 in Paper III

For overall prescription in the entire sample, the difference between the share of prescription among the digital contacts and the share in the office-based consultations was 31.5 percentage points (called crude difference in Paper IV). Adjusting for the socio-demographic factors in the logistic regression model gave somewhat smaller difference between the two types of consultations. The estimated difference in probability of a prescription, i.e. simply adjusting for co-variates, was 0.28.

There was a significant difference between the two forms of consultation depending on specific condition. Urinary tract infections in women had lower differences in prescription rates than throat and skin infections. The grouping was made based on the differences in available information for the prescribing physician, with some diagnoses requiring image or visual data (skin infections) and others also laboratory information (typically throat infections). The study is not designed to claim a causality in these differences between diagnoses groups. But it does seem useful to carefully assess effects of digital services based on what differences there are in clinical management of the condition, and not stop at the adoption of a new tool for meeting the patient.

As described in the methods chapter, Paper III aspired to model the estimation of differences so that unobserved differences in choosing one or the other type of contact would not bias the results. Interestingly, the estimated differences in prescription were larger in both the two propensity models (except for throat infections). In other words, when individuals with the same propensity to choose either contact (based on socio-demographic characteristics) are compared, digital contacts seem to lead to even lower prescription.

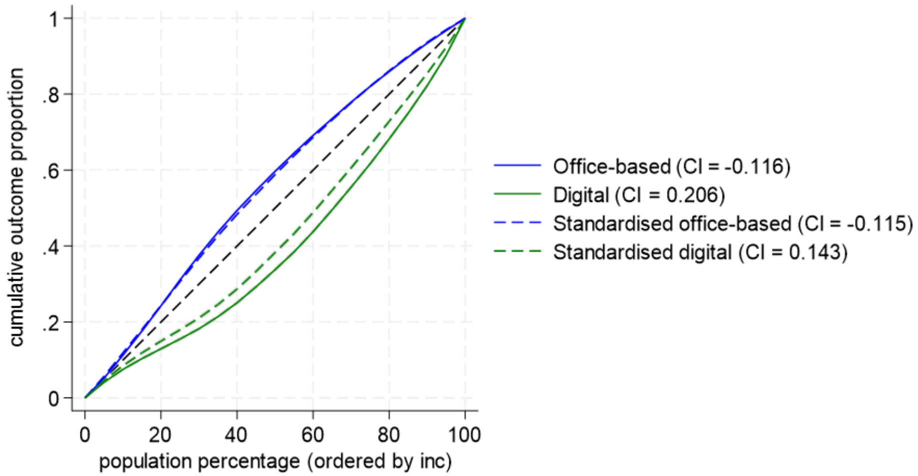
There may of course still be lower prescription rates due to a difference in indication or severity level within any one given diagnosis. And again, if patients have the same probability of antibiotic prescription for any same condition regardless of whether they contact an office-based or a digital provider, that would lead to proportionally lower levels of prescription in the more easily accessible contact form. But the larger difference when moving from a descriptive (or naïve) model to quasi-experimental models does strengthen the observation of prudent prescription in digital services.

Finally, to understand the socio-demographic factors at play with antibiotic prescription relative to the choice of care, Paper III also included an analysis of how prescription differences were associated with these patient characteristics. The results indicate that the choice of contact interacts with age and sex with regards to antibiotics prescriptions. Female and older patients had higher probabilities of prescription if they made a digital compared to an office-based contact. Hence, there seem to be a risk that even though digital provision is generally associated with lower prescription, groups with high prescriptions rates are prescribed relatively more in digital settings.

Utilization of digital services differed by income (paper IV)

The first and most important result of the study in Paper IV is that the two types of compared consultations showed large income inequalities and that digital primary care utilization was clearly inequal with a pro-rich distribution (concentration index 0.205, figure 6). The office-based visits showed a pro-poor distribution, similar to other studies of traditional primary care on the topic, with a concentration index below zero (-0.116). The latter also confirmed that the project database is based on a robust sample. The needs-standardised utilization did not change the distribution radically, although it did 'soften the picture' a bit. The sensitivity analysis also showed that the standardised estimates, as expected, are sensitive to the exact model specification. When controlling socio-demographic factors were excluded, the concentration index moved towards zero, although marginally.

Figure 6. Concentration curves and indexes (CI) for crude and needs-standardized office-based and digital primary care utilization across income



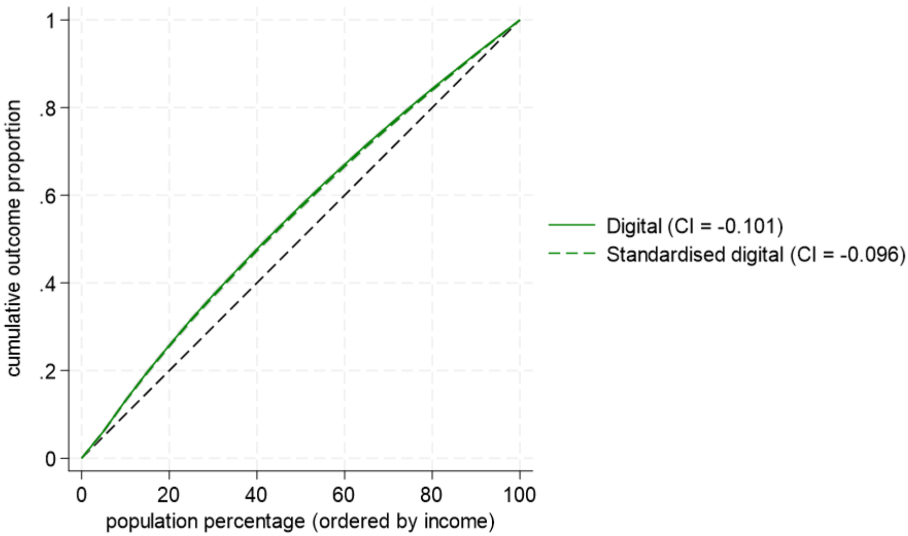
Source: Figure 2 in Paper IV

The result about inequality in service utilization with respect to income, is conclusive and aligns with the results from Paper I when the analysis was conducted on aggregated level with utilisation and income grouped on average municipal level. From a practical policy perspective, the analysis could end with this. The needed direction of change is clear, also before trying to define and measure equity, as the differences are arguably large enough to merit direct action on supporting low-income groups to make use of digital services.

To design the most precise and effective policy possible, more knowledge about the reasons for this inequality is needed, which is where the decomposition of factors of contribution to inequalities comes in. In Paper IV, the decomposition provided some indication to guide action. Even though the majority of the income related inequalities for digital services were unexplained, the results indicated that low education and being born outside Sweden are associated factors.

An interesting finding presented in Paper IV was that among only those patients who had at least one digital contact, the distribution of utilization was actually pro-poor (index value -0,101, figure 7), and even more so than for office-based services in the full sample. This means that within the population group using this service, utilization does not increase with income. The study did not decompose this distribution, and similar work should be part of follow-up studies, but the result indicated that the factors associated with income-driven utilization may work differently for digital users.

Figure 7. Concentration curve and index of utilization across income for patients with minimum 1 digital contact



Source: Figure 3 in Paper IV

Discussion

Digital services in health will continue to increase in volume and type of applications. This thesis aims to answer if emerging digital contacts in Swedish primary care are beneficial for higher attainment of a set of health system objectives. Not surprisingly, the studies conducted provided a mixed picture. Indeed, they presented conclusive evidence of some aspects. Already at this level of knowledge and evidence, it is clear that by advancing how, when and for whom digital services are applied, we can make better use of them. We know that satisfaction among users of digital health services is generally high, meaning digital services seem to increase health system responsiveness to population expectations (Gabrielsson-Järhult et al., 2021, Clemens Scott et al., 2017). In combination with expectations on efficiency and cost-savings and of course the technical development, digital services, in some format, will become increasingly standard practice.

This chapter discusses aspects related to the themes of this thesis, which are not covered in the papers but complement the studies and their results. The chapter is forward looking, moving the discussion of what has been assessed and evaluated so far, by discussing necessary development of data availability, analytical dimensions, and perspectives on what role digital primary care services can or will play in the future.

Data on primary care in Sweden are substandard

The PhD project's study object is primary care, which is generally a difficult health care area to describe and evaluate because of its wide scope of services and patients. In addition, the large elements of prevention and early-stage explorative diagnostics, core tasks in primary care, challenge evaluation methods because of difficulties in attribution and time-perspective.

In Sweden, there is no adequate national data collection on primary care and data look very different across the 21 regional health care administrations. This leads to slow, costly and not the least data quality impediments in research, especially research on new forms of consultations like digital contacts.

Regional authorities' cooperation on primary care data collection

The closest Sweden gets to a national database, which can serve as a comprehensive repository for primary health care data, is hosted by the Swedish Association of Local Authorities and Regions. Their database *PrimaryCareQuality* (skr.se/primarvardskvalitet) is a useful resource for many purposes. But the lack of individual patient level data and identification make it limited for several monitoring and evaluation tasks. In the same organisation's official activity statistics there is information on both outpatient office-based visits and remote digital contacts, but this distinction is not available for all regions. In addition, the statistics reflect the producer's perspective, i.e. there is no information on the patient's place of residency, a lack of distinction that especially devalues data on digital services (see 'anywherization' below). Information on the patient's age, gender and diagnoses is also missing. In summary, these statistics fail to meet demands for a wide range of assessment and research tasks, which hampers very standard monitoring of contemporary primary care development.

Logically, with more stringent national governance in health information systems, clinical medical records systems would not deviate as much as they do. The new medical records systems developing in collaborations between regional administrations are moving slow and national support is surprisingly low. A case in point is the so called SUSSA collaboration including nine Swedish regions aiming at developing a future joint health information system, replacing the existing record systems across the regions (Läkartidningen, 2023).

National authorities' primary care data collection

While specialist outpatient providers have been obliged to submit diagnosis and procedure data on individual level (with patient identification) to the so-called *Patient register* hosted by the National Board of Health and Welfare since 1987, this national data collection system still lacks most aspects of primary care information. The regulation of the Patient register does not allow for collection of data from primary health care centres (SFS 2001:707), in spite of many attempts have been made to enlarge the scope of the register.

The key obstacles to a national primary care individual patient level data collection, or rather excuse not to collect these data, are integrity aspects (Socialstyrelsen, 2021). But other health registers held by the National Board of Health and Welfare carry the same problems as a developed Patient register including primary care data would do. Even though the medical records for clinical use are built with a different purpose than system monitoring and research, there is a consent assumption in data collection in clinical practice, building on a general agreement to contribute personal data to research for quality improvement and rational use of resources, which is part of the informal contract between the individual and the government (local, regional, state) (Ludvigsson et al., 2015). It is reasonable to assume that most patients are aware the information is used beyond the direct clinical purpose, for monitoring and payment in the regional administration, but also for research. The same logic should be applicable to holding a national register of individual level data on primary care, which would support research similar to what is presented in this thesis.

The thesis's changing landscape and study object

A maturing policy formulation environment in Sweden

During the time of conducting this thesis, a normative development can be observed in the attitude to digital services in government enquiries and publications. It is safe to say that, in its infancy, the fierce debate about whether digital primary care services are any good at all has changed to a more insightful and constructive policy dialogue about how to make the best use of digital tools.

Redefining what the default is in providing primary care

In 2018, the National Board of Health and Welfare formulated criteria for when a digital contact is justifiable to use (Socialstyrelsen, 2018). The perspective was that the physical encounter between a physician and the patient is the norm but when a set of criteria is met, a digital contact can preferably substitute the physical (left column, table 3). Six years later, in 2023, a government policy document describes a very different perspective. Now, the suggested approach is that regional administrations must provide a remote contact in outpatient care (including primary care), unless a physical contact is necessary (Ds 2023:27). This shifts the 'default' option from the office-based physical meeting, to a "remote" (in practice digital) mode of provision.

Table 3. Illustration of change in public policy attitude about the role of digital care services.

2018		2023
Guiding principles by the National Board for Health and Welfare (Socialstyrelsen, 2018)		**Proposed new legislative text (Effektiv och behovsbaserad digital vård, Ds 2023:27)**
Digital care services are suitable when the following principles are met: 1. Legislation or medical evidence do not presuppose a physical meeting. 2. The digital service is adjusted to the individual patient's need and ability to use it. 3. The care provider has enough information about the patient's medical status to provide effective and safe care. 4. Necessary follow-up and coordination with other care providers is possible.[1]		The regional administration shall provide outpatient care remotely, unless provision by a physical contact is not considered necessary [for the particular case].[2]

It is probable that when the practical shift is made and most encounters are taking place in a digital format, the perspective of what is the default changes also in clinical practice. For example, once digital services are the norm for first contact services, the digital setting ought to be better placed to produce and manage "enough" information as in the 3rd guiding principle from 2018: *The care provider has enough information about the patient's medical status to provide effective and safe care*, simply because data collection can be automated easier in a digital setting.

Although (Ds 2023:27) is not yet legislation, it shifts the normative perspective of what should be the starting point for patient contacts in primary care. In the 2018 guiding principles from the National Board for Health and Welfare for when a digital contact is suitable, all criteria are equally important for a physical contact. By substituting the wording, they form an excellent description also of what is needed to provide qualitative traditional office-based services.

Sweden is of course not alone in its starting point that digital services are complementary rather than first choice. In Japan and France, provider-patient

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[1] Original text in Swedish: *För att vård och behandling ska lämpa sig för digitala vårdtjänster gäller att följande principer är uppfyllda:*
1. Gällande författningar eller aktuell kunskapsstyrning förutsätter inte ett fysiskt möte.
2. Den digitala tjänsten är anpassad till den enskilde patientens behov och förutsättningar att använda tjänsten.
3. Vårdgivaren har tillgång till tillräcklig information om patientens hälsotillstånd och sjukdomshistoria för att kunna ge en god och säker vård.
4. Nödvändig uppföljning och koordinering med andra aktörer är möjlig.

[2] Original text in Swedish: *Regionen ska erbjuda öppen vård genom distanskontakt om det inte bedöms vara nödvändigt att vården utförs genom fysisk kontakt.*

telemedicine services are restricted to after an initial face-to-face meeting between the physician and the patient, and in the former, the physician is responsible for deciding to shift over to a remote format of consultation. Several countries also require a physical follow-up meeting, or written consent by the patient that the remote consultation is enough (Hashiguchi, 2020). The governance of what is the natural starting point for a medical consultation is enforced by different means such as legislation, payment regulation, or medical guidelines. Arguably, relative to the common self-perception that Sweden is an innovative society, we are late in this transformation. Already in 2015, Ontario adopted a *digital first philosophy* in its digital health strategy, which intended to pave the way for purposeful use of digital services (Desveaux et al., 2019).

The perspective of 'default' or 'first entry point' meets different objectives

The demand for regulation of digital services was in its infancy largely driven by several stakeholders' frustration about the market driven digital services development and how it [mis]used differences in reimbursement mechanisms (see Introduction), jeopardising quality and safety of care in several aspects. Indeed, it can be argued that the proposed legislation from 2023 to change the default view from office-based to digital originates from an efficiency objective, as apposed clinical objectives of quality and safety, although these objectives are not necessarily contradictory.

It can also be more rational to see the digital option as default, but only conditional on specific criteria and medical indications, just like any choice of intervention for any medical problem. One learning from the English NHS 'digital first primary care' policy was that specific conditions only manageable face-to-face should not be subject to a compulsory referral via the digital contact (Helen, 2019). This is analogous to prescription policies aimed at restricting use of certain pharmaceuticals by allowing only narrow specialists to prescribe. This policy may be effective, but pending referral rules, it risks creating unnecessary visits to primary care providers only to get the referral.

Types of contact, and digital platforms, will develop continuously

Differences in diagnoses and place along the care continuum

Several results presented in Papers I and III showed that the effects of emerging digital services are not the same across medical conditions, neither in terms of how care seeking is distributed, nor in clinical effects, as exemplified by antibiotic prescription rates. These results complement other studies on digital primary care services providing emerging evidence about which specific services and conditions are effectively managed by digital services. Especially monitoring of chronic conditions by means of digital tools have been proven effective in many studies, but evidence comes predominantly from studies on single-condition tools and vary by type of condition (McBeath et al., 2022).

These differences in conditions met by different encounter types and digital platforms will continue to develop, as both digital tools among general primary care providers and condition specific platforms will advance. For any given condition, analogously to differences between conditions, the usefulness of digital services varies along the care continuum.

Integration of digital and office-based services changes the object of study

The largest and most notable shift in the Swedish digital primary care landscape the last five years is probably that digital means of communication has become a standard alternative for patient contacts also in traditional office-based primary care clinics. At the time Paper I was submitted, only five of the 21 Swedish regions had implemented a digital alternative for patients to communicate with their 'go-to' primary care clinic.

The literature has also documented the intuitively plausible effect that, for many patients, digital contacts work best when there is already an established relationship between the clinician and the patient (Greenhalgh et al., 2018) or when patients are selected for continuing the care pathway in a digital format (Shaw et al., 2018), as opposed to just randomly or at their (medically) uninformed choice do so only from a convenience perspective.

A recent interview study found two overarching themes that Swedish primary care clinicians argue are next steps in the development (Hägglund et al., 2023a). The first one was blended or hybrid care. This result possibly carries an aspect of *confirmation bias*, as it has been suggested and discussed in length since Göran Stiernstedt's government inquiry *Digi-physical care*[3] (SOU 2019:42). The second theme was technical innovation in the form of developed ancillary technologies, specifically those that can solve current digital limitations and make them more effective. For example, when the remote digital contact can include, or integrate with, other digital tools for remote monitoring, the argument that the physical meeting cannot be replaced changes. The physician doesn't have the same need for it when real time information about temperature, pulse, blood pressure, etc, is available.

Integration of services and implications for studied effects

Driven both by explicit policy and clinical development, integration of digital services, shifting them from digital-only providers to comprehensive primary care, may also affect the utilization pattern across patient groups and the population at large. The Paper IV study of distributional effects in utilization shows a clear

[3] In Swedish: Digifysiskt vårdval - Tillgänglig primärvård baserad på behov och kontinuitet

socio-economic divide in utilization of the digital service but even so a pro-poor distribution within the group of digital users. This is an important finding we don't seek to explain but hypothesise that once patients have started using digital services, this consumption may be distributed in a similarly pro-poor way just as traditional primary care. In other words, when the digital services are better integrated with office-based service provision, it may result in distributional effects, which will need to be incorporated in the evaluation modelling.

A recent study shows that digital primary care in two Swedish regions had larger utilization among patients with low socio-economic status, which may seem contradictory to the results in Paper IV, and most earlier studies on the topic. The study compares utilization across socio-economic groups in a population where all patients had access to an integrated digital tool used by the primary care clinic where they were enlisted (Eriksson, forthcoming). These providers were reimbursed primarily by capitation and hence had no financial incentives to meet the patient in one or the other type of contact, other than possible cost savings. The patients could choose which type of contact they preferred and faced the same user fees regardless of contact type, hence they had only time and travel costs to consider.

There may be several reasons for the intuitively contradicting results. The study measured different outcomes than Paper IV, and applied different methodologies. Also, although it is difficult to see that the actual consultation technique can make a significant difference, Eriksson's study was on a text-based patient-provider chat function. One hypothesis to explain the radically different results is that the selection of the study population was from medical records managed by the publicly funded and managed primary care system. Health care seeking behaviour for different types of service platforms may be decisive, which of course brings us back to the risk of biased selection in observational studies.

Integration, or a hybrid form of service provision, is a tool, not an objective

The Introduction chapter refers to the intense debate about how digital services may fragment provision and create discontinuity of care. Certainly, there are risks in this domain. But it is also helpful to distinguish between different parts of this fragmentation. Some of the most famous primary health care scholars (Car et al., 2021, Starfield et al., 2005) have suggested a framework with four core primary care functions, which are essential for effectiveness of primary health care. These, sometimes called 'the four Cs', are:

- (first) Contact;
- Comprehensiveness;
- Coordination;
- Continuity.

Further, the different aspects of the last function, continuity, have been suggested to be arranged into a hierarchy of informational (medical information across different healthcare encounters), longitudinal (duration and consistency of the patient-provider relationship), and interpersonal (trust and understanding of the patient) continuity (Saultz, 2003, Haggerty et al., 2003).

The first C, i.e. the first contact, is exactly what early digital primary care contacts studied in this thesis were about. The challenge of how well the other Cs work comes thereafter. But the digital format, in which all events can be recorded and sorted without any selected manual work, at least conceptually ought to be well-suited to coordinate care and create at least informational and longitudinal continuity.

The challenges with integration of service types are not at all new to digital primary care

The doubts and threats to continuity and coordination in primary care did not come new with digital primary care services. When electronic medical records became common, these opened for more than one physician or medical team to build and make use of patient information, documenting and sharing information more efficiently and effectively than previously. But that also opened new frontiers and challenges in patient care led by family medicine. Today, nobody argues that medical records better fulfil their function in health care when they are in paper format, i.e. in the hands of one clinic.

Similarly, in countries with different traditions with respect to team-based and single-doctor primary care clinics (compare for example Sweden and Denmark), continuity and coordination mean different practical patient management. Moving from one way of practicing primary care to another certainly challenges continuity and coordination, but neither electronic medical records nor team-based work are seen as determinant to achieve care quality, it rather depends on how they are applied.

Supply side factors in digital health are difficult to capture and are missing in much of the literature

Linked to the ambition to integrate digital and office-based primary care services, or create hybrid forms of service provision, is understanding more about who is providing services. Supply side factors may play a role in several of the aspects evaluated and discussed in this thesis. Paper III on antibiotic prescription separated appointments by physicians and nurses, and discussed among other things the fundamental difference in how triage is conducted in the two forms of encounters. Paper III also briefly discussed if younger physicians are more attracted to working digitally, as it has been shown that younger physicians can be more prone to follow guidelines than older colleagues, and referred to some evidence to that effect (Schmidt et al., 2018).

Because of the nature of the service, supply side factors of digital care cannot be studied the same way as traditional health care services. A case in point is the urban-rural divide in utilization documented in various ways in this thesis and in much of the literature, which starkly contrasts to the expectations we had on future remote services 10 years ago. In their telemedicine overview report from 2020, OECD described numerous country examples of remote digital services designed especially to provide care to difficult-to-reach patient groups (Hashiguchi, 2020), framed as opportunities with telemedicine. But because digital services can be produced and consumed in different places, it is not a matter of where the supply is located physically. Some of this divide can be patient side (or demand) effects, as for example differences in digital literacy. But there are probably also supply-side factors at play. In Sweden, marketing of services by digital-only providers has been more intense in urban areas but even if regulation of this has been suggested, there is no evidence of its effects (SOU 2019:42).

Is money well spent as we use digital services more often?

The chapter presenting the aims of this thesis ends with a section discussing evaluation of cost and cost-effectiveness of digital primary care contacts. As mentioned above, the ethical platform for priorities in Swedish health care from the 1990s has a third criterion; cost-effectiveness of interventions. This criterion is practically only used consistently for public subsidy of prescribed pharmaceuticals in out-patient health care. More generally, in the Swedish prioritisation tool-box, it is also used in developing medical guidelines, vaccination and screening recommendations, and other guiding documents, primarily by the national level health authorities.

In the standard situation, the cost-effectiveness analysis results in that the intervention is both more effective and more costly. The answer to whether the intervention is then societally beneficial on a large-scale implementation depends on whether the cost-effectiveness ratio is more beneficial than the alternative. Digital care services are often described as being both more effective and come at a lower cost compared with the old alternative, i.e. the new intervention dominates the old (in both dimensions). This is not common but when it happens, it should of course be applied instantly. It is also possible that a digital health service could be societally beneficial in a situation where it is less effective than the alternative, but still cost-effective due to a beneficial cost-effectiveness ratio (Klok and Postma, 2004). It may be politically difficult to argue for something that is in fact ‘worse’ medically, but the implication is that the saved resource would give more health by being applied somewhere else.

To approach an answer to whether new digital services are cost-effective, hence in principle whether they should at all be funded publicly in Sweden, we need more evidence on (incremental) cost-effectiveness and cost-utility ratios. This is so far very scarce in the digital primary care literature, except for single studies on disease-specific platforms.

What is present in the literature, is a discussion about why economic evaluation of digital services is so difficult (Bergmo, 2015, Gomes et al., 2022, Mumtaz et al., 2023, Brönneke et al., 2023). Gomes and colleagues summarise the difficulties by comparing the cost-effectiveness evaluation approach between interventions that are traditionally assessed, and digital service interventions. Table 4 lists the summary of challenging aspects along Comparator (what product/service is compared), Product evolvement (how the technology develops in the market), Patient involvement (which affects both costs and effect), Costs (of providing the service) and Effects (as measured typically by quality adjusted life-years in a cost-utility evaluation or a clinical indicator in a cost-effectiveness evaluation).

Table 4. Challenges in cost-effectiveness evaluation of digital services

	Pharmaceuticals and Medical devices	Digital intervention	Implications/ mitigation need
Comparator	Usually a well-defined comparator, e.g. placebo or competing device.	Mix of new and old, often only complementing the old alternative or requiring complex integration.	Consider both digital and non-digital comparators and whether the latter replaces or complements existing technology.
Product evolvement	Fixed or predictable updates.	Continus and driven by many stakeholders.	Account for the rapid evolution and its impacts on costs and benefits, and the timing of the analysis.
Patient involvement	Passive, generally limited to compliance.	Active user input (patient or physician) always required.	Consider user time (costs) and user experience (benefits).
Costs	Most often constant and linear.	Fixed (development) and variable costs (very marginal). New opportunities in sharing. Cost savings huge but dependent on large care system transformations.	Development costs not always included in cost analysis. Mean cost per user should be based on the eligible population and expected uptake rates.
Effects	Most benefits reflected by individual health changes, but long term.	Often instant feedback of gains and other effects. Larger variation in effects. Esier involvement of family members.	Include non-health benefits, include both to patients and other parties (e.g. health professionals, carers). Consider all relevant impacts outside the health care sector.

Source: Author’s own adaption and summary from (Gomes et al., 2022)

A recent literature review on cost-effectiveness of artificial intelligence tools in health care describes similar problems as in Gomes et al and Bergmo et al, with the additional caveat that these same challenges in evaluation will be exacerbated when more advanced machine learning becomes increasingly common (Vithlani et al., 2023).

What is new in digital primary care?

While the definition *digital primary care* provided in the introduction above is wide, the digital services studied in this thesis and most research referenced are narrow in scope. The study area therefore requires a portion of demystifying for the purpose of putting this research in perspective. The actual remote digital contact studied has not in and by itself changed medical practice, yet. First, ordinary telephone appointments, planned or not, have been around as long as the telephone (Mermelstein et al., 2017). The same is true for ordinary email systems, although integrity and patient identification is difficult outside purposely designed systems. Then trying to make use of interactive video technology to advance the meeting between the patient and the medical professional is an endeavour documented at least back to the 1950s, even though the appearance of internet naturally meant a disruptive change (Moncrief, 2014).

Strictly speaking, the development of digital primary care services as available to date, generally means moving a conversation between the patient and a medically educated professional from taking place in the same room to an arguably similar conversation remotely. This digital contact has not, yet, changed considerably since the onset of the service a few years ago. It’s still one-to-one contacts between a patient and a medical professional managed by either text-based asynchronous messages or synchronous meetings on a screen, or a combination thereof. A large share of the contacts provided in these digital formats have a medical service content that is similar to traditional phone calls (as for example illustrated in Paper I). This shift in itself does not necessarily qualify for being called an innovation, at least not unless it transforms the patient-physician meeting in some way.

This also leads to that there is a substantial lack in documentation and research of how the content of the medical consultation has changed. Recent developments, with elements of digital triage systems, increasingly making use of artificial intelligence by large language models, enables medical guidance before, during, and after the encounter with a human medical professional (e.g. new applications in the Swedish 1177 service). Even though a digital triage function was shown to evert some unnecessary physician visits already at the turn of the century (Bergmo et al., 2005), these interactive systems, which don’t need medical staff all through the contact, are embryos to what *digital health services* may mean soon (Hamidi and Roberts, 2023).

Digital services soon, and research and regulation of these

The effects of relatively less face-to-face time are not studied

A common complaint in Sweden is that medical staff have too little time per patient to provide services of good quality. Digital tools have the opportunity to increase both frequency and time per visit. This will however come with relatively less time face-to-face, as for example the new triage systems indicate. When face-to-face contact time decreases and is increasingly replaced by eHealth solutions, there are valid arguments for that "humanitarian" quality of primary care may be in jeopardy (Boers et al., 2020). The argument goes back to continuity and person-centred care (Rudebeck, 2019), but ultimately the effects of less of the patient's time spent personally with a medical professional and more with a software are not yet known.

Different technologies will have different distributional and thereby equity effects

As discussed in Paper IV, there is a need to try to separate what is effects of the technical platform from effects of how its applied, including market conditions under which they work. The effects documented in the study can be mitigated, especially if their causes are better understood. Technological innovation can work both for and against equity objectives (Weiss et al., 2018), and looking forward digitalization will increasingly make use of artificial intelligence. This will mean the distributional effects on utilization will also be affected by other mechanisms than the format of contacting a physician, as studied in this thesis. For example, with the currently dominating large language models, the risk of algorithm bias increases, in which inequities can reinforce themselves if not managed (Smith et al., 2020, WHO, 2023).

The reimbursement debate and regulation will need to start new, with much better understanding of new technology

The fee-for-service model that has been applied with the non-residency reimbursement scheme used for digital providers in Sweden is particularly ill-suited for prevention and chronic care management, a large part of traditional, and future, primary care. There is an underlying problem in that strategically purchasing prevention is difficult, as it is difficult to attribute the health gains in a population group to the efforts of a primary care provider, or a network of such (Barros and Martinez-Giralt, 2003). For preventive services like immunization, fee-for-service and performance based reimbursement can be effective, but for chronic conditions the right incentives are harder to establish by these payment mechanisms (Zwaagstra Salvado et al., 2021). By extending performance-based payments for specific quality related results or adherence to guidelines, chronic conditions are more recently approached with attempts to apply long-term value-based reimbursement models. There are several techniques for this, for example impact bonds, combining a strict population group responsibility with payment based on specific health outcomes.

Appropriate public funding of digital services will probably also be increasingly difficult when more and more of the service content is shifted from human led activities to algorithms, and even more so when machine learning is used effectively. In line with the Gomes et al review of difficulties (see table 4 above) and also discussed in a literature review (Wolff et al., 2020), artificial intelligence will drive the marginal unit cost for many out-patient health care visits towards zero. Then fee-for-service reimbursement schemes for digital primary care seem irrelevant.

Research on the next generation of digital health care services will be very interesting but at least as difficult

The challenges with evaluation of digital primary care described in this thesis will be further exacerbated with artificial intelligence techniques. The understanding of what the new technology is actually doing, and explaining it in a research article, is already an identified difficulty (Vithlani et al., 2023), as well as the difficulty in evaluating a service that by design is highly personalised and therefore work differently between patients. Similar to earlier telemedical innovations, the tools evaluated are largely targeting single conditions, and effects after these tools are integrated into for example primary care clinics' practice, are unknows (Jiao et al., 2023).

Implications and further work

Suggestions for policy development in the Swedish context

Separate the technical platform regulation from provider market regulation

In the sometimes heated debate about benefits and shortfalls of digital primary care it has been difficult to separate different modes and technical platforms of care provision from the market structure and public reimbursement aspects. In 2022 the Ministry of Social Affairs assigned Björn Eriksson to investigate how digital providers can become a more ”continuity-based part of digiphysical care” (Ds 2023:27). The assignment carries the same intrinsic problem as this thesis, which is the separation of the mode of service provision (i.e. the remote digital contact) from the characteristics of the organisational entities that have hitherto provided them (i.e. digital-only providers).

The question is not so much about what is beneficial to do on a distance, it’s how the different forms of care are organised relative to the task of a particular medical condition. If a multiprofessional team is needed, the one-to-one digital contact is ill suited. Similarly, when an integrated service-chain along a care continuum and clinical record sharing is important, digital services organised and purchased in parallel to other services are ill-suited for the task. This can however not be blamed on the platform technique itself, but on how its applied. Conceptually its rather the opposite, i.e. digital services ought to be particularly well suited for connecting multiple professionals and sharing information.

Recognize that both production and consumption can take place anywhere

When services are provided from anywhere and patients can reside anywhere, regional responsibility for guidelines and regulation as well as patient entitlements will be increasingly difficult. This ‘anywherization’ is exemplified by the antibiotic prescription studied in this thesis, as regional regulation and incentives for prudent prescription will be less effective when provision and utilization are delinked from geography.

Explore ways to manage the growing responsibility gap

Dual provision of primary care with digital-only providers not taking responsibility for medical results and complex needs, as described in the debate about emerging digital primary care services, is an example of a responsibility gap. This is not new. For example, many surgical procedures are provided across Sweden, for which the patient's home region assumes responsibility for follow-up. With new digital services, this will increase. In the longer perspective, there will increasingly be providers that are not even presenting a medical professional, but provides a consultation with a non-human speaking partner. The health sector shares this responsibility gap with most other sectors (de Jong, 2020).

Respond to the distributional failures of digital primary care services

This thesis clearly documents lower than desired use of digital primary care among both low-income groups and elderly, in addition to indication of low use among several more groups, who generally have large health care needs. It is documented that older people in Sweden value continuity in care relatively more (Cohen and Lindman, 2024). Regulation and integration of digital primary care can give more focus on ensuring appropriate care for health conditions, which are common among elderly. Preferences of this age group are documented and do not correlate well with the mild infection diagnoses commonly managed in digital services at the moment (Kastbom et al., 2024).

Rethink public purchasing of digital services based on the nature of the service

The attempts to identify a 'true' price on digital services is doomed to fail and a new paradigm for funding highly scalable health services is needed. One of the specific system features enabling the early consumption of digital primary care services was driven by the fee-for-service payment system for consultations outside the region of residency (see Introduction). Soon, regions agreed that the price-tag of a traditional visit was not reasonable for a remote digital contact. The lower cost per contact was also documented by early research (Ekman, 2018, Ekman et al., 2020), but whether a medical case and the associated episode of contacts in fact comes at a lower cost has been more difficult to document, as it depends on case definition and substitution rate. The leading approach in recent years has been to encourage traditional primary care providers to open digital entry points to their clinics, in line with the ambition to develop hybrid integrated service models. This should be seen in the light of the parallel development of value-based approaches to paying for health care. Fee-for-service models are increasingly seen as outdated and replaced by various versions of trying to pay for outcomes related to defined bundles of services (Zimlichman et al., 2021).

Suggestions for research

The funding application to Forte from 2018, leading to a grant which partly funded this thesis, says: *The overall research question posed is to what extent such care* [digital] *is a cost-effective and equitable alternative to traditional primary care in the Swedish context.* The subsequent studies have indeed delivered a range of answers to this question and contributed to moving the front of knowledge forward. It has also revealed a range of aspects, which call for further investigation.

Recognize the large variation in case-mix within diagnoses

The next generation of studies with a similar ambition will need to be more specific about the study object. The question will increasingly need to address the application of the technology for those condition and indication segments it serves, rather than the technology itself. The analogy is the Swedish approval process for including a new pharmaceutical in the public benefit scheme by The Dental and Pharmaceutical Benefits Agency (TLV). The agency's subsidy decisions are not based on the assessment of a new drug per se but to a specific application of it, e.g. based on a set of indications, or other sub-groups of condition or patients. The risk of overuse of a technology with subsidy approval applied on patient groups for which they are not cost-effective is common, and tend to increase with multiple providers (Copp et al., 2024), which is exactly how the digital care market develops in Sweden.

Being specific about condition and indication is not only for cost and medical effectiveness studies. An early review identified factors of patient satisfaction with digital health services (Clemens Scott et al., 2017). Knowledge of these factors could help implementers to match interventions as solutions to specific problems. In Paper I it was explained that digital services may replace office-based visits for some conditions but replacing very little of others. This is not only concluded from a medical provision perspective but also because patient groups have different care seeking behaviours.

Increase understanding of causes to the distributional failures

Some of the differences in utilization along factors like income and age are easy to understand and well documented. Other differences need more research to understand underlying factors and what would be effective policy. As the formal financial barriers are low, care seeking behaviour among low-income individuals may benefit from more empirical research. The decomposition in different factors (Paper IV) gives indications, but there are probably underlying causes to these differences, e.g. varying digital literacy across these factors or supply side factors inducing demand.

Design studies that use large language models on medical records data

The future of large language models can probably solve many of data collection problems. In the data used for this thesis there is a large variation in case-mix within the population seeking care, which is most likely not fully observable by the variables at hand even if patient groups are selected very carefully. For example, it is plausible that within a group of urinary tract infections coded the same way, there is a pattern in how patients choose type of primary service depending on how severe their symptoms are. Most studies separate and/or adjust for age and sex in estimating effects, but do not relate to the selection bias problem in generating the data sample. Careful text analysis of clinical records, which have been applied in a few studies (Entezarjou et al., 2021) can handle the 'within diagnose' case mix problem but this naturally puts a limitation to the number of observations that can be managed in a study. This is now changing with various types of large language data models.

Retail care services are similar in many aspects and studies on digital primary care services can be replicated for these

Health care services for relatively mild conditions, which may or may not have been underserved previously, are in parallel to digital services emerging in many health systems by the name of retail care or walk-in clinics. Broader scope for pharmacies' service provision like the NHS Pharmacy First and similar (Stewart et al., 2018) can have a similar function in a health system. These services' care is often promoted with similar arguments of lower access barriers and relatively low cost, and can complement and in parts substitute traditional primary care modes of service provision. They also carry similar challenges in that while they meet a demand, regulators and purchasers have little knowledge and evidence as to how they integrate with other health care and whether they are cost-effective and equitable from a health system perspective (Hoff and Prout, 2019). From a research perspective there are many similarities and most of the studies evaluating digital primary care services are purposefully replicable for these types of services.

Conclusions

The expansion of digital primary care in Sweden has changed patient consultations in primary care. Access to services has advanced in various ways, and there are opportunities to use resources more efficiently. But these services also face criticism for disrupting needs-based health care utilization and encouraging medically unnecessary demand in a publicly funded system. The overall aim of this thesis is to evaluate whether Sweden's primary care performs better with the emerging digital primary care.

The thesis evaluates a set of performance effects of digital primary care against traditional office-based consultations in four studies that assess both clinical outcomes and distributional impacts. It produces new evidence by showing that digital primary care often targets mild infections and cater predominantly to younger, urban demographics. It shows that digital primary care has a lower frequency of antibiotic prescriptions, which varies by diagnosis and demographic factors. Unlike traditional primary care, the digital services demonstrate a pro-rich utilization pattern.

The thesis shows that digital primary care, similar to other use of new technology in complex environments that find a demand, can contribute to an improved health care system but necessitates developed regulation.

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What motivated me to pursue a Ph.D. mid-career and finally settling it literally just days before I turn fifty? After all, I have been a visiting teacher in health systems and financing to a long list of universities since 2010, I thought I knew the academic world and at least the basics of theory and methods.

When I was 31 years old, just a few years past the turn of the century, I was having lunch in the canteen with my dear and inspirational boss Joe (google the name plus "health financing") and visiting Mr X (a very prominent, academically merited and as 'world known' as a health economist can be, but not an important person to me, hence his name doesn't qualify for mentioning here). We discussed the use of a Ph.D. thesis. As it often goes, much of the discussion was about its usefulness for the career, less about the experience, knowledge, skills and the academic public good that it potentially creates. Mr X said: "Well, Joe, for your generation, it has not been so important, you have clearly made a fantastic career anyway. But it's different for this generation", and he turns to me, adding "for you a Ph.D. is an absolute necessity to get anywhere in the world". He couldn't have been more wrong.

Frankly, I wasn't inspired to pursue a Ph.D. at the time, and Mr X had done his best to kill the idea totally. It came later, at some point I can't specify. But clearly, discussions about health care with my, to be, supervisor Björn Ekman had something to do with it. And without him I had not been pushed over any point of no return, whenever that was. Björn has an incredible dedication to scientific work, which is inspirational. I also want to deeply thank Hans Thulesius, my co-supervisor, and Eva Arvidsson. Both are co-creators of the project, clinically experienced specialists in family medicine, and indispensable with all their enthusiasm to discuss the functionality and use of primary health care across our different academic disciplines and professional backgrounds. Simply fun and interesting. A thankful thought of gratitude goes to all you dear people in the research group Global Health and Social Medicine, a jolly, skilled, and devoted crowd. Finally, I also think of all you inspiring people I have met in my professional life during the years since my last graduation, my Master degree in Economics at Uppsala university, 25 years ago last month. I am proud of what I have learnt from you and this thesis work. Thank you!

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Paper I

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Utilization of digital primary care in Sweden: Descriptive analysis of claims data on demographics, socioeconomics, and diagnoses

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ABSTRACT

Objective: As digital technologies for health continue to develop, the ability to provide primary care services to patients with new symptoms will grow. In Sweden, two providers of digital primary care have expanded rapidly over the past years giving rise to a heated debate with clear policy implications. The purpose of the study is to present a descriptive review of digital primary care as currently under development in Sweden.

Methods: Descriptive analysis of national coverage data on the utilization of digital care by sex, age, place of residence, socioeconomic status, and most common diagnoses. The data are compared with samples of corresponding data on traditional, office-based primary care, out-of-hours care, and on non-emergency telephone consultations to obtain a comparative analysis of digital care.

Results: Digital primary care in Sweden has increased rapidly over the past two years. Currently, more than 30,000 digital consultations are made per month, equivalent to around two percent of all physician-led primary care. Digital care differs in some ways to that of traditional care as users are generally younger and seek for different conditions compared with office-based primary care. Digital care is also similar to traditional care as utilization is higher in metropolitan areas compared with rural areas. Similar to general health care use, there is a negative correlation between use of digital care and socioeconomic status. User profiles by age and sex of digital care are also similar to those of out-of-hours care and non-emergency telephone medical consultations.

Conclusions: By providing a detailed description of the development of digital primary care the study contributes to a growing understanding of the contributions that digital technologies can make to health care. Based on current trends digital primary care is likely to continue to increase in frequency over the coming years. As technologies develop and the public becomes more familiar to interacting with medical providers over the Internet also the scope of digital care is likely to expand. As the provision of digital primary care expands across Europe and beyond, policy makers will need to develop regulating capacities to ensure its safe, effective and equitable integration into existing health systems.

1. Introduction

1.1. Background and purpose

Over the past decade or so, the use of the Internet for health care has moved rapidly from a source of information to consultation to the actual delivery of medical services. Across countries, different types of digital health services have been introduced that link the patient directly with a medical service provider. However, despite the seemingly rapid developments in the area of digital information and communication technologies (ICT), the pace has not been as fast as once expected. For example, a survey of health sector experts in the late 1990s found that respondents predicted that around 20 percent of office-based visits could be replaced by Internet-based ones by 2010 [1]. While some countries have moved faster than others in introducing Internet-based health care models for some groups of patients or types of conditions, in no country has the overall share of total services reached those levels.

However, recent developments may hasten the move toward more

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Internet-based medical provision also in the field of primary care. Various types of providers have initiated services to supply health care directly to patients through common digital platforms. In the U.S., companies such as *American Doctor*, *Teladoc*, and *Doctor-on-demand* provide a range of health care services, including diagnostics and treatments. In the U.K., *GP-at-Hand*, a private company using the *Babylon* platform, has contracted with the NHS to provide primary care services to around 16,000 people in a district in north London [2]. And in Sweden, a country of 10 million people with a publically funded national health service of generally high quality, several private for-profit providers have started offering digital primary care to the public.

As these services are relatively new, in particular in the European context, not much is known about their use or impacts. In a recent systematic review of the evidence base on digital care for emerging symptoms, the authors identify only two studies of relevance and conclude that no firm conclusions can be drawn as to the clinical or economic effects of this type of primary care [3].

In this study, digital care is defined as a primary care physician consultation by means of some digital platform, such as a webpage or mobile application. Interactions between patient and doctor is then made by means of chat or video. Digital care involves both text, sound, and images and can be delivered both synchronously and asynchronously. Due to the ubiquitous nature of digital technologies, digital care is by many seen as a way of improving access to primary care and something that will continue to grow over the coming years.

However, concerns have also been raised in the public debate that digital providers mainly cater to the relatively well-off with minor health problems residing in larger cities. As such, they are seen as not contributing to the overall provision of primary care to those most in need, but mainly cherry-picking patients for short-term gains. This issue has been raised also in the U.K. [4].

Against this background, the purpose of the study is to contribute to a broader understanding of digital care as currently under development in several countries across Europe and beyond. Using national coverage data on digital care and a sample of data on traditional, office-based primary care, we present a descriptive assessment of the recent utilization of digital primary care as currently operating in Sweden. By providing a detailed description of the development of digital primary care the study informs policy makers and health care experts of the contributions that digital technologies can make to health care.

1.2. Context

Health care in Sweden is the responsibility of the 21 counties or regions (Regions henceforth; the 290 municipalities are responsible for some elderly care). While the majority of hospitals are public, primary care is supplied by both public and private providers (around 41 percent of all clinics are private). Primary care providers are reimbursed by the Regions through a combination of fee-for-service (FFS) and capitation. The scope of services is regulated in formal agreements between the Regions (as the purchasers of services) and the providers and include digitally based prescriptions.

Most health care is funded publically through regionally based income taxes and general government block grants. Around 15 percent of health care is paid for out-of-pocket (OOP) to cover user-fees, pharmaceuticals and medical devices [5]. Primary care is free of charge for children below 18 or 20 (varies across Regions) and above 85 years of age. In addition, around six percent of the population have access to private health care insurance, mostly paid for by the employer. However, private insurance only makes up for around one percent of total health expenditures [5].

In contrast to most other OECD countries, primary care in Sweden is mostly provided by multi-professional health care clinics to which the public can freely register. While the quality of care in Sweden is high in an international perspective [5], there is a general perception of reduced access to services, including to primary care [6,7]. For example, recent data show that no Region is able to live up to the national patient guarantee mandates that include being able to see a primary care doctor within seven days after initial contact [8]; compliance rates vary between 77 percent and 95 percent. Furthermore, user satisfaction with traditional services has been going down over the past few years (from 66 percent in 2012 to 60 percent in 2017; www.vantetider.se), and patients frequently express concerns about the difficulty of accessing care and having to navigate a complex system. In contrast, users of digital care are generally highly satisfied (around 90 percent in follow-up surveys; personal communication with the two largest digital providers, Kry and Min Doktor).

Digital care in Sweden is mainly provided by two private, for-profit firms, which initiated operations in 2014 and 2015, respectively. Together, they supply around 90 percent of all digital consultations in the country. In addition to these two large operators there are a number of smaller private providers also offering similar types of digital services. Finally, around five Regions have started offering digital care alongside their regular, in-office services [9]. The digital providers are reimbursed by the Regions on a per-consultation basis and services include those provided by traditional primary care providers, including prescriptions for pharmaceuticals. Around 10 percent of digital consultations is made up of patients with a private health care insurance policy that includes coverage for digital care.

The recent developments in Sweden build on a history of gradual introduction of Internet-based health care services. A decade ago, Umefjord et al. [16] reviewed the introduction of an Internet-based medical consultation system, *Ask-the-doctor* (2008). Among other things, they looked at the utilization of the service by sex and age finding both differences and similarities compared with traditional care. They concluded that “Asynchronous text-based consultation is likely to expand in the near future.” (p. 120) and that “some of the consultations in established physician–patient relationships are likely to be replaced by online synchronous communication including the use of web cameras.” [9]. The current study is able to assess those predictions by providing a comprehensive review of current developments.

2. Material and methods

In order to provide a comprehensive review of the development of digital care in Sweden and how it compares with other types of primary care, the study uses data from several different sources. During the study period of June 2016 to December 2017, the majority of digital providers collaborated with existing primary care clinics in the Jönköping Region. The collaboration has enabled the digital providers to operate within the formal structures of the regional systems. As the digital providers are national in scope the vast majority of patients are not from the Jönköping Region. Among other things, this means that the digital providers are reimbursed according to an out-of-county schedule. To manage the operations, the Jönköping Region collects data on the digital consultations in a separate database. As a consequence, the data cover around 90 percent of all digital consultations that took place in Sweden during the study period. Data on patients from the Jönköping Region are not included in the current database as these are reimbursed by an in-county schedule and recorded separately.

The data are analyzed over the study period by sex, age, diagnosis, and place of residency (Region and Municipality). We also look at utilization across the days of the week and hour of day. Data on digital care for those with private health insurance come from one of the major digital providers that serves such patients.

With regards to traditional, office-based primary care there is currently no national coverage database with comparable data in Sweden. To obtain a comparison with traditional primary care, data were obtained from one Region, that of Kronoberg Region, in the south-east of the country; population 200,000. These data were grouped in a similar way to allow for a relevant comparison between the two models of primary care. In addition, to obtain a broader understanding of the use of primary care, data were also obtained on the use of out-of-hours primary care and on the use of the national, non-emergency telephone number (1177) from the same region. To the extent possible, also these data are analyzed along the chosen parameters described above. Finally, data on socioeconomic status of households across municipalities were obtained from the national bureau of statistics (www.scb.se). All data used in the analysis are in the public domain and only anonymized individual level data have been accessed by the authors of the study.

The data on digital care were analyzed by means of summary statistics, such as correlations, means, and distribution measures and presented in suitable tables and graphs. To make comparisons between the digital care and office-based care, suitable indicators, such as shares and averages have been constructed using the available data and presented by similar means.

3. Results

3.1. Growth in digital care utilization

Since the start of the study period, when a total of 1459 patients (only 123 of whom were publically funded) were seen, digital care in Sweden has grown rapidly; Fig. 1. In December of 2017, almost 29,000 digital consultations were made, indicating an average monthly growth rate of around 20 percent during this period. The expansion has been driven by an increase in the publically reimbursed consultations while the number of private patients have remained stable. In total, around 265,000 digital consultations have been made during this period and preliminary data from the start of 2018 indicate that the increase continues at the same rate.

3.2. Digital care by age and sex

Digital care is used by all ages, from 0 to 97 years; Fig. 2. However, there are two main categories of users: the parents of young children and the relatively young adults.

Except for children below 15 years of age, more women than men use the digital care services. For both men and, in particular, women, there is a steep increase in the use of digital services at ages 18-19.

As noted earlier, digital care is also used by those with access to a voluntary private health care insurance. While these individuals are also covered by the public system, they have chosen to fund their use of digital care by means of the insurance policy. Compared with the publically funded patients, the privately funded users of digital care are relatively older and men constitute a larger share than women.

To illustrate similarities and differences between digital care and other types of primary care, the age profile of the use of digital care, office-hours and out-of-hours office-based care, and of telephone nurse consultations for Kronoberg Region in 2017 are shown in Fig. 3.

Among parents of young children digital care show a similar pattern to out-of-hours visits and telephone nurse consultations. Among adults, however, the users of office-based primary care services during office-hours are generally older and such visits dominate among those older than 50 years of age. Among the elderly, out-of-hours visits and telephone consultations remain a common way to access primary care while the use of digital care falls to reach very low numbers in this group.

3.3. Digital care by place of residence

The utilization of digital primary care in Sweden is highly concentrated in the larger metropolitan areas of Stockholm, Västra Götaland (Gothenburg), and Skåne (Malmö); not shown. In particular, the number of visits by people in Stockholm is around three times higher than in the two other larger cities of Sweden and several times higher than in the rest of the country. However, when adjusting for population size the previous highly skewed distribution of visits across regions becomes less pronounced; Fig. 4.

Stockholm is still the largest single region when it comes to digital visits to primary care with almost twice as many visits per capita than the second largest region (Skåne). Behind these two regions the use of digital care per capita shows a gradual reduction from around 20 visits per 1000 inhabitants to around 10. There is no significant difference between the publically funded patients and the privately funded ones when it comes to area of residence (not shown).

3.4. Utilization of digital care and socioeconomic status by municipality

Although digital care is available to all Swedish citizens nominally on an equal basis, there is a concern that digital services are used predominantly by better off individuals. To investigate this issue, Fig. 5 plots municipality-level utilization of digital care per 1000 inhabitants (y-axis) in 2017 against a measure of socioeconomic status, the share of households in the particular municipality with an income of less than 60 percent of the national median income (x-axis) in 2016.

3.5. Expenditures for digital care

As noted, the digital providers are reimbursed according to a particular out-of-county schedule, the levels of which have been revised over the study period. From June to December 2016, digital providers were reimbursed between SEK2,007 (1USD = 8.8SEK, September 2018) and SEK1,772 per visit depending on type of patient. From January 2017 to June 2017 the reimbursement levels were revised down to between SEK1,128 and SEK893. From July 2017 the levels were revised further down to between SEK611 and SEK376. A recent proposal by the association of regions and counties (SKL) has suggested further revisions of the reimbursement scales.

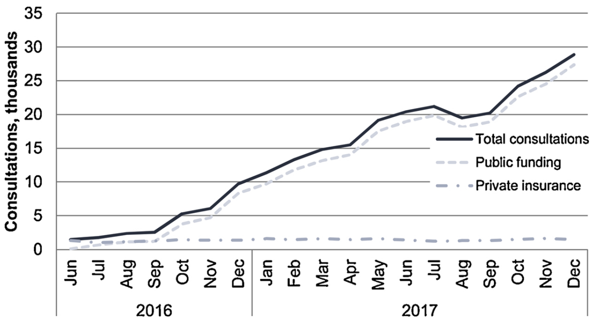

Fig. 1. Total number of digital physician consultations per month, June 2016 - December 2017.

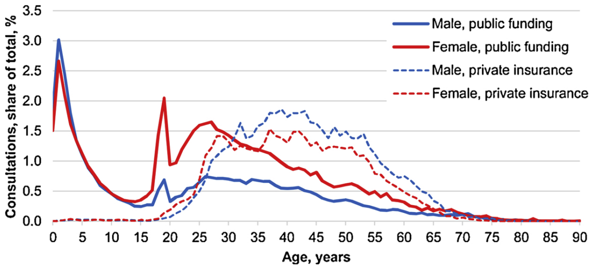

Fig. 2. Digital consultations by age and sex, publically funded (n = 237,291) and private insurance funded (n = 45,307), June 2016-December 2017.

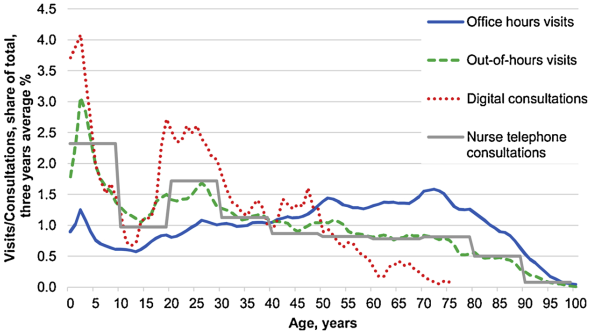

Fig. 3. Visits and consultations by age and sex, office hours physician visits (n = 219,073), out-of-hours physician visits (n = 17,430), digital physician consultations (n = 1885) and nurse telephone consultations (n = 80,399), Kronoberg Region, 2017. The figure shows three years moving average except for nurse telephone consultations where it shows ten years average.

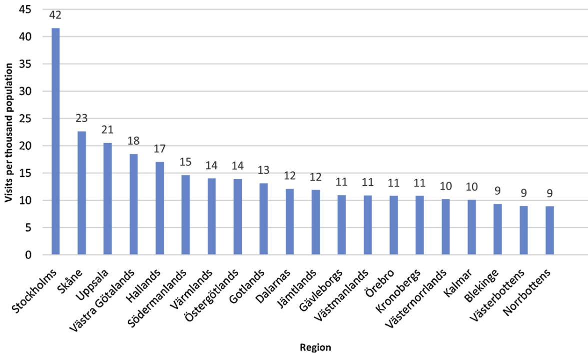

Fig. 4. Digital consultations per 1000 inhabitants by Region, 2017.
Note: Data do not include observations from the 13 municipalities of Jönköping Region and the municipality of Heby due to missing observations (n = 276).

However, along with the increase in the number of digital consultations, the total reimbursements for these services have increased during the study period; Fig. 6.

3.6. Most common diagnoses by sex and age

All digital care providers are reached either by a webpage or a mobile (smartphone) application. The types of conditions and diseases that they can treat are clearly specified on the homepages of all providers. These include infections and skin conditions of various types, some intestinal conditions, and some men's and women's specific health issues. Some providers also offer some types of mental health care. Table 1 shows the most common diagnoses across five age groups for total national digital care (Panel A), office-based, physician visits in Kronoberg Region (Panel B), and out-of-hours visits in Kronoberg Region (Panel C); all data are for 2017.

For all types of care, diagnoses vary by age and sex. For digital care, skin conditions are the most common illness among small children, while respiratory and ear infections are the most common complaints in office-based primary care among this group. Among women, urinary tract infection is the most common condition for both digital care and out-of-hours, office-based care while other conditions, including

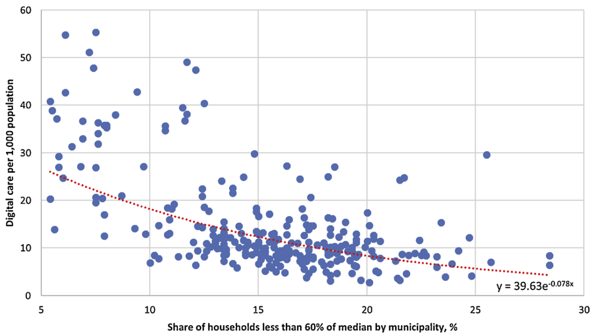

Fig. 5. Per capita use of digital care (2017) and socioeconomic status by municipality (2016).
The analysis suggests a fairly strong negative relationship between use of digital care and socioeconomic status at the municipality level with a correlation coefficient of -0.6 ($p < 0.01$).

hypertension and depression, are more common in traditional care during office-hours (Panel B). For digital care, other common diagnoses include impetigo, tonsillitis, sinusitis, and acne (not shown).

The data also allow for an analysis of when digital providers are contacted during the day and across the week. Digital care is available around the clock and the data show that contacts are made on all hours of the day. Most contacts, however, are made between 9am and 12noon with a small increase after 6 pm (not shown). Furthermore, contacts are made on all days of the week with Monday being the day with the most visits and Saturday the least (not shown). The weekly utilization pattern is similar to that of traditional, office-based care with most visits being made on Mondays.

4. Discussion and conclusions

Digital primary care by means of some digital platform such as a computer, tablet, or smartphone, has increased rapidly in Sweden since its introduction in mid-2016. We find that over the study period some 265,000 digital consultations have been reimbursed by the regional health authorities. The rapid increase and the relatively weak evidence base for the efficacy and safety of digital medical consultations have given rise to a lively debate in Sweden. Similar developments are also occurring in other countries and both of the two largest digital providers in Sweden are currently expanding across several countries in Europe. This study contributes to informing this debate by reporting on both differences and similarities of digital care compared with other types of primary and non-emergency care consultations.

While the increase in the use of digital care is significant, it is important to put the number of digital consultations into context. There are around 15 million office-based, physician primary care visits in Sweden every year (with an additional 27 million non-physician visits; [10]). This means that the current number of digital consultations only make up around two percent of all primary care physician visits in the country. On current trends, it will take more than two decades for digital care to replace office-based care to levels predicted by some health care experts in the late 1990s. However, this is unlikely to be a relevant scenario. Digital care may replace the need for office-based visits for some types of diseases and conditions, leaving others relatively untouched.

Part of the controversy around the increase in digital care stems from the reimbursement of digital services. The funds are taken from the particular clinics with which the patient is registered in the home Region. Some Regions have changed the funding mechanism and are now allocating general funds to reimburse the digital providers. It is likely that the regional health authorities will need to find more effective ways of paying digital providers in the future as utilization continues to increase.

As to the use of digital care by age and sex, we find both differences and similarities with traditional models of primary care and medical consultations. While women tend to use all types of services more compared to men, digital care is used by people who are relatively young compared to office-based services. The relatively large use of

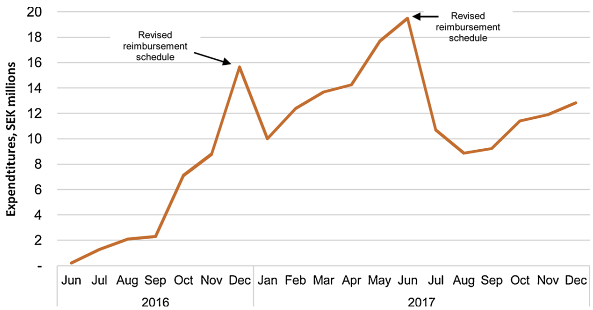

Fig. 6. Total monthly reimbursements, June 2016 – December 2017; Million SEK.
The revised reimbursement levels resulted in temporary drops in the overall public spending on digital care.

Table 1
Most common diagnoses by age groups: Total digital care (Panel A); Total traditional, office-based visits for Kronoberg Region (Panel B); and Total out-of-hours visits for Kronoberg Region (Panel C); 2017.

Age groups	All	Women	Men
Panel A:	**Total digital care, Sweden**		
0-9	Non-specific skin condition	Non-specific skin condition	Non-specific skin condition
10-19	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
20-39	Acute URI, non-specified	Acute UTI	Acute URI, non-specified
40-59	Acute URI, non-specified	Acute UTI	Acute URI, non-specified
60-	Acute UTI	Acute UTI	Erectile dysfunction/Renew prescriptions/URI
Panel B:	**Traditional, office-based visits, Kronoberg Region**		
0-9	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
10-19	Acute URI, non-specified	Acute URI, non-specified	Acute URI, non-specified
20-39	Depression	Depression	Depression
40-59	Hypertension	Myalgia	Hypertension
60-	Hypertension	Hypertension	Hypertension
Panel C:	**Out-of-hours visits, Kronoberg Region**		
0-9	Acute URI, non-specified	Acute URI, non-specified	Acute media otitis
10-19	Superficial wound	Acute tonsillitis	Superficial wound
20-39	Acute tonsillitis	Acute UTI	Superficial wound
40-59	Acute UTI	Acute UTI	Wound
60-	Acute UTI	Acute UTI	Wound

Notes: URI – upper respiratory infection; UTI – urinary tract infection.

digital care by, in particular, women around 18–20 years of age is most likely driven by several factors, including demand for contraceptives and the fact that services are free-of-charge up to the age of 20 in most Regions. A similar age and sex distribution for digital care is seen for out-of-hours primary care and for nurse telephone consultation services.

There is some evidence that digital care is used more by those living in urban areas. This is particularly noteworthy given the common belief that telehealth is an important tool for reaching patients in remote areas. In Sweden, three of the five regions that use digital care the least (see Fig. 5) are all geographically large regions with relatively small populations situated in the north of the country. The regional pattern may, however, be at least partly explained by the relative recent appearance of digital primary care and by the marketing campaigns of the providers that have focused on the larger metropolitan areas of the country. In addition, private-for-providers would be expected to become established in such areas first before expanding to less populated areas. Importantly, the regional utilization pattern of digital care is no different from traditional models of care. For example, the Stockholm Region has the highest per capita utilization rate for office-based services (www.kolada.se).

There is a tendency in most countries that health care is used by relatively better off individuals [11,12]. In Sweden, there is a general concern with socioeconomic inequalities when it comes to access to regular primary care services [13]. We found a significant negative correlation between the use of digital care and socioeconomic status at the municipality level. The reasons for this finding may, however, be found in the fact that better off individuals have better access to the Internet and are more likely to using digital technologies. As digital care continues to expand, it will be important to understand how it is used by different population groups to ensure equity in the use of health care more broadly.

We also report important differences between digital care and office-based primary care when it comes to the diseases and conditions that are most prominent. Clearly, there are limitations to what can be done in terms of diagnosis and treatment by means of a digital platform as opposed to a physical meeting. While these limitations are largely reflected in the current types of conditions for which digital providers cater, there are additional important aspects to consider. For example, several digital providers testify to the particular needs that some patients exhibit. These needs relate to sensitive and possibly stigmatizing issues, such as severe acne among young people, women in violent relationships, and some mental and dependency problems (personal communication). In such cases, digital care may offer a suitable model of care.

More investigation is needed to evaluate digital primary care. Among other things, the clinical and patient reported outcomes of digital care need to be compared systematically with those of other forms of primary care. In addition, more evidence is needed on the extent to which digital services provide an effective substitute for traditional care or whether it leads to additional use of services and subsequent expenditure increases [14].

Further research based on individual level data will also be needed to investigate the distributional impact of scaling-up digital primary care. The basic principle of health care in many countries is that those with the largest medical needs should be prioritized. As noted, there is some evidence that traditional primary care runs contrary to this principle and the two models of care need to be assessed through large scale analysis of data that includes information on patients' socioeconomic background, ethnicity, and health status.

One way to regulate the provision of digital care is for regional and national health authorities to develop new ways of reimbursing digital providers of primary care. The current system in Sweden is poorly designed for these types of services as evidenced by the relatively drastic and sudden revisions in the reimbursement levels that have taken place. Appropriate adjustments to the reimbursement system will also require evidence on the cost-effectiveness of digital care compared with traditional primary services [15]. In addition, regulatory agencies will need to enhance their capacities in order for digital primary care to become an effective, safe, and equitable part of the publically funded health services. This would include the management of chronic diseases such as diabetes, heart failure, and mental ill health, all of which pose significant burdens in most OECD countries. Future research and analysis in this field will need to focus on these regulatory issues. By providing a comprehensive review of the current state of digital care in Sweden, this study contributes to the expanded understanding of these services for effective policy development in that country and beyond.

Authors' contributions

BE initiated the original idea and led the study. HT and EA provided additional information on primary care in Sweden and on overall approach of the study. OC provided data and information on primary care in one county and provided detailed comments on earlier drafts of the study. JW provided overall information on study approach and on policy implications. AL contributed to the statistical analysis. All authors read and contributed to all parts of the study and approved the final version of the manuscript.

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Conflict of interest

None.
Summary table

What was already known about this subject?

- Digital primary care has been increasing rapidly over the past two years.
- The scope of digital care is expanding to several areas of non-emergency care.
- Concerns have been raised that digital care operates counter to basic principles of prioritization of care.

What did this study add to our knowledge?

- Digital primary care in Sweden has increased by around 20 percent per month from mid-2016.
- Utilization of digital primary care in Sweden by age and sex is somewhat different from office-based care, but similar to out-of-hours and non-emergency telephone consultations.
- Use of digital services occur in the whole country, although more so in urban regions.
- There is some indication that digital care is used more by better off households; lack of data prohibits an effective comparison with office-based primary care.

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Paper II

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Study protocol: effects, costs and distributional impact of digital primary care for infectious diseases—an observational, registry-based study in Sweden

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ABSTRACT

Introduction The ability to provide primary care with the help of a digital platform raises both opportunities and risks. While access to primary care improves, overuse of services and medication may occur. The use of digital care technologies is likely to continue to increase and evidence of its effects, costs and distributional impacts is needed to support policy-making. Since 2016, the number of digital primary care consultations for a range of conditions has increased rapidly in Sweden. This research project aims to investigate health system effects of this development. The overall research question is to what extent such care is a cost-effective and equitable alternative to traditional, in-office primary care in the context of a publicly funded health system with universal access. Three specific areas of investigation are identified: clinical effect; cost and distributional impact. This protocol describes the investigative approach of the project in terms of aims, design, materials, methods and expected results.

Methods and analysis The research project adopts a retrospective study design and aims to apply statistical analyses of patient-level register data on key variables from seven regions of Sweden over the years 2017–2018. In addition to data on three common infectious conditions (upper respiratory tract infection; lower urinary tract infection; and skin and soft-tissue infection), information on other healthcare use, socioeconomic status and demography will be collected.

Ethics and dissemination This registry-based study has received ethical approval by the Swedish Ethical Review Authority. Use of data will follow the Swedish legislation and practice with regards to consent. The results will be disseminated both to the research community, healthcare decision makers and to the general public.

Strengths and limitations of this study

- ► This research project applies a system-wide approach by designing studies that cover several outcome areas, recognising that impact from new forms of primary care varies across performance areas.
- ► The project builds up and will use a database on individual patients and their characteristics that is uniquely large in the Swedish context.
- ► The studies will not build on random allocation of patients to either of the two models of care, which may negatively affect the strength of conclusions about causal effects.
- ► The studies will also not be able to differentiate between different forms of digital primary care (eg, synchronous and asynchronous consultations), or an expected future situation where digital care is more integrated with in-office services.

BACKGROUND

As healthcare systems come under increasing fiscal and operational pressures, growing attention is given to the need to strengthen the role of primary care to prevent illness and promote population health.[1–3] In parallel, expectations are rising among policy-makers about the use of digital care technologies to enhance the performance of healthcare provision.[4 5] From a health systems perspective, there are several potential opportunities and possible risks. Purchasers of services are attracted by potential efficiency gains and savings on healthcare spending. For patients, accessing care by means of a digital platform reduces access barriers in the form of travel and waiting time. At the same time, fears have been raised that easier access to primary care through digital medical service providers may lead to overuse and create inequities in the use of healthcare services.[5–7]

The experience of expanded provision of digital primary care in Sweden over the past 3 years is a case in point. Since 2016, the number of digital primary care consultations has increased 10-fold, reaching around 60 000 consultations per month.[8] While users of digital care generally express satisfaction with this service, policy-makers and experts in general practice have warned of the potential risks of overuse of medical services and medication leading to cost escalations.[9]

As large-scale use of digital primary care in the context of a publicly funded healthcare system is a relatively recent phenomenon, significant gaps in the understanding and evidence of the effects of digital care exist. The purpose of this research protocol is to describe the aims, methods and expected findings of a research project that aims to address some of these gaps.

Aim and objectives of the research project

The overall aim of this research project is to evaluate the extent to which digital primary care constitute a cost-effective and equitable alternative to traditional, in-office primary care in the context of a publicly funded health system. The general approach of the project is to compare the effects of digital care with those of traditional primary care services. *Digital care* is defined as care provided through digital channels for consultation beyond physical meetings, telephone, mail and email. It includes both synchronous video and asynchronous text and can be provided by both dedicated digital providers and traditional offices. To ensure a balanced and relevant comparison between the two models of primary care, the analyses will focus on three illnesses that are common in both types of care: upper respiratory tract infection (URTI), lower urinary tract infection (LUTI) and skin and soft-tissue infection (SSTI).

The specific objectives of the study are to:

1. Evaluate effects of digital primary care in terms of overall utilisation of primary care services and of compliance with prescription guidelines.
2. Compare the costs of digital primary care with those of in-office primary care for the chosen conditions.
3. Analyse utilisation of digital primary care across socioeconomic and demographic characteristics of patients.

Context of primary care in Sweden

Healthcare in Sweden is the responsibility of the 21 regions.[10] The Regions fund medical care by raising income taxes and provide services through publicly owned and managed hospitals and primary care clinics, or by contracting with private providers. The institutional organisation of primary care is characterised by relatively large healthcare clinics that employ several different types of medical professionals. There is a total of some 1140 such clinics in the country, around 2/3 of which are publicly owned. Primary care providers receive the largest share of their reimbursement through a needs-adjusted capitation (approximately 82% of total reimbursement) based on a listing system with free choice of provider. A minor share of revenue comes from a fee-for-service payment. Both parts of reimbursement, and their relative share, vary by region. Adult patients pay a user fee that also varies across Regions; on average around US$20 per visit to a primary care physician, with a nationally imposed ceiling amount of approximately US$110 per year.[11]

While primary care services are generally regarded as being of high quality, Sweden has a long-standing issue with waiting times to primary care.[10 12] Indeed, in the most recent review of access to healthcare services, the National Board of Health and Welfare found that no region was able to live up to the national patient guarantee mandate of providing care within 7 days of initial contact.[13]

Access to primary care is particularly poor outside of normal office hours[14] and have most likely contributed to the relatively rapid uptake of digital primary care services offered by a total of 13 private and public providers.[9] The two largest providers of digital care in Sweden are KRY and Min Doktor. Together, they provide around three quarters of all digital consultations. These visits are funded by a flat fee per patient contact from the region where the patient is resident, regardless if the patient is listed with a primary care provider or not. A copayment of around US$10 is levied on all digital visits.[15]

The entire resident population in Sweden enjoys formal entitlement to both forms of primary care. As private actors continue to expand digital services, the Regions and private providers of traditional in-office primary care also develop digital primary care. While digital care currently only constitutes around 2% of total primary care visits, it is expected that this share will grow over the coming years. Understanding the implications of this process is regarded as vital for effective policy development and decision-making (with the COVID-19 pandemic, which has caused a large upsurge in demand for digital primary care from March 2020, the increase over time can be expected to grow even faster).

REVIEW OF EXISTING EVIDENCE ON DIGITAL PRIMARY CARE

The first part of this review includes original research articles published in peer-reviewed journals with a focus on high-income countries. The second part of the review includes systematic reviews of the evidence on digital primary care. Given the comparative novelty of digital primary care, the current evidence base is relatively limited and largely inconclusive as to the effects of digital care on relevant outcomes.

In the Swedish context, Ekman[16] showed that digital primary care was overall around 40% less costly than traditional primary care. Half of the cost difference arise on the provider side and half on the patient side. A recent study used a small sample of Swedish patients to investigate if digital primary care reduced visits to traditional primary care clinics in the Skåne region.[17] The authors found no support for this hypothesis but could not rule out that the higher use of traditional services among those who also used digital care was due to other factors not controlled for in the analysis.

Many studies have shown that low-income population groups consume relatively more primary care than high-income groups, as compared with specialist and hospital services, also after controlling for differences in needs.[18–20] Urban and younger population groups use digital services more frequently, but there is to date no studies available on the distributional effects of digital primary care and how this compares with the traditional form.[8]

In the UK, the users of the recently evaluated Babylon digital primary care application were generally younger than the average primary care patient. The evaluation did not find that use of digital primary care had any impact on the use of secondary care. Importantly, antibiotic prescription rates were lower than the overall rate, possibly due to harder restrictions in prescription rules for this form of service.[21] Many evaluations of digital services focus on a specific diagnosis or application, and results are not necessarily applicable to primary care services generally. For example, a UK study of Skype consultations for patients with diabetes found the service to be equally safe and effective as in-office visits.[22]

A study with a relatively large sample found similar rates of antibiotic use and guideline-concordant antibiotic management as for traditional care, with the exception of less appropriate streptococcal testing.[23] Ray *et al* found that digital care for children generated more antibiotic prescriptions and the patient was less likely to receive correct antibiotic management compared with children visiting traditional care.[24]

Several studies, including those using similar diagnoses as in the current project, have shown that digital care is less costly per visit. One study shows the largest savings in cost per visit occurs for the patient, while provider costs differ less between the two forms of care.[25] Gordon *et al* showed that digital visits generated a similar level of follow-up visits as in-office visits, but less laboratory tests, resulting in lower costs per episode of care.[26] Mehrotra *et al* similarly found lower use of laboratory tests, although higher rates of antibiotic prescription.[27] Even though several studies show digital visits can be provided at lower cost than in-office visits, the introduction of digital services has generated larger volumes of additional visits, resulting in larger overall spending in some settings.[28 29]

Literature reviews

Armfield *et al* have reviewed the literature of Skype as a tool for providing digital care in 2012 and 2015. The first review concludes an increasing use of web-based consultations but no evidence for how performance is affected.[30] The second review found more articles on the use of Skype, but a lack of formal evaluation of its clinical and economic benefits.[31] A review of reviews of cost-effectiveness in eHealth services for somatic conditions found a positive effect in the majority of studies, although few studies of family medicine were available.[32] A review of economic analyses comparing telehealth services with traditional care found a majority of studies showed lower costs for the telehealth form of provision, although most of these studies only compared provider costs and did not have a patient perspective.[33] A regional health technology unit in Sweden found no conclusive evidence on clinical benefits and cost effectiveness of digital consultations for emerging symptoms in primary care, as compared with traditional physical visits.[34] Bashshur *et al* conclude that evidence on cost effectiveness in favour of digital primary care is still scarce, but growing.[35] It is noticeable that most literature reviews on the subject of digital care do not target primary care specifically, show mixed results in terms of effects and costs, and find limitations in sample sizes and outcome measures.[36]

METHODS AND ANALYSIS

A key analytical aim in any evaluation of an intervention or programme is to be able to control for any confounding factor that may affect the outcome measures. One way to do this is to randomise participation into either an intervention group or a control group.[37] In the current case of digital primary care in Sweden, randomisation of patients to either digital care or traditional care is not possible. As described below, the current study will aim to address these challenges by means of quasi-experimental methods.

Study design and data sources

This research project applies a retrospective, observational (non-randomised) design, using patient-level register data from seven regions of Sweden for the years 2017–2018. It is expected that the final database will contain data on some 1 000 000 individuals (around 10% of the entire population of Sweden). No previous study of digital primary care in Sweden has taken a system-wide approach by designing studies that covers several outcome areas. It is also unique in collecting a large database combining detailed clinical data from several regions in Sweden.

Sample and data collection

The sample of individuals consists of all patients who were diagnosed with at least one of the three index diagnoses URTI, LUTI, SSTI, in one of the target regions during the study period of 1 January 2017 to 31 December 2018. The seven regions (Jämtland-Härjedalen, Stockholm, Örebro, Östergötland, Kronoberg, Halland and Jönköping) constitute a fair representation of Swedish regions in terms of demographic and socioeconomic characteristics, rural and urban populations, and geographical location.

The data will be collected from four different types of sources: (1) Regions (n=7); (2) digital providers (n=2); (3) National Board of Health and Welfare (three separate databases); and (4) Statistics Sweden (two separate databases). While there is no national database on primary care in Sweden, the existence of a national identification number enables the collection of data from different sources and subsequent linking individuals into a single database.

Table 1 Variables, indicators and sources of information

Variable	Indicator	Source of information	Comment
A) Identification			
_id	Personal identification number	Statistics Sweden, Regions, Providers	Anonymised data including a non-identifiable id number will be provided to the researchers
Contact id	Visit/contact identification number	Statistics Sweden, Regions	To identify all separate primary care visits and contacts
B) Index diagnoses			Sample variables
i) URTI	Upper respiratory tract infection	Regions	ICD (International Classification of Diseases) -10 chapters B, H, J, R
ii) LUTI	Lower urinary tract infection	Regions	ICD-10 chapters N, O
iii) SSTI	Skin and soft-tissue infection	Regions	ICD-10 chapters A, B, F, H, I, K, L, M, N, O, P, T, Z
Other diagnoses			Indicators to control for health status
i) Diabetes	Diabetes mellitus	Regions	ICD-10 chapters E10, E11, E12, E13, E14, E15, E16, E17, E18
ii) COPD	Chronic obstructive pulmonary disease	Regions	ICD-10 chapter J44
iii) Hypertension	Hypertension	Regions	ICD-10 chapters I10, I11, I12, I13, I14, I15
Total number of diagnoses		Regions	Any other diagnosis registered in patient record
C) Primary care providers			
i) Digital provider	Indicator if digital contact during study period	KRY, Min Doktor	Date and time; category of provider; laboratory examination; medical prescription
ii) Traditional primary care provider	Indicator if traditional consultation during study period	Regions	Date and time; type of consultation; category of provider; laboratory examination; medical prescription
iii) After-hours visit	Indicator if after-hours primary care visit (non-emergency) during study period	Regions	Date and time; category of provider; laboratory examination; medical prescription
D) Other care			
Other types of care	Emergency visits, inpatient care, outpatient care	National Board of Health and Welfare	Indicators of other types of care during study period
E) Background variables			
i) Socioeconomic indicators	Disposable income, employment status, level of education	Statistics Sweden	Indicators to control for background factors
ii) Sociodemographic indicators	Age, sex, marital status, country of birth		

After-hours visits refer to visits to clinics during evenings, weekends and nights. As a general starting point, the study will view these visits as part of traditional primary care.

To ensure an effective data collection process and in order to avoid a situation where the researchers need to handle either original data (not anonymised) or an encryption key for the anonymised data, all data will be collected by a special unit of Statistics Sweden. Table 1 describes the indicators and the sources of information.

Data on digital consultations will be collected from the two largest providers of digital primary care, KRY and Min Doktor and from Jönköping Region. Due to the national system for inter-regional billing, the two providers of digital care operated out of this region during the study period. The Jönköping Region keeps a database on these consultations enabling the identification of this group of patients.

Regional health administrations will provide data on diagnoses and procedures from all relevant primary care visits. Each visit contains information on diagnosis, location of provider, type of visit, staff category, time of visit, laboratory testing results and prescription of medication. The National Board of Health and Welfare provides data on prescribed and dispensed pharmaceuticals from a Swedish national drug registry and data on specialist visits in outpatient facilities and hospitals are collected from a national Swedish patient registry. Data on income, education, place of birth, residence, marital and labour market status are provided by Statistics Sweden's databases.

The principal investigator of the research project (BE) is responsible for handling the final data set in accordance with national regulations and the principles and guidelines for data handling at Lund University. The storage, management and handling of the data set are described in a special data management plan developed by the research group.

As stated as one of the limitations of the study, this registry-based quantitative approach will not address important questions such as the perceptions of medical staff and patients of digital primary care. The design has however been developed by a multiprofessional research team including practising specialists in family medicine.

Patient and public involvement

The research project is developed in response to a new form of providing primary care services and an emerging change in patient care seeking behaviour. The design of the studies has however not involved patients or the general public. The project should be complemented by research on patients' experiences and preferences.

Study objective 1: effects of digital primary care

Evaluation of the impact of digital care on overall utilisation

Under the first objective, the study aims to investigate two possible effects of the use of digital primary care. The first effect relates to the question of whether digital primary care substitutes for traditional, in-office care or if the use of digital services leads to an overall increase in primary care utilisation. The guiding hypothesis is that digital care substitutes fully for traditional care and that there is no overall increase in the use of primary care services.

Given the current study design and context, the study aims to evaluate this issue by means of quasi-experimental methods, including matching and single difference[37 38] and by focusing on specific diagnosis-based episodes of care (Ashwood *et al*[28] address this question using matching and double difference. This approach is not possible in the current project as no preintervention data will be collected). The analysis will make use of a model that takes the data generating process into consideration, including the possible existence of a large share of zeros on the predictor side. Estimating the probability of using traditional primary care while controlling for the use of digital care will allow for the testing of the guiding hypothesis of full substitution of digital care. By generating a quasi-control group (through matching), the model can test whether the same holds also for the matched sample of patients.

Evaluation of digital primary care on prescription practices

The second effect of digital care under investigation concerns the question of whether there are any differences between the two models of primary care in antibiotic prescription behaviour. While all three index diagnoses are infections, a particular case may only require antibiotic treatment under certain conditions. While prudent and specific use of antibiotics is a general aim, the Swedish strategic programme against antibiotic resistance has developed guidance for the administration of antibiotics by diagnosis, also with respect to digital care,[39] which will be used for defining the effects measured on prescription and use of antibiotics for each diagnostic group.

For each of the groups, the analytical aim is to estimate the probability of a correct prescription. Based on diagnose, available laboratory test results and patient information (age, gender) in the project database, an indicator variable will be generated taking the value 1 if correct prescription and 0 otherwise. The probability of correct prescription will be estimated by a logit regression model with a binary dependent variable estimating the effect of traditional and digital primary care. The general estimation model is:

$$E(Y \mid X, C_1, ..., C_k) = P(Y = 1 \mid X, C_1, ...C_k) \quad (1)$$

where Y is the dependent indicator variable of correct antibiotic prescription. X is a binary indicator variable for digital care (X=1; 0 otherwise). C are control variables, including age, sex, income, education level and indicators of comorbidity.

Adherence to prescribed antibiotic medicine

Rational use of drugs, including antibiotics, in primary care is dependent on many factors beyond the formal prescription.[40 41] An important aspect is the patient's adherence to prescription. In the context of traditional and digital care, this may be of interest, as adherence is dependent on, for example, verbal instructions in the doctor–patient meeting and proximity of a pharmacy. The study will therefore estimate differences in dispensation between the two forms of providers with a similar model to (1), where (Y) takes the value 1 if prescribed antibiotics are dispensed and 0 otherwise.

Study objective 2: cost differences between forms of primary care provision

Under the second objective, the study aims to compare the cost of care between the two forms of primary care, separately for each of the three index diagnoses. Furthermore, the costing analysis will estimate the resources used for both a single visit and for an entire episode of care.

Estimating the cost of a digital contact and a traditional primary care visit

The study will adopt a societal perspective by collecting cost estimates across all relevant sectors and the individual patient. The costing analysis will apply the general approach to costing healthcare programmes as described in, for example, Drummond *et al*.[42] The approach involves the three main steps of *identification* (of all cost items), *quantification* (or measurement of resources) and *valuation* (of the items). Statistical analysis of cost differences will include the bootstrap approach.

The study will identify all cost units of both providers, patients, and any other part of society. Direct costs for providers include staff time and laboratory tests. Staff time will be limited to time spent by the treating physician. The indirect provider costs include administration, management, office rent and service development costs.

Patient direct cost items include user fees, pharmaceuticals and expenses for travel. The indirect cost carried by the patient is the value of time spent. This includes travel time, waiting time and the actual meeting with professional staff. Only the estimated time patients wait in the facility is included, as this time cannot be spent on productive work, that is, there is no clearly identifiable opportunity cost. For a digital visit, this means time spent with the digital device registering and waiting for a consultation. In traditional care, it is the time from arrival in the facility to the commencement of the consultation. Costs in the form of informal care by people related to the patient is assumed to be negligible for the studied diagnoses. Similarly, intangible costs such as pain and discomfort of care are assumed to the marginal and estimated to zero.

A large and decisive part of provider cost in healthcare is staff time. For digital services, time spent per patient as recorded by each providers' digital system will be used for calculating the average time spent per patient for the respective diagnosis. For traditional primary care, a survey of time spent per patient will be conducted among a sample of clinics. The questionnaire will separate patient time and time spent on patient-related administration.

Indirect provider costs (administration, management, office rent, development) for both forms of provision will be estimated with a top-down approach using costs from annual reports by private providers. To estimate development costs, which include staff training and software development, conventional accounting rules for immaterial assets write-off will be applied.

All patient time will be valued by the average Swedish gross salary plus social security contributions and benefits, for all patients aged 18–66. The study will apply the friction cost method for measuring indirect costs related to time spent by patients, by adjusting the salary level for labour market participation rate.[43]

Estimating the cost of an episode of care

The result of the above cost estimates will describe the difference between the two models of care for a single visit or digital contact. However, additional medical care may be needed if the treatment is ineffective. For management of chronic conditions, eHealth solutions have been shown to be effective in reducing health service consumption.[44] To assess the differences in cost per case between the two forms of care, the study defines the episode of care for each specific condition under study. Each episode of care starts with a new contact, called an *index visit*, generating one of the three diagnoses LUTI, URTI or SSTI. The study further defines the episode as all visits to healthcare providers over a 2-week timeframe starting with the index date, similar to Gordon *et al*.[26] A sensitivity analysis will test different timeframes, as factors such as waiting time and drug prescription can influence the length of an episode.

For visits to specialised outpatient clinics, the official reimbursement rate for the respective services will be applied. For the few hospital services that can be anticipated in these episodes, official average cost-per-patient data will be applied, representing the average cost per case in Swedish hospitals.

Study objective 3: equality in health service utilisation

In addition to effectiveness and costs, an important performance aspect of developed primary care is how utilisation is distributed across the population. The aim of the third study objective is to answer if there is a difference in socioeconomic distribution between digital and traditional primary care utilisation. The study will compare the distribution of utilisation by income and education levels across the two populations using one or the other form of service.

Measuring inequalities

The possible differences in utilisation will be analysed in three steps. The first is descriptive statistics of both forms of primary care utilisation across demographic and socioeconomic groups. Income is measured as individual total labour income and for education the International Standard Classification of Education is applied to define the levels of education status, as provided by Statistics Sweden.

In the second step, the study will calculate a concentration index (CI) as a summary measure of differences in the distribution of utilisation between the two forms of care. The method builds an index value from the cumulative distribution of healthcare utilisation and socioeconomic indicators[19] and will produce comparable numbers of how consumption of services are distributed across users of the two models of care, by income and education. It runs between −1 and 1 and equals 0 when there is perfect equality, meaning the cumulative utilisation equals the distribution of the socioeconomic indicator. For the income distribution, the type of service with the highest (lowest) index number has the most prorich (propoor) distribution of utilisation. In the case of perfect inequality, it would take the extreme values if all healthcare was used by the least wealthy (−1) or the wealthiest (1) individual. This can also be illustrated graphically by a concentration curve, which in the case of an index value 0 is a straight diagonal line. The estimation is defined as two times the covariance of the number of visits to either form of primary care (u) and the relative fractional rank of the ith individual in the income distribution (R), divided by the mean of u (μ):

$$CI = 2\mathrm{cov}(u_i, R_i)/\mu \qquad (2)$$

However, groups with lower socioeconomic status tend to have lower health status.[45] When this is the case, differences in use of services will underestimate the inequalities. For the comparison of digital and traditional primary care, the above indices will ignore any differences in the composition of the two population groups using one or the other form of care. For this purpose, the third step will assess the distribution of utilisation related to households' socioeconomic status, after adjusting for differences in need across the population.

This is done by applying a horizontal equity approach.[19] Horizontal equity occurs when individuals in equal need (as defined by selected indicators) are treated the same (in terms of utilisation), irrespective of income. The approach starts by obtaining an indirect standardisation of utilisation for healthcare need. An ordinary least squares regression estimates a predicted number of visits for each individual based on the variables age, sex, a morbidity index, labour market participation and ethnic background. The study will make use of the individual diagnosis information in the project database to create a disease burden index, using the variables for chronic illnesses and presence of other diagnoses, and test an alternative method with a vector of binary variables for presence of each diagnosis, similar to Gerdtham.[46]

The regression output provides the expected number of visits to the two forms of care the patient would use if she consumed care as a patient with the same characteristics do on average. The indirectly standardised utilisation for each individual is obtained as the difference between actual and predicted utilisation plus the sample mean utilisation. Then, a new needs-standardised CIs is calculated, which compares the equality in utilisation between the two forms of primary care services, adjusted for factors included in the regression.[19]

DISCUSSION

The current research project aims to contribute to the evidence on the effects, costs and distributional impacts of scaling up digital primary care in the context of a universal public healthcare system. The proposed analyses described in this protocol take a quantitative approach to evaluating the effects of digital care. Using a large database on individual patients and their characteristics, a number of specific questions will be addressed. However, there are also a number of limitations to the suggested approach. First, the absence of random allocation of patients to either of the two models of care will affect the strength of any conclusions about causal effects. The use of quasi-experimental methods to the data will offset some of these limitations.

Second, the quantitative approach will not be able to address other important questions of digital care, such as medical staff and patient perceptions and experiences of the care. Hence, the studies produced under this research project will complement those of other approaches. Third, the studies will not be able to differentiate between different forms of digital primary care. For example, it will not address the issue of whether synchronous consultations are more effective than asynchronous ones, or vice versa. Similarly, the research project aims to compare two distinct forms of primary care, not a situation where the models act in some combined or integrated form of service provision. Fourth, while the study will make use of a large database covering services over 2 years from a representative sample of regions, the application of digital primary care continuous to develop, both in its scope and form. As the technology and practice of digital primary care matures, it is likely that both patients and providers will adjust to its limits and possibilities. Obtaining an early understanding of these limitations and opportunities is critical for effective policy development, with relevant lessons for most other countries.

Finally, it is important to note that the specific issues of digital primary care and the methodologies applied for analyses which the research project aims to investigate are also relevant for any new form of primary care provision, for example, pharmacies and other retail clinics providing services traditionally conducted by in-office primary care.[6 47] The current studies will thus be able to contribute to an improved understanding of the effects of changing primary care more broadly.

Ethics and dissemination

Ethical approval has been provided by the Swedish Ethical Review Authority (reference number 2019-01500). This is a registry-based study. As such, use of data follows the Swedish legislation and practice with regards to consent. For more information about ethical aspects and consent in registry-based studies in Nordic countries, see Ludvigsson *et al*.[48]

The outputs of this study are relevant to a wide set of stakeholders and asked for in many different fora. The results will therefore be disseminated both to the research community, healthcare decision-makers and to the general public. Each separate study objective as described above will generate at least one scientific article. The research team will also organise policy dialogues on digital primary care where evidence from the project will be presented.

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Paper III

Original Research

DIGITAL HEALTH

Evaluating the effect of digital primary care on antibiotic prescription: Evidence using Swedish register data

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Abstract

Background: The growing use of digital primary care consultations has led to concerns about resource use, equity and quality. One of these is how it affects antibiotic prescription. Differences in ease of access for patients and available diagnostic information for the prescribing physicians are reasons to believe prescription rates may be affected.

Objectives: We estimated differences in antibiotic prescription between traditional office-based and digital contacts, if these differences varied between groups of diagnoses depending on the availability of information for the prescribing physician, and if differences were associated with socio-demographic patient characteristics.

Methods: Using individual level register data for a sample of patients diagnosed with an infection over a two-year period, we estimated differences in prescription between the two types of contacts and applied propensity score techniques to mitigate possible problems with treatment selection bias.

Results: The share of antibiotic prescription was 28 (95% CI 27–30, $p < 0.001$) to 33 (95% CI 29–36, $p < 0.001$) percentage points lower among digital contacts as compared to office-based contacts. For urinary tract infections, the differences in prescription rates between the two contact types were smaller (34 to 41 percentage points difference) than for throat and skin infections (50 to 60 percentage points difference). For women, rural, older, and people born outside Sweden, digital contacts were associated with higher prescription rates.

Conclusions: Antibiotic prescription rates were significantly lower for digital contacts compared with office-based contacts. The findings suggest that digital primary care may be an effective alternative to in-person visits without undue consequences for antibiotic prescription levels, although to varying degree depending on diagnosis.

Keywords

Primary care, digital contacts, antibiotics prescriptions, socioeconomic factors, Sweden

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Introduction

Digitally provided services in primary health care have increased sharply over the past decade and provide both opportunities and challenges to health care systems. A key quality concern is the effect that digital primary care services may have on antibiotic prescription rates. In digital contacts patients cannot necessarily be examined in the same way as in office-based visits. Lower barriers to a prescribing physician attributed to easier patient access online and a more anonymous patient–physician relationship could lead to higher rates of antibiotic prescription, if they are given on less strict medical indications.[1,2]

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In Sweden, digital primary care has developed rapidly over the past six to seven years. It is likely that the low access to traditional primary care services has contributed to the development,[3] but also a strong innovative digital sector and the generally high digital literacy among the population. It has been shown that antibiotic prescription is higher in Swedish municipalities with shorter waiting time to primary care.[4] Improved access to care through digital means could negatively affect recent years' gains in lower antibiotic consumption in Sweden.[5] In Swedish primary health care, large focus is given to prudent prescription, which is encouraged financially and through strict treatment protocols.[5,6]

The current evidence on the effects of digital primary care on antibiotic prescription rates is still relatively limited. Furthermore, contextual differences are likely to impact prescription behaviour and thereby the relevance of the emerging evidence, which largely consists of studies from the US.[7] We found one systematic review on the impact of consultation on antibiotic prescribing in primary health care, which showed a mixed picture regarding the effect on prescribing.[8] Beyond the review, one study found higher level of prescription among digital contacts for urinary tract infections.[9] However, a study on antibiotic prescription for sinusitis found lower prescribing in the group of digital contacts.[10] A study of acute respiratory infections found no significant difference in prescription levels.[11]

In the Swedish context, three studies with similar aims but adopting different approaches have been published.[12–14] One study selected patient cases from an electronic records system at a local private group of clinics, providing both in-office and digital contacts in the form of asynchronous text-based messages.[13] Prescription rates were compared for sore throat, dysuria (indicating urinary tract infection), and respiratory symptoms, and findings showed that asynchronous digital contacts were not associated with higher prescription rates compared with office visits. Another study compared nation-wide contacts from private digital providers in Sweden with traditional office-based visits in primary care in one region (population 300,000) over a two-month period. They found almost five times higher odds of an antibiotic prescription during office-based visits, although with large variation between diagnoses.[14] Both studies applied descriptive logistic regression with basic patient characteristics such as age and sex. Applying a differences-in-discontinuity estimation, making use of data from before digital contacts were available and the difference in user fees at the age of 20, one study found that digital meetings were at least as restrictive on antibiotic prescriptions as traditional care.[12] In addition, a recent working paper (preprint) on utilization of digital primary care documented generally lower levels of prescriptions among digital contacts.[15]

Evidence for possible differences in antibiotic prescriptions between traditional office-based contacts and digital contacts is inconclusive. We also found that few studies have applied more than descriptive regression analyses, only using data on crucial differences in the patient mix as controlling covariates. Further, we note the differences in barriers to access between the two types of contact and that these differences may vary between different infection diagnoses. The fact that a single diagnosis can include a spectrum of severity (heterogeneity) that is not observable in quantitative data and include a possible self-selection in care seeking behaviour has not been assessed. With its early adoption of digital primary care services and emphasis on restrictive antibiotic use, Sweden provides a case for assessing prescribing effects of new forms of primary care services.[16] We define a digital contact in this study as an online consultation, remotely provided either by video or chat function.

To contribute to an improved understanding of the effect of digital primary care, the aim of this study was to evaluate differences in the probability of antibiotic prescription between digital and office-based primary care. Specifically, we analyse differences in the probability of prescription by sub-groups of infections, as differences in prescription rates between digital contacts and traditional primary care may vary with differences in what clinical information is available. We also investigate if single socio-demographic patient characteristics were associated with differences in prescribing between digital and office-based contacts.

Conceptual framework and context

Patient characteristics as factors for antibiotic prescription

A primary care contact for an acute but mild infection is typically initiated by the patient and can lead to a prescription of antibiotics. With the introduction of digital services, the barriers to seeking and accessing a medical provider who can prescribe an antibiotic were reduced for many patients. With lower barriers to seeking care, it is likely that for any given diagnosis, there is a self-selection among patients which correlates with the severity of the infection. With the new lower barrier alternative that was previously not available, patients with less severe infections may be more prone to contact health care. Early evidence from England supports this possibility.[17] If patients have the same probability of antibiotic prescription for any same condition regardless of whether they contact an office-based or a digital provider, it would lead to proportionally lower levels of prescription in the more easily accessible contact form since more patients with less severe infections would present themselves to that health care provider, given the lower barrier for contacting health care. By means of register data, a possible patient self-selection in play relative to the severity of each diagnosis is not possible to observe.

However, data on socio-demographic factors that can impact the response to the potentially lower care seeking and access barriers to providers, such as age, sex, income, and education level, are available. These factors are all related to various aspects of digital literacy, including health care seeking behaviour[18] and often vary between traditional and digital contacts.[19] It is also well documented in Swedish official statistics that age and sex are associated with the level of antibiotic prescription, which is generally lower among men and increase with age.[20] It has not been studied if these factors can explain possible differences in prescription between office-based and digital contacts, even though evidence unambiguously shows that both access to services and quality of care are dependent on patients' socioeconomic characteristics.[21]

Differences in required information to prescribe antibiotics

After initial contact by the patient, there are factors on the provider side, which can affect the probability of prescription depending on type of contact. A digital contact includes fewer investigative tools and hence less information on which to base the treatment decision. However, according to Swedish guidelines for some diagnoses, most prominently lower urinary tract infections in non-pregnant women, the decision can often be taken solely based on patients' self-declared health status.[22] This implies that the same information is available to the physician in either model of care and any differences in prescribing between the two types of contacts are due to factors of access barriers and guideline adherence. For some infection diagnoses, data available to make a decision about prescription are lacking in digital types of contacts. This situation limits the advantageous effect of low barriers to digital care and requires that patients contacting a digital physician have an additional care contact apart from meeting the physician. An example is tonsillitis, for which a streptococcal antigen test is recommended for decision making according to Swedish guidelines. In a third group of diagnoses, which includes several skin conditions, the patients' self-declared health status in combination with a visual aid can in theory, but not necessarily in clinical practice, adequately inform the decision about whether to prescribe antibiotics.

The above implies that the share of contacts leading to a prescription in office and digital types of contacts differ between diagnoses that require only patient-reported health status compared with diagnoses that require either a visual investigation, a physical meeting, or a laboratory test. More restrictive prescriptions in digital contacts relative to office-based contacts for diagnoses that require clinical data beyond what the patient's anamnesis can provide would then be expected.

The Swedish primary care context

Funding and provision of health care in Sweden is the responsibility of 21 independent regional administrations. In primary care, all regions apply a predominantly capitation-based payment and a broad service package requirement, but contracts and reimbursement rules vary considerably. Sweden's primary care is characterised by a mix of public and private clinics with multi-professional teams. The free provider choice for patients was strengthened with new legislation in 2010 by liberalising the rules for establishing new clinics.[23] The intention to support a more patient responsive primary health care system was partly met, although effects on waiting times and geographical access were not large.[24] In addition, primary care visits outside the patient's home region are reimbursed by the home region on a per-visit-bases. This inter-regional billing system works in parallel with the capitation system and has been important for the evolvement of publicly funded digital primary care services, as digital providers operating nationwide have used it to charge for contacts.

Methods

Sampling and data collection

We used a purposive Swedish consultation level dataset for 1 January 2017 to 31 December 2018. The data were collected for an ongoing project of the effects on the Swedish health system following the fast-growing use of digital primary care. The dataset combines detailed clinical data on traditional office-based and digital contacts by residents in five Swedish regions spread across the country, including both mid-sized cities and rural areas. Only adult patients (from age 18 and older) were included, as prescription data on children were not captured in the same way across regions.

The sample included all patients who had been diagnosed with at least one of three different types of infections during the study period: urinary tract infections, upper respiratory tract infections and skin and soft tissue infections. A national identification number enabled linking of data from different sources on the level of each individual. Data on the socio-demographic variables sex, age, income, education, residency and place of birth of these individuals were collected from Statistics Sweden. Data on diagnoses from specialised care (outpatient and inpatient) were collected from the National Board of Health and Welfare and used to construct a Charlson comorbidity index value for each patient.[25]

We selected the infection diagnoses which have recommendations on antibiotic use by the Swedish strategic programme against antibiotic resistance (STRAMA)[26] to focus the study on conditions that are specifically sensitive to careful antibiotic prescription. The specification of diagnoses captures both coding by the International Classification of Diseases 10th edition and the International Classification of Primary Care used by many physicians.[27] Supplement 1 provides a table with the exact diagnosis codes. The final sample is described in Table 1.

Statistical analysis

We first tabulated the crude differences in prescription between office-based and digital contacts (results in Table 3). We then estimated the difference in probability to receive a prescription of antibiotics (the outcome)

Table 1. Descriptive statistics of sample.

Variable	Office-based contacts	Percentage or SD*	Digital contacts	Percentage or SD*
N	217 678	(95.7%)	9 850	(4.3%)
Provider type				
Physician	120 974	(55.6%)	9 845	(99.9%)
Nurse	36 833	(16.9%)	4	(<1%)
Other	2 263	(1.0%)	1	(<1%)
Missing	57 608	(26.5%)	0	(0.0%)
Age, years, mean (SD)	51.5	(20.2)	37.3	(14.0)
Sex				
Women	134 817	(62.3%)	7 362	(74.7%)
Men	82 861	(37.7%)	2 488	(25.3%)
Annual gross income, SEK, mean (SD)	206 874	(162 641)	241 263	(278 495)
Education level				
Elementary	49 203	(22.6%)	975	(9.9%)
High school	105 057	(48.3%)	4 778	(48.5%)
University	60 715	(27.9%)	4 066	(41.3%)
Missing	2 703	(1.2%)	31	(0.3%)
Charlson Co-morbidity Index groups				
Full health	191 144	(87.8%)	9 201	(93.4%)
One diagnosis	16 943	(7.8%)	398	(4.0%)
Multimorbidity	4 367	(2.0%)	43	(0.4%)
Missing	5 224	(2.4%)	208	(2.1%)
Geographic region[a]				
Rural	56 072	(25.8%)	1 624	(16.5%)
Sub-urban	161 606	(74.2%)	8 226	(83.5%)

(continued)

Table 1. Continued.

Variable	Office-based contacts	Percentage or SD*	Digital contacts	Percentage or SD*
Country of birth				
Foreign	36 082	(16.6%)	761	(7.7%)
Sweden	181 596	(83.4%)	9 089	(92.3%)

Source: Digital primary care study; consultation level data for sampling period.
[a]Only the three largest Swedish cities are classified *urban*, where no patient in the sample is resident.
* We conducted statistical analysis for differences between the groups. The tests (chi^2-test for the categorical variables and *t*-test for the continuous variables) show statistical differences between the two groups (*p*-value < 0.001).

between office-based and digital contacts (treatment choices) by applying three different regression models (results in Table 4). First, a logistic regression model was applied, in which the patient characteristics are used as controlling factors to adjust for case-mix. The estimated coefficients were used to predict the differences in levels of prescription between the two types of contact. With the intention to mitigate the potential bias in the first regression model's treatment estimate due to self-selection of contact type, two propensity score models were applied. These two models make use of the patient characteristics to estimate the propensity to choose one or the other type of contact.

Propensity score models

Because the assignment to one of the contact types (digital or office-based) was not random in our material, there are most likely unobserved mechanisms influencing the choice of contact that correlate with the outcome, prescription of antibiotics. We applied modelling based on the potential outcomes framework, which attempts to mitigate the selection problem.[28] As the potential outcome of choosing the other contact than the de facto chosen is not known, the potential outcomes framework is a set of estimation techniques that attempts to estimate the unobserved potential outcome in the data and compare the two intervention groups.

Specifically, we modelled the relationship between antibiotic prescription and type of contact using propensity score matching and inverse probability weights models. Both approaches estimate what would be the effect if everybody in the sample had the same type of contact. They both reflect the probability of contact assignment conditional on the observed characteristics of the sample, hence the name 'propensity'.[29] However, they differ as to how the differences in the characteristics of observations are used. In propensity score matching, observations are matched by finding patients with the same probability of selecting one or the other type of contact. In our sample, the matching was based on the equal propensity to choose an office-based or digital contact. In the inverse probability weighting model, each contact groups' observations are weighted so they become the inverse of their probability to have selected the other type of contact.[30] The two approaches complement each other to strengthen the analysis of the effect of digital care on the identified outcomes. As both techniques use covariates of the observations to obtain comparable treatment and control groups and meet the assumption of independence between the outcome and treatment choice, the observations in the matched samples should be balanced in their characteristics, that is, the mean and covariance of variables should be close between treatment levels.[31]

For these models we used Stata's treatment effect commands *teffect psmatch* and *teffect ipw*, [32] to estimate the difference between the two types of contacts with respect to prescription. We specified each model using the variables available (Table 1) to achieve the highest possible balance between covariates after the propensity estimates. The main result for each model and sample group (Table 4) is the average treatment effect, that is, the difference between two mean outcomes in the hypothetical situation when all patients had chosen one or the other contact. This can also be seen as the estimated average casual effect in the population.[33,34]

Diagnose groups to reflect differences in available information for prescribing antibiotics

We identified three groups of diagnoses to analyse the effect that information availability may have in the probability of antibiotic prescription across the two treatment alternatives. We specified a first group of diagnoses for which no additional information than the patient's description is needed to prescribe as lower urinary tract infections in women. A second group was defined by the throat infection diagnoses pharyngitis and tonsillitis, which typically require laboratory data to prescribe. A third group was defined by three skin infections that may be assessable over video: borrelia (Lyme disease); impetigo; and erysipelas (Table 2). Supplement 1 provides a table with the exact diagnosis codes per group.

Table 2. Information needs for prescribing by diagnoses group.

Diagnosis group	Information needs for prescribing
Group 1: Lower urinary tract infections in non-pregnant women.	Patient-reported health status only.
Group 2: Throat- and respiratory tract diagnoses pharyngitis and tonsillitis.	Patient-reported health status and physical examination and/or laboratory test.
Group 3: Skin infections borrelia (Lyme disease), impetigo, and erysipelas.	Patient-reported health status and assessment by physical examination, video or photo.

Socio-demographic factors and prescription

To meet the objective to investigate each socio-demographic factors' association with differences in prescribing between the two types of contacts, we tested if the share of prescription by type of contact differed depending on the level of each patient characteristics age, sex, co-morbidity status, income, education, place of residence, and country of birth (see Table 1 for the list of covariates). Equation 1 describes our general model.

$$\log(\text{odds})\,\text{prescription} = \beta_0 + \beta_1(\text{type of contact}) + \beta_2(\text{socio-demographic factor}) + \beta_3(\text{type of contact} \times \text{socio-demographic factor}) \quad (1)$$

Each characteristic's interaction effect with type of contact on prescription was measured separately in a logistic regression analysis, resulting in log odds coefficients of interaction between type of contact and patient characteristics (β_3 in equation 1). Formally, we tested if there was an interaction effect between type of contact and the socio-demographic factor in the association with prescription. Based on the same estimations, we calculated and graphed the predicted prescription rates by type of contact for each characteristic.

Results

Differences in prescription between types of contact

The share of contacts leading to an antibiotic prescription was significantly lower in digital contacts as compared with office-based contacts, regardless of estimation model or diagnosis grouping. When no adjustments for case-mix or modelling of the data were made, including the entire sample, the difference was 31.5 percentage points (Table 3). Of the three groups of infection diagnoses defined by differences in information need for prescription, the difference in prescription was smallest (41.2 percentage points) among lower urinary tract infection diagnosis (group 1). In group 2, with diagnoses which typically require a physical meeting or laboratory test to prescribe antibiotics, the difference was larger (52.3 percentage points). Skin infections, requiring a visual or image assessment, had the largest difference in prescription between the two types of contact (59.4 percentage points).

All three regression models showed a lower share of prescription for digital contacts. By the first model, in which we predicted the differences in levels of prescription based on the coefficients from a logistic regression model, the probability of a prescription at a digital contact was 28 percentage points lower than at an in-office visit. The respective propensity score models both showed 33 percentage points lower prescription for digital contacts in the total sample (Table 4). For lower urinary tract infections, the estimated difference in prescription between digital and office-based contacts was smaller (34 to 41 percentage points depending on model) than for skin infections (48 to 58 percentage points difference) and throat infections (52 to 53 percentage points difference) in all regression models. The lower difference to skin infections were significant in all models, but undecisive relative to throat infections due to the matching model's large confidence intervals.

The estimated differences in prescription between types of contact were larger in the two propensity models. In particular, the inverse probability weighting model showed significantly larger prescription differences in all groups except for throat infections. The results indicated that when we compared individuals with the same propensity to choose one or the other care contact based on socio-demographic characteristics, the differences in prescription were higher.

Prescription and socio-demographic factors' interaction with type of contact

Four socio-demographic factors had a significant interaction with type of contact in the regressions, that is, the share of antibiotic prescriptions by type of contact differed depending on the level of the factor (Table 5). Figures 1 to 4 show the predicted rates of antibiotic prescription for these factors. For men, the effect of contacting primary care in a digital format was associated with less probability to receive a prescription as compared to women making the same choice of contact (urinary tract infections excluded, Figure 1). With increasing age, there was a considerable increase in prescriptions for digital contacts, especially for the oldest group, but only small differences for the office-based contacts (Figure 2). This age pattern was consistent across groups of diagnoses (not shown). For people living in sub-urban areas, contacting digital services was associated with a lower rate of prescription than for people living in rural areas (Figure 3) and for people born in

Table 3. Crude differences in shares of prescription between office-based and digital contacts, by type of diagnosis groups.

Diagnosis group	Office-based		Digital		Difference (%-points)
Total sample					
N	217 678		9 850		
Prescriptions (%)	109 356	(50.2%)	1 838	(18.7%)	31.5*
Group 1: Lower urinary tract infections in women					
N	26 964		2 929		
Prescriptions (%)	22 736	(84.3%)	1 262	(43.1%)	41.2*
Group 2: Throat infections					
N	21 909		886		
Prescriptions (%)	14 336	(65.4%)	116	(13.1%)	52.3*
Group 3: Skin infections					
N	11 264		698		
Prescriptions (%)	8 746	(77.6%)	127	(18.2%)	59.4*

* $p < 0.001$.

Table 4. Difference in prescribing probability between in-office and digital contacts, by groups of diagnoses and by estimation model [95% confidence interval]*.

	Descriptive logistic regression	Regression by propensity score matching	Regression by inverse probability weighting
Total sample	0.28 [0.27, 0.30]	0.33 [0.29, 0.36]	0.33 [0.33, 0.34]
Group 1: Lower urinary tract infections	0.34 [0.31, 0.37]	0.41 [0.28, 0.54]	0.41 [0.38, 0.43]
Group 2: Throat infections	0.52 [0.49, 0.55]	0.52 [0.49, 0.57]	0.53 [0.50, 0.56]
Group 3: Skin infections	0.50 [0.44, 0.56]	0.62 [0.59, 0.65]	0.60 [0.57, 0.64]

* p-value for all differences is <0.001.
Supplement 2 provides each models' specification, as well as mean and variance differences for each covariate.

Sweden, digital contacts were not associated with higher prescription than for foreign-born, which was the case for in-office contacts (Figure 4).

For level of income, education and multi-morbidity, there was no significant interaction effect with type of contact regarding prescription level, that is, shares of prescriptions did not change with these factors in combination with office-based and digital contacts (Table 5).

Sensitivity analysis

The results may be sensitive to data collection differences across regions, due to differences in health information systems such as electronic medical records and database management. To check if results held across regions, we estimated the differences in prescription between contact types also per region (results not shown). The results

Table 5. Log odds interaction coefficients between type of contact and patient characteristics with regard to level of antibiotics prescriptions.

Interaction with digital contact (base rate)	Sex	Age	Income	Education	Co-morbidity	Rural	Country of birth
Men (Women)	−0.35*						
Age 40–64 (18–39)		0.58*					
Age 65+ (18–39)		1.15*					
2nd income quintile (1st)			0.05				
3rd income quintile (1st)			−0.12				
4th income quintile (1st)			0.01				
5th income quintile (1st)			0.16				
High-school (elementary)				0.03			
University (elementary)				0.10			
One diagnosis (Full health)					0.02		
Multimorbidity (Full health)					−0.85		
Sub-urban (Rural)						−0.21*	
Sweden (Foreign born)							−0.20*

* $p < 0.05$.

remain largely robust to these adjustments in the samples. The share of prescriptions in digital contacts was significantly lower and the differences were smaller in lower urinary tract infections than for the other specified diagnosis groups across all regions, consistent with the full sample analysis.

As Table 1 shows, there are differences between the types of contact with regard to which profession the patient meets. In the digital contacts the staff category is almost exclusively a physician, which is not the case for in-office contacts. There are also observations with missing data for in-office contacts. To ensure our results hold, regardless of which profession provides the service, we conducted sub-analyses with comparisons of physicians only. The differences to our main results are small in all estimation models, with a slightly smaller difference in prescriptions overall when we compare physicians only. Table 6 replicates crude percentage differences in prescriptions from Table 3, with differences for only physicians as a comparison. Other results are not shown but in line with these comparisons.

Discussion

This study evaluated the differences in antibiotic prescription between traditional office-based and digital contacts in the early phase of the digital primary care development in Sweden. Antibiotic prescription rates were significantly lower in digital contacts compared with office-based contacts and this held true for all defined sub-groups of diagnoses. Differences in antibiotics prescriptions between the two types of contacts vary by diagnoses. We found smaller difference in antibiotics prescriptions for lower urinary tract infections in women than for the groups of diagnoses requiring image or visual data (skin infections) and indication of the same for diagnoses requiring laboratory testing (throat infections). Other studies comparing digital contacts with physical contacts have also found differences between groups of diagnoses.[13,14] Although we cannot conclude what leads to these differences, the findings are in line with our conceptual framework that differences in prescription rates between types of contact can be related to differences between conditions in how much patient information the prescribing doctor has. In contrast, an earlier US study found double the number of antibiotics prescriptions for urinary tract infection during digital contacts than office visits, hypothesizing that inability to examine the patient could instead lead the physicians to a more ‘generous’ prescription.[9] This does however not seem plausible from more recent evidence, which in line with our results show lower prescription rates for digital contacts.

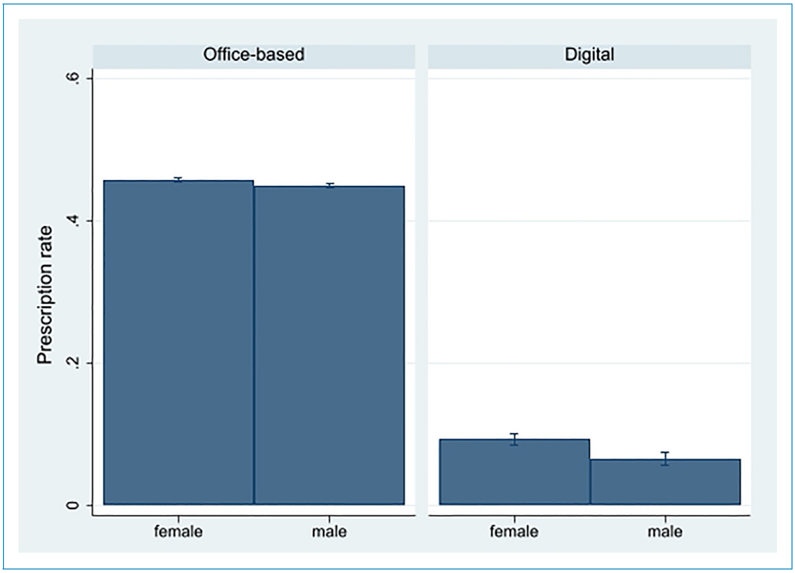

Figure 1. Predicted rates of antibiotic prescription by sex and type of contact (95% confidence intervals).

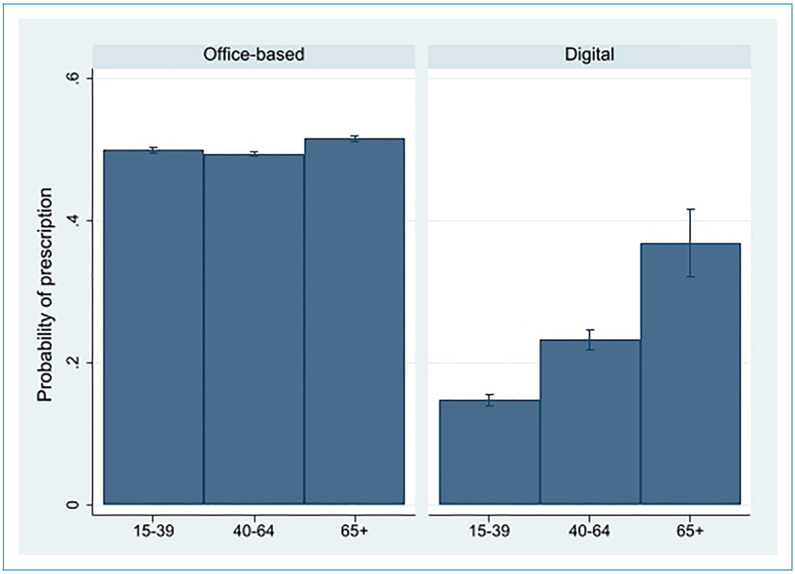

Figure 2. Predicted rates of antibiotic prescription by age and type of contact (95% confidence intervals).

The propensity score modelling approach from the potential outcomes framework, making use of patient characteristics to make assumptions about choice of contact type, produced somewhat higher estimated differences in prescription, as compared to the descriptive regression model. Hence, when we attempted to mitigate the

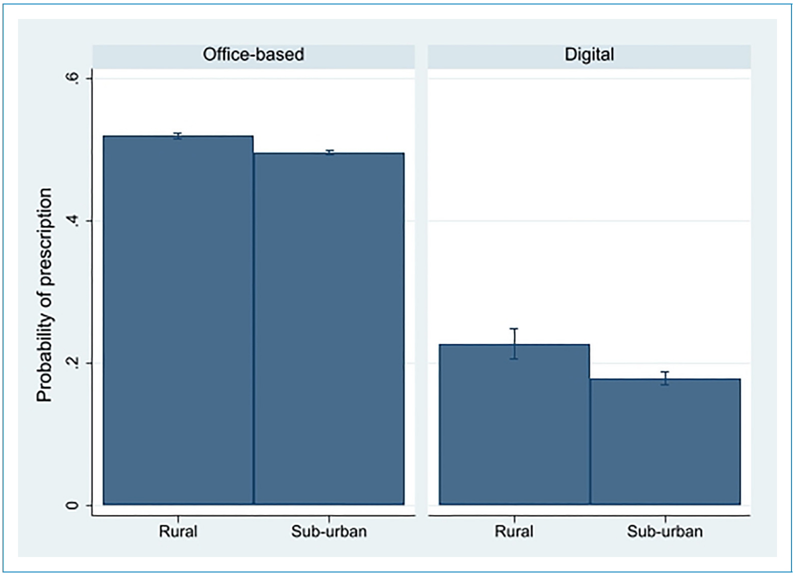

Figure 3. Predicted rates of antibiotic prescription by geographic region and type of contact (95% confidence intervals).

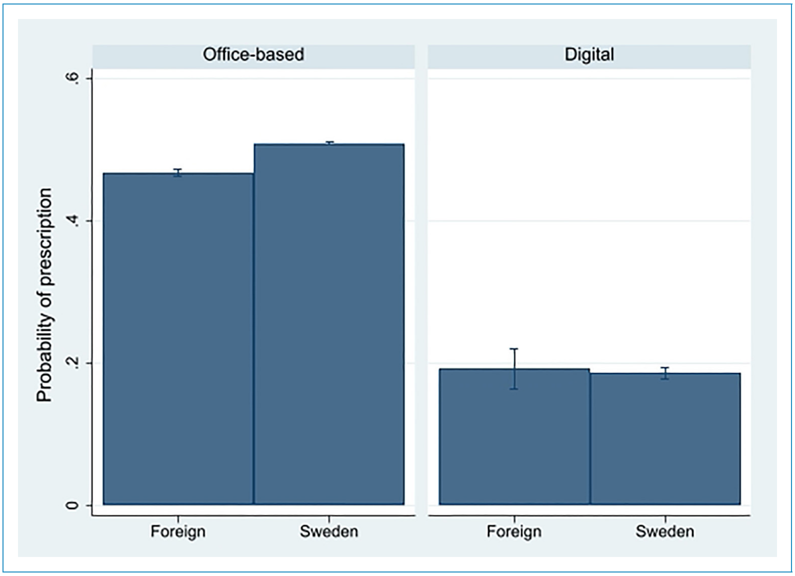

Figure 4. Predicted rates of antibiotic prescription by country of birth (quantiles) and type of contact (95% confidence intervals).

problem of a possible selection bias in the register data by applying the propensity models, we observed larger differences than in purely descriptive comparisons. The differences between the models were not conclusive but illustrate the problems with the almost exclusively observational studies in the literature, as the differences in

Table 6. Comparison of crude differences in prescription for all providers and physicians only.

Diagnosis group	Office-based	Digital	Difference (%-points)
Total sample			
All providers	50.2%	18.7%	31.5*
Physicians only	47.1%	18.7%	28.4*
Group 1: Lower urinary tract infections in women			
All providers	84.3%	43.1%	41.2*
Physicians only	83.1%	43.1%	40.0*
Group 2: Throat infections			
All providers	65.4%	13.1%	52.3*
Physicians only	65.4%	13.1%	52.3*
Group 3: Skin infections			
All providers	77.6%	18.2%	59.4*
Physicians only	80.5%	18.3%	62.2*

* $p < 0.001$.

prescription are possibly larger than we observe in descriptive statistics. The only earlier study evaluating the effect of digital primary care on antibiotic prescription that applied both a descriptive model and a matching technique did not observe any differences between the modelling techniques, but that study applied direct matching on observations and not a propensity score technique, and was conducted in a different context.[11]

This is the first study that has assessed which socio-demographic factors may drive antibiotic prescription in digital primary care. It has been repeatedly documented in public official statistics that antibiotic consumption increases with age and is lower among men than women, measured as share of population size.[20] A Swedish study on traditional primary care with data from 2016-2017 indeed showed that women and patients in the highest age groups had significantly higher levels of dispensed antibiotics.[35] It also found higher levels among high-income groups. Our study indicates that the choice of contact interacts with age and sex with regards to antibiotics prescriptions. Male patients had lower and older patients higher probabilities of prescription if they made a digital contact than an office-based contact. Furthermore, the uptake of digital services in Sweden has been faster in urban than in rural areas.[36] The significantly lower level of antibiotic prescription in digital contacts among patients residing in sub-urban areas relative to rural that we found, suggests that the effect of generally lower prescription rates for digital contacts were strengthened among patients in sub-urban areas.

Whilst it has been shown that high co-morbidity was associated with higher rates of antibiotic prescriptions in traditional, office-based care,[4] we saw no significant multi-morbidity interaction effect with type of contact, as variation in digital contacts were large and we only had 43 patients in the multi-morbidity group. The same study found that patients born in Sweden received antibiotic prescriptions at a higher rate in traditional primary care, although another study found the opposite result for dispensations.[4,35] Our results show that higher antibiotic prescription for people born in Sweden may only be true in traditional in-office care (Figure 4). But we also note that there may be other aspects of ethnicity than country of birth, that we cannot capture in Swedish register data. We could also not observe any significant interaction between educational level and digital contacts with regard to antibiotic prescriptions.

We note that the study is limited to a geographical selection of Sweden and does not include the three main urban areas, where digital services grew fastest in the beginning. Antibiotic prescribing for mild infections indeed varies across Swedish regions.[37] The strength of using data from several regions in the analysis carries risks that differences in coding practice between physicians, clinics and regions, and data administration systems, affect the results. We observed large differences in the crude prescription rates for in-office contacts (33–76% for all diagnoses) across the five regions while differences were considerably smaller in digital contacts (17–21%).

There are several factors that may affect prescription patterns, which would need further studies. Some are related to the care process and could affect rates of prescription in both directions, depending on how they influence the decision process of patients and prescribing medical staff.

When the patient contacts the care facility, the triage functions are different in the two forms of care. In Swedish office-based primary care, the first contact is often with a nurse. When there are symptoms of a mild infection some of these contacts may not lead to an infection diagnosis, but instead lead to advice on self-care and expectance (watchful waiting). In contrast, the digital providers offer a more direct contact with a physician and this higher probability to see a physician directly could lead to a smaller share of prescriptions in our study. It has also been suggested that built-in clinical support tools available to physicians working on digital platforms could enable more prudent prescription.[38,39] Notably, phone contacts are not included in this study. Differences in opportunity to contact the provider over phone by types of contact may impact both choice of contact and the diagnostic process. Also, digital tools develop both technically and in their practical applications, and medical staff and patients become more used to them, which will affect the care process and calls for updated studies on this topic. Finally, when the physician meets the patient, there might be individual factors that affect prescription rates and explain the observed lower prescription rates in digital contacts. One of these is if younger physicians are more attracted to working digitally, as it has been shown that younger physicians can be more prone to follow guidelines than older colleagues.[40]

In addition to care process factors, there are several structural aspects in the Swedish primary care system that could affect the differences we have observed. Digital providers in Sweden work on a fee-per-visit basis while office-based providers largely operate on a capitation rate. As the digital service is only reimbursed when a physician contact takes place, the incentive is to meet patients also on less severe indications. These contacts may not have taken place if the payment system had been based on capitation. Again, more contacts based on less severe indication (but with the same diagnosis) would lead to a proportionally lower prescription rate among diagnosed digital contacts. If on the other hand prescription rates had been on the same level in the same situation, it would imply that digital contacts follow guidelines less strictly. Further, growth of digital contacts was in Sweden initially driven by private for-profit providers. This difference in market conditions could also affect prescriptions. With the market reforms approximately ten years earlier, there were signs of an increase in antibiotic prescriptions among private office-based providers.[41,42] Generally, a shift to more patient demand-driven health care have raised concerns about providers' ability to base their decisions strictly on medical grounds.[43]

Conclusions

We conclude that digital services do not generally imply higher antibiotic prescription levels among their contacts than traditional primary care, but rather the opposite. The results are relevant for continued development of service provision and can support further policy development with regards to digital primary care. Continued studies of antibiotic prescription will be important in the context of growing digital primary care services. These services evolve fast and potential patients will be increasingly used to contact them, and new forms of hybrid contact forms are likely to develop. As such, the results presented in this article can also be seen as a base-line study of the effects of increasing digital primary care.

Contributorship: JW formulated research questions, defined methods, conducted the statistical analyses and drafted the manuscript. HT ensured clinical relevance in the design of the study, guided the selection of variables, interpreted results and contributed to writing the manuscript. EA led the diagnoses selection, advised on clinical relevance and critically revised the manuscript. BE was the Principle Investigator of the project, conducted the acquisition of the data, guided model design and statistical analyses and edited the manuscript.

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Ethical approval: Ethical approval has been provided by the Swedish Ethical Review Authority (reference number 2019-01500). This is a registry-based study. As such, use of data follows the Swedish legislation and practice with regards to consent. For more information about ethical aspects and consent in registry-based studies in Nordic countries, see Ludvigsson et al.[44]

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Paper IV

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RESEARCH **Open Access**

From office to digital primary care services: analysing income-related inequalities in utilization

Jens Wilkens[1*], Hans Thulesius[1] and Björn Ekman[1]

Abstract

The use of digital technologies to deliver primary health care has increased over the past decade. While some technologies have been shown to be medically effective and efficient, the effects of digital primary care on the policy goal of equality in the use of such types of care have not been studied using large register data. The aim of this study was to analyse how digital contacts differ from officebased visits by income as an indicator of socioeconomic status. Specifically, we estimated differences in primary care utilization across income, factors of contribution to these inequalities, and applied a needs-based standardisation of utilization to estimate differences in equity.

We used a purposively built consultation level dataset with 726 000 Swedish adult patients diagnosed with an infection, including clinical and sociodemographic variables. Applying concentration indexes (CI) and graphical illustrations we measured how the two types of services are distributed relative to income. We estimated how much of the inequalities were attributed to different sociodemographic factors by decomposing the concentration indexes. Standardised utilization for sex, age and comorbidity allowed for the estimation of horizontal inequity indexes for both types of services.

Utilization by the two types of care showed large income inequalities. Office-based visits were propoor (CI -0.116), meaning lowincome patients utilized relatively more of these services, while digital contacts were prorich (CI 0.205). However, within the patient group who had at least one digital contact, the utilization was also propoor (CI -0,101), although these patients had higher incomes on average. The standardised utilization showed a smaller prorich digital utilization (CI 0.143), although large differences remained. Decomposing the concentration indexes showed that education level and being born in Sweden were strong attributes of prorich digital service utilization.

The prorich utilization effects of digital primary care may risk undermining the policy goals of access and utilization to services regardless of socioeconomic status. As digital health technologies continue to expand, policy makers need to be aware of the risk.

Keywords Primary care, Digital health services, Service utilization, Equality, Concentration index, Register data, Sweden

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Introduction

The emerging digital health technologies to deliver services raises questions about its effects on several key performance dimensions, and emerging evidence suggests that these services can provide quality and cost-effectiveness opportunities. Distributional effects across the population, how utilization relates to demography, socio-economic status and health care needs also belong to the key concerns, which need to be understood for future development and regulation. There are many reasons why patients' opportunity to interact with primary care providers through digital tools may lead to a different utilization pattern than for traditional services. For example, as age is decisive for health care needs, and correlates with digital literacy, the transformed means to access health care providers created by digital channels are likely to impact utilization.

There is a small but growing evidence base on the effects of digital primary care on the use of services across demographic and socio-economic groups. Clearly, younger people use more digital services than others [1, 2], which has also been shown in Sweden's neighbouring country Finland [3, 4]. For other factors, global evidence is more inconclusive. There are examples of high income being associated with higher utilization [5], but others have not been able to establish any such link [1, 6]. Global evidence is also inconclusive with regards to whether inhabitants of rural or urban areas use more digital health services. Patients with rural residence, or long distance to a provider, do use relatively more digital services according to some studies [1, 6, 7], while others show the opposite or inconclusive results [5, 8, 9]. More recently, Doty et al. point out that more evaluations of effects across socio-economic levels are needed following several countries' attempts to incentivize digital primary care [10].

In Sweden, several studies have documented that early on when digital primary care options became available, utilization among wealthy, urban, female, and young population groups was unproportionally high [11], [12]. That there was an actual difference in utilization as compared to traditional office-based consultations was also shown in several studies, with more visits among young, higher income, urban, and people born in Sweden [13–15]. These observations have been confirmed in a study that estimated the relative importance of socio-economic factors for utilizing digital primary care [16].

When differences in care needs are considered, the comparison is further complicated. Interest in digital care applications has been shown to be lower among multimorbidity patients [17] and in patients with low education [18]. We found no studies that have explicitly applied an equity, or needs-based methodology, to evaluating utilization of digital primary care services beyond standardizing income and education groups by age and sex before comparing average utilization.

A corner stone in Sweden's and several other countries' health legislation is that health utilization shall be based on need, which implies that ability-to-pay should not be decisive in who uses health services [19]. To improve the understanding of the distribution of digital primary care utilization, the aim of this study was to analyse how digital contacts differed from traditional office-based visits by income and other socio-economic factors in the early phase of digital primary care.

The specific objectives were to:

1 Estimate equality in service utilization across income for the two types of primary care contacts;
2 Estimate factors of contribution to these inequalities in utilization;
3 Estimate horizontal equity in utilization for the two types of primary care contacts by applying a needs-based standardisation of utilization.

What defines equality and equity?

The body of literature on equality and equity of health care utilization is large and clearly the two terms can be defined in various ways. The distribution of health care utilisation is of interest for several reasons. Utilisation can be more medically effective when consumed by those in most need, or those who can gain most health from the utilization. The resources used to provide the service are also used more cost-effectively if those who can gain the most consume them. But ultimately, in the context of this study, the key interest is the strive for fairness, through a needs-based utilization of health care resources, a central objective in many countries.

A common and well recognised interpretation of equality in health care is to measure how utilization relates to income, as an indicator of individuals' ability to pay for health care services. Equal utilization is then present when health care consumption is equal across income levels [20]. The most commonly used alternative is probably education, which can be argued is more relevant for studies where many of the subjects are above working age [21].

Equity in utilization is more difficult and requires incorporating and operationalising a normative value judgement about what is a fair distribution [22]. Further, this phrase does not have an obvious practical definition, even though the concept of fairness in resource use has been applied by for example WHO [23]. If there had been a perfect measurement of care need, utilization distributed evenly across this need could be defined equitable [24]. However, it can also be argued that equity is achieved when utilization is distributed across an equal ability to benefit from that care, not the care need itself. Or even that the equal distribution of interest is the final attainment of health status [25], which can be seen as a higher ambition. Yet other aspects that can be considered are differences in preferences about health status or procedures available to meet this status [26]. Ultimately, the various definitions are dependent on a value judgement and thereby represent a variety in desired objectives [27].

Horizontal equity, that individuals with equal need are provided equal treatment irrespective of socio-economic characteristics or ability to pay, has become the most common approach in empirical literature on utilization, applied in multiple studies on equity in primary care [28], [29]. The precise measures will differ in their applications depending on the definition of need and availability of data. For example, health status as a need variable is in some studies survey-based and self-assessed and in others based on diagnoses from medical records. In this study, we applied the horizontal equity approach by adjusting all individuals' utilization across the population by the need variables sex, age, and a diagnosed-based comorbidity index.

Materials and methods

Data

We used a Swedish consultation level dataset for the calendar year 2018, collected for a project on the effects of the use of digital primary care in the Swedish health system [30]. The dataset combines clinical data on traditional office-based and digital contacts by residents in both urban, sub-urban and rural areas in seven Swedish regions purposefully chosen to represent differences across the country. These regions had a total population of 3.2 million, almost a third of Sweden's 10.2 million population. Because utilization relative to income is the primary factor of study, and child care has different access points and co-payment rules in the regions, only patients from age 18 and older were included in the analysis, a total of 726 087 patients.

The sample included all patients who had been diagnosed with at least one of three different types of infections during the study period: urinary tract infections, upper respiratory tract infections, and skin and soft tissue infections. This diagnosis-based selection was made early in the project, because mild infections were the main reasons for contacting digital providers when this service was made available [11]. The diagnosis-based sample also means non-users are not in the material. A national identification number enabled linking of data from different sources on the level of each individual. Data on the socio-demographic variables sex, age, income, education, residency, employment status and country of birth of these individuals were collected from Statistics Sweden and follow their standard official definitions and categorization [31]. Income was defined as the individual's gross income for the calendar year 2018, hence was neither related to other household income, nor equivalised for household composition. Data on diagnoses from specialised care (outpatient and inpatient) were collected from the National Board of Health and Welfare and used to construct a Charlson comorbidity index (CCI) value for each patient. The index values were then grouped in values zero (full health), one diagnosis, and multimorbidity (including severe or multiple diagnoses). The CCI was originally developed to classify comorbidity for estimating the risk of death [32], but has since been extensively used and validated for predicting utilization and cost [33] and gives different weights to conditions in order to reflect this. We used the most recently suggested diagnosis-list adopted to the Swedish context [34]. The final sample is described in Table 1 and the Venn diagram in Fig. 1.

During 2018, 607 586 individuals in the sample regions made at least one office-based visit and no digital contact (83.7% of sample, group A in Table 1 and Fig. 1), and had on average 4.4 visits. Another 103 264 people (14.2%, group B) made only digital visits and had on average 1.5 contacts. A smaller group of 15 237 (2.1%) people utilized both types of services (group C). This group had on average 6.3 contacts, of which 4.3 were office-based visits and 2.0 were digital contacts (not shown). In total, 726 087 people had at least one contact with primary care, which is 23% of the population in the seven regions. People in group B (digital contacts only) were considerably younger and had substantially higher income compared with those in group A. Utilization was generally higher among women. The difference was even larger for digital contacts than office-based primary care, mainly due to the infection diagnoses sample with a large group of women with urinary tract infections. The data also show a lower share of patients with co-morbidity, a foreign birth place, residence in rural areas and low education among the digital primary care users.

Methods

The first specific objective, to measure equality in service utilization across income for the two types of primary care contacts, was met by applying a concentration index and a two-dimensional graphical illustration with concentration curves. The concentration index (Eq. 1) measures the accumulated utilization of the service across the population ranked from lowest to highest income, defined as two times the covariance of the number of visits (u) and the relative fractional rank of the i^{th} individual in the income distribution (R), divided by the mean of u (μ) [20].

$$\text{Concentration Index} = 2_{cov}\left(u_i, R_i\right)/\mu. \quad (1)$$

This results in a value 0 if individuals regardless of income have the same utilization, which in a graphical

Table 1 Descriptive statistics of sample

	Office-based contacts only (Group A)		**Digital contacts only (Group B)**		**Both types of contact (Group C)**	
Variable	Number	Percentage or SD*	Number	Percentage or SD*	Number	Percentage or SD*
Number of patients	607 586	(83.7%)	103 264	(14.2%)	15 237	(2.1%)
Average number of contacts	4.4	(6.3)	1.5	(1.3)	6.3	(7.0)
Annual gross income, mean SEK	212 003	(266 929)	294 485	(920 678)	225 518	(200 408)
Age, years, mean (SD)	54.0	(20.0)	35.9	(12.6)	35.3	(13.8)
Sex						
Women	341 116	(56.1%)	67 494	(65.4%)	11 067	(72.6%)
Men	266 47	(43.9%)	35 77	(34.6%)	4 17	(27.4%)
Charlson co-morbidity index groups						
Full health	517 578	(85.2%)	95 036	(92.0%)	14 058	(92.3%)
One diagnosis	42 271	(7.0%)	3 838	(3.7%)	738	(4.8%)
Multimorbidity[a]	12 008	(2.0%)	468	(0.5%)	100	(0.7%)
Missing	35 729	(5.9%)	3 922	(3.8%)	341	(2.2%)
Education level						
Elementary	138 711	(22.8%)	8 934	(8.7%)	1 702	(11.2%)
High school	275 738	(45.4%)	39 665	(38.4%)	7 006	(46.0%)
University	184 232	(30.3%)	53 97	(52.3%)	6 473	(42.5%)
Missing	8 905	(1.5%)	695	(0.7%)	56	(0.4%)
Country of birth						
Foreign	111 077	(18.3%)	15 132	(14.7%)	1 675	(11.0%)
Sweden	496 509	(81.7%)	88 132	(85.3%)	13 562	(89.0%)
Geographic region						
Rural	141 804	(23.3%)	4 976	(4.8%)	2 467	(16.2%)
Sub-urban	202 07	(33.3%)	28 547	(27.6%)	4 068	(26.7%)
Urban	263 712	(43.4%)	69 741	(67.5%)	8 702	(57.1%)
Employment status						
Non-employed	276 990	(45.6%)	14 720	(14.3%)	2 955	(19.4%)
Employed	330 596	(54.4%)	88 544	(85.7%)	12 282	(80.6%)

* SD, Standard Deviation. Pearson's Chi2-test for the categorical variables and ANOVA for the continuous variables show statistical differences between the three groups (*p*-value < 0.001) for all variables

[a] Individuals with more than one diagnosis recorded in the national patient register

Source: Digital primary care study; consultation level data for sampling period

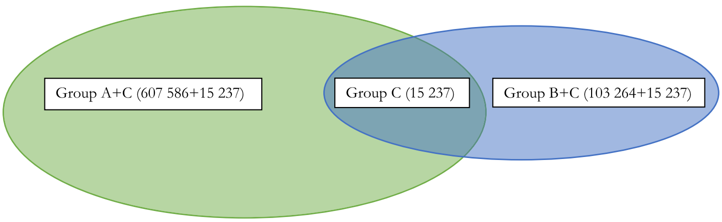

Fig. 1 Venn diagram describing the volume of contacts by type in the data sample

Groups **A, **B** and **C** refer to Table 1

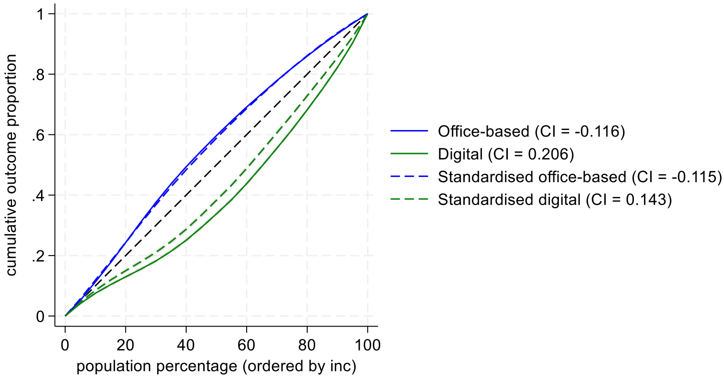

Fig. 2 Concentration curves and concentration indexes (CI) for crude and needs-standardized office-based and digital primary care utilization across income ($n = 726\,087$)

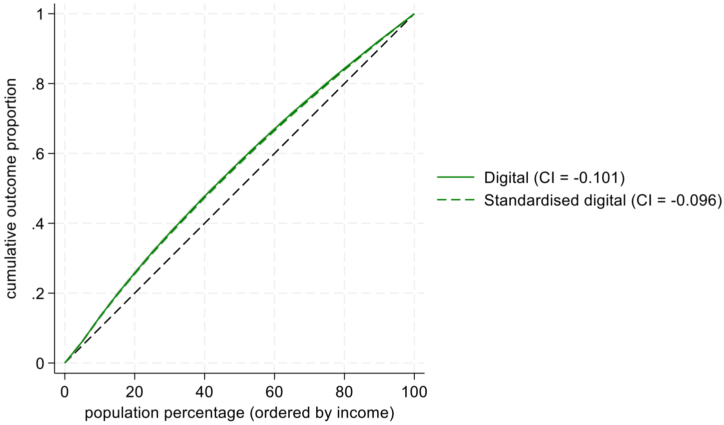

Fig. 3 Concentration curve and index of utilization across income for patients with minimum 1 digital contact ($n = 118\,501$)

illustration is represented by the 45-degree line (see Fig. 2 in Results section below). A concentration index below 0 means utilization was higher among low-income individuals and graphs a curve above the diagonal line, a value above 0 describes the opposite situation with pro-rich utilisation of the studied service.

Concentration indexes were first measured for both types of consultations across the entire sample, i.e., all patients were included in the same income ranking and their utilization by type of service was separately accumulated. This illustrated differences between the two services across income. Next, the same index was applied for two separate groups of patients to measure the distribution within groups. One estimate for patients who had used office-based services at least once (groups A + C in Table 1) and another who had used digital services at least once (groups B + C, see results in Fig. 3). Hence, there was an overlap of patients who had used both types of consultations (group C).

To meet the second specific objective, we estimated factors of contribution to the income inequalities in utilization measured per above. The index was decomposed into how much contribution to the income inequality can be attributed to a set of factors (defined by the variables presented in Table 1), by applying a decomposing (Eq. 2) applicable for any linear regression model with a dependent health outcome or utilization variable (y) and independent variables (x) with estimated regression coefficients (β) [35]. The total concentration of utilization, C, with respect to income, is the sum of each factors' concentration index, $\Sigma_k C_k$. Further, the weight of each factors' specific concentration index is given by the estimated beta coefficient β in the ordinary least square regression, where $\bar{x}$ is the mean of the respective factor and μ is the mean of contacts. The last term is a residual component, reflecting the income-related inequality in utilization that is not explained by systematic variation in the available factors. In a perfectly specified model this estimate would be zero.

$$C = \Sigma_k (\beta_k \bar{x}/\mu) C_k + C_\varepsilon/\mu \quad (2)$$

This decomposing technique proposed by [35] has been widely used and is transparent in its relatively simple computation and interpretation. We note that it has been criticised for carrying a set of assumptions and that the literature presents many alternative approaches to decomposition. The concentration index is a bivariate rank dependent index, i.e. it relates individuals' level of utilization to their relative income rank (as applied in this study). Indeed, the applied decomposition method assumes *rank ignorability*, i.e., it decomposes the utilization part of the covariance and ignores the association between the covariates and rank [36]. This means that for any explanation of changes in covariates, the income rank is assumed to remain the same, which may be troublesome as factors that impact utilization often also impact income [37]. The method also assumes exogeneity, i.e. that the error term is uncorrelated with the independent variables [38]. Hence, our chosen method is descriptive and cannot claim causality even though most literature where its applied uses language like a *factor is contributing* to a certain part of inequality. However, the several alternatives proposed are, although more sophisticated computationally, also more difficult in their interpretations, as acknowledged by their authors [36, 38].

For the third specific objective, to estimate horizontal equity, we applied indirect standardised utilization for need before relating it to income in a concentration index, which can be either pro-poor or pro-rich the same way as crude inequalities. The approach is referred to as the horizontal inequity index, which takes the value zero when individuals with the same need utilize the same volume of care irrespective of their income [39].

An ordinary least square regression estimates the parameters α, β, and γ (Eq. 3). Utilization was standardised for age, sex and co-morbidity by the need-variables (x_j). Further, to avoid biased estimates of the need variables, the non-need variables (z_k) country of birth, education level, employment status and geographic region were used as controlling factors. For example, not controlling for education level could have led to that the model estimated a higher needs adjustment through the correlation with our health status variable, co-morbidity. While education is correlated with utilization, we only want standardization of what we have defined as need. The remaining variation should come through the variable income in the estimation of inequity by the concentration index of needs-adjusted utilization [29].

$$y_i = \alpha + \sum_j \beta_j x_{ji} + \sum_k \gamma_k z_{ki} + \varepsilon \quad (3)$$

Then the estimated parameters, the individual values of the standardizing variables, and sample means of the controlling variables are used to predict the utilization of each individual ($\widehat{y}_i$) in the sample. Finally, the standardised utilization ($\widehat{y}_i^{is}$) is equal to the individual's utilization minus the predicted, plus the population average (Eq. 4). This indirect standardisation is the model's interpretation of needs-based utilization.

$$\widehat{y}_i^{is} = y_i - \widehat{y}_i + \bar{y} \quad (4)$$

Unlike most studies comparing equity for different types of care, commonly to answer if primary care is more or less equitable than hospital services, our two types of contacts are (arguably) intended to meet the same need. Therefore, for the comparison of utilization across the entire sample, we sought to standardise the utilization of both services by the same scale of need and calculated the needs-standardised utilization by total contacts for every patient. Standardising utilisation of the two services separately would have risked that young, well-educated and healthy individuals would have seemed to need relatively more (digital) services than others simply because this is how the service was consumed. After standardization the concentration indexes were calculated separately for all patients who had at least one office-based visit in one group (groups A and C in Table 1), and all patients who had at least one digital visit in another (groups B and C in Table 1). This way, the needs standardisation of each patient's utilization was the same regardless of what type of visits the patient had, and the income rank was the same, which made the distributions comparable across the same income rank as for the two first crude concentration indexes by Eq. (1). For the separate analysis of utilization and income distribution comparing the groups using only one or the other type of service (results in Fig. 3), we standardised utilization solely by individuals in the respective groups.

Results

Comparing all patients' utilization by the two types of care showed large income inequalities. Low-income patients were more frequent users of office-based visits while high-income patients used more digital contacts

Table 2 Decomposition of concentration indexes (CI) by type of primary care

Factor[a]	Office-based visits			Digital contacts		
	Contribution	Weight	Factor specific CI	Contribution	Weight	Factor specific CI
Age	-0.006	0.581	-0.010	0.019	-1.882	-0.010
Sex	-0.003	-0.048	0.055	-0.007	-0.124	0.055
CCI	-0.003	0.038	-0.072	0.000	0.001	-0.072
Education	-0.013	-0.228	0.056	0.023	0.401	0.056
Country	-0.003	-0.042	0.060	0.022	0.366	0.060
Geography	-0.003	-0.193	0.014	0.013	0.914	0.014
Employment	-0.032	-0.160	0.200	0.013	0.067	0.200
Sum	-0.061			0.083		
Total CI	-0.116			0.205		
Residual	-0.055			0.122		

[a] For full names and categories used, see Table 1

(see Fig. 2). The digital use was even further from equal use on the pro-rich side (Concentration index 0.205[1]) than the office-based visits on the pro-poor side (Concentration index -0.116).

The standardised utilization to measure equity showed that when adjustment for need is applied, utilization among those who used digital contacts were considerably less pro-rich (Concentration index 0.143), while the needs-adjustment does not change the distribution of office-based utilization substantially.

However, within the respective two groups of office-based and digital service users, utilization was pro-poor in both types of care. For those 622 823 patients who had at least one office-based visit (groups A and C in Fig. 1), the concentration index was -0.073 (not shown). Standardizing utilization within this group did only marginally change the distribution (concentration index -0.068).

Among the 118 501 patients who had at least one digital contact (groups B and C in Table 1), the concentration index value was -0,101 (see Fig. 3), i.e., utilization was distributed even more pro-poor across income within the group of digital users than within the office-based users. Standardizing utilization within the digital users group also had little effect (concentration index -0.096). The crude concentration index value for the 103 264 'only-digital' patients was -0.018 (not shown). These patients have considerably higher income on average, but within the group, utilization is also pro-poor, although close to equally distributed.

We also ran all standardizations without the non-need z-variables (Eq. 3) to see if only including the need variables age, sex and co-morbidity changed the results. As expected, the standardization effect, i.e. the difference to the crude inequality indexes, were then larger but the difference was very small (not shown).

Decomposing the unequal utilization by types of primary care presented in Fig. 2 explained some of the inequality. For office-based visits the model specification could explain just above half of the pro-poor inequality in utilization (0.061 of the 0.116 index value, Table 2), of which employment status contributes to half due to large income inequality and sensitivity to utilization. On the contrary, due to a negligible income effect, differences in age did not contribute to inequality, even though it was strongly associated with utilization of office-based visits.

The large pro-rich inequality among digital contacts is explained to a smaller degree (0.083 of 0.205, Table 2). High education level and being born in Sweden were the factors relatively strongly associated with the pro-rich inequality in digital contacts. For both factors, income inequality was high and there was a large sensitivity to utilization.

Discussion

In this study we find that utilization of new digital primary care services is unequally distributed in the population with a clear pro-rich pattern, while our results show a clear pro-poor distribution of traditional office-based services, the latter in line with earlier studies. But the results also reveal that within the group of digital service users, the distribution is pro-poor. One interpretation is that primary care provided by digital means, once patients have started using it, has potential to be distributed in a similarly pro-poor way as traditional primary care.

There is a contradiction in that rural and elderly patients, who ought to have the most to gain from digital

[1] p-values < 0.001 for all estimates of concentration indexes.

services due to its travel-free nature, were using them less than others. There should be large gains in bridging this gap, although these factors had little contribution to the unequal utilization across income. For elderly, the lower use is intuitive as digital literacy is generally lower among this group [40]. Qualitative studies have found elderly in Sweden are ambivalent to using digital services and that they are also more hesitant to the privately driven digitalisation of primary care [41]. Continuity in personal contacts are also valued higher among elderly [42], which has been more difficult with digital-only service providers.

The inconclusive results in global literature indicates that the specific context and type of services are decisive factors for how utilization varies across population groups. A case in point is the Danish national digital patient portal (sundhed.dk) designed as an entry point to meet a wide range of health purposes in the population. An evaluation found no difference in overall use of the portal by sex, age, education and self-rated health. But the authors conclude that there might still be large inequalities in sub-groups of different conditions, as well as inequities, if utilization had been measured in relation to specific needs [43].

All studies above in practice used a normative approach by comparing digital services with traditional office-based care. But even though the latter is the starting point available for comparison, it cannot be assumed that traditional primary care is distributed optimally across the population. Also, not all differences between population groups in digital primary care necessarily mean utilization is less equal than in the office-based alternative. The digital contacts may complement the traditional visits by various aspects, e.g. by condition, in a way that makes them more equal. If young people consume a lot more digital care within a specific diagnosis, it may be that they have few contacts in traditional primary care for the same diagnose. There may even be a link, so that these digital contacts were made because there was underutilization of some kind in the previously only available alternative.

The observed inequalities in utilization of digital primary care can also be seen in the light of a long-lasting debate in Sweden about a more demand driven care. Health care with low or inadequate regulation has always been prone to inequities, perhaps most famously described by "the inverse care law" [44]. The differences to the pre-existing alternative office-based visits across population characteristics indicate that the relation between need and use is not the same for the two types of services. As a result of increased patient choice, especially after the 2010 legislation that liberalised the rules for where and how new primary care facilities could be established, a shift towards less pro-poor utilization was observed [45–47]. It has been frequently suggested that the digital primary care market have further exacerbated this [48]. Importantly however, these arguments build on the digital care market development, not digital service provision per se. It is difficult to empirically separate what is caused by market conditions and what is due to a newly adopted technology, especially as the development was driven by new private digital-only providers in the early phase of digital primary care in Sweden, well into our study's time-period.

Similarly, we were not able to separate possible supply-side effects in this analysis. One of these is the risk that a supply-induced demand exists, for example by digital-only providers marketing their services more heavily in urban areas with a more affluent population.

The study is undertaken on data from before the COVID pandemic. Related to distributional effects in utilization, the question is then how socio-economic aspects interacted with the increase in digital primary care during the pandemic. The long-term effects are difficult to assess and probably local context matters a lot. For example, one study concludes that even though older and low-income patients seemed to have increased remote utilization during the pandemic, different groups did so by different means (phone, web, chat) and these modalities have varying implications for the relevance and quality of care [49].

Further on limitations, we recognise that the sampling defined by users of primary care, i.e., not including non-users, may have implications for our interpretation of utilization relative to income. We did not capture the distribution of the probability of a visit, as all observations have at least one visit of some type. Instead, we measured the visit frequency of both types of contact, conditional on at least one contact of any kind. It has been shown earlier that the conditional number of visits (non-zero) favours the poor in most OECD countries. The probability of seeing a doctor (i.e. making at least one visit) is distributed equally or pro-rich across income. But lower income patients, once they do see a GP, are likely to consult more often [39, 50, 51]. While the latter is confirmed for office-based visits in our study, we do not know if the former is true also for our context, and if so, what it looks like for digital services.

We note that our sample is a set of common infectious diseases, as these were the absolutely dominating conditions for digital services. We cannot extend the interpretation of our results beyond these conditions, or how it varies between them. Further research on chronic conditions should therefore follow.

We used crude individual gross income data, i.e. this variable was not equivalised for household income or composition, as this data were not available for the study.

It could have been interesting to see if another definition of income had affected the results.

We also recognise that the model specification applied for indirect standardisation assumes that our variables reflect the concept of need. But just like any study on equity, our results are probably biased by unobservable variation in need correlated with income [52].

Conclusions

This study, based on a large sample of infection diagnoses, shows that the introduction of digital services in Swedish primary care did not support attainment of equality in health utilization across income. When digital services increase in scope and scale, public governing and purchasing bodies need to find ways to ensure primary care overall is consumed without consideration of the patient's ability-to-pay. Socio-economic factors are at play, but in different ways depending on type of contact and probably also by medical problem. To formulate effective policy for this, further research is warranted to understand how developing digital services, increasingly integrated with office-based services, and growing digital literacy among patients, affect the utilization pattern. Supply side factors like how office-based and digital services are organised and under what conditions they work should also be included.

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Authors' contributions
JW formulated research questions, defined methods, conducted the statistical analyses, and drafted the manuscript. HT ensured clinical relevance in the design of the study, interpreted results and contributed to editing the manuscript. BE was the Principle Investigator of the project, conducted the acquisition of the data, guided model design and statistical analyses, and edited the manuscript.

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Availability of data and materials
The data used in the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and content to participate
Ethical approval has been provided by the Swedish Ethical Review Authority (reference number 2019-01500). This is a registry-based study. As such, use of data follows the Swedish legislation and practice with regards to consent. Ludvigsson et al provide more information about ethical aspects and consent in registry-based studies in Nordic countries [53].

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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Publisher's Note

Primary care in transition

Jens graduated with a Masters in Economics from Uppsala University in 1999. Since then, he has worked with health systems and financing analyses and project management in health care, as staff and consultant in national health agencies, international organisations and NGOs. With this thesis, he evaluates health system effects of emerging digital primary care in Sweden. This health service area has developed fast and provides many opportunities. It has also caused a lot of debate about its value and shortcomings. The thesis suggests how to comprehensively evaluate the effects of these new services and builds evidence about some of the effects. The thesis uses a large and purpose built database and applies both descriptive statistics, propensity score matching and concentration indices for the various studies. The results show that digital services were used predominantly for mild infections by younger, urban patients, that antibiotic prescriptions were less prevalent in digital than in office based consultations, with variation between diagnoses, and that digital primary care utilization in Sweden was relatively more common among high income patients.

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