Online versus In-Person Services: Effects on Patients and Costs *

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Abstract

Online delivery of one-to-one services offers potential convenience and cost savings, but little is known about its overall effects on consumers and the total costs of provision. We study online healthcare, focusing on primary care doctor consultations. We use novel data from Sweden and an effectively random assignment of patients to online nurses, who differ in their propensities to direct patients to online (as opposed to in-person) doctor consultations. We find that online consultations are delivered sooner, are shorter, and yield similar rates of diagnosis, prescriptions, specialist referrals, and patient satisfaction as in-person consultations. We also find no significant adverse medium- or longer-term health or employment effects from online consultations. But in the short term, online consultations increase emergency department (ED) visits and in-person primary care follow-up consultations, which eliminate their total mean cost savings. However, for patients without hospitalizations or ED visits in the previous three years (58% of the sample), online consultations save about half the cost of in-person consultations, suggesting that sorting patients across modes is key to reaping online's benefits.

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1 Introduction

In today's hybrid world, many organizations decide which one-to-one (1:1) services to deliver online and which ones in person, and which users should get which type.[1] These decisions may be consequential for both providers and users. Although switching to online provision can reduce costs and increase convenience, the nature of meetings can change when they are conducted through a screen, which may affect quality, user experience, and downstream costs and outcomes. Despite the increased prevalence of online provision in recent years, there is limited evidence from direct head-to-head comparisons of in-person and online 1:1 services. To better inform decision makers, we need a deeper understanding of the trade-offs associated with each mode of service delivery.

Choosing the right mode of delivery is particularly important in healthcare. For providers, including private and public healthcare organizations and insurers, the shift to online services presents opportunities for productivity gains, which are urgently needed due to rising costs in aging societies. For patients, online healthcare services provide convenience, 24/7 access, time savings, reduced risk of contagion, and the potential to break the relationship between physical location and quality of care(Dahlstrand 2023). Key to healthcare delivery are patient consultations with primary care physicians (PCPs) – also known as general practitioners (GPs) – to whom we refer here as 'doctors'. These doctors usually provide the first access point to the healthcare system and serve as gatekeepers for other healthcare services.

In this paper, we examine the impacts of switching doctor consultations from in person to online on various patient outcomes and taxpayer costs. To do so, we assemble new data on individual consultations in Sweden, where national health insurance covers both public and private providers. The primary source of our data is Europe's largest digital healthcare firm, which, since 2019, has provided registered patients with comprehensive primary care, including both in-person and online doctor consultations. The data we analyze, which encompass both types of consultations, are matched to anonymized individual panel data on patient demographics and numerous health outcomes and previous healthcare utilization from the rest of the healthcare system.

One challenge in comparing online and in-person consultations is that we rarely observe comparable patients in both modes. To overcome this, we focus on patients registered

[1] By 1:1 services, we mean meetings between one service provider and one consumer, which could take place, for example, in banking or financial advising, tutoring, mental health therapy, legal advising, and healthcare consultations.

with a hybrid primary care provider, which is a common practice in primary healthcare organizations today; these patients may be directed to online or in-person consultations. At times when doctors are busy, the patients in our sample meet online with nurses, who then determine whether doctor consultations are needed, and if so, whether they should be in person or online. We begin our analysis by estimating ordinary least squares (OLS) regressions to compare the outcomes of patients directed to in-person (as opposed to online) consultations, controlling for a rich set of potential confounders.

A second challenge arises if patient cases are sorted between delivery modes on factors that we cannot observe. To address this issue, we construct a semi-ordered instrumental variable (IV) model where nurses receive noisy signals of patient illness and decide (i) whether patients should consult a doctor (an ordered decision based on perceived illness severity), and (ii) if so, whether this consultation should be online (an unordered decision, since online consultations can be arranged sooner but lack the option of physical examination). We assume that patients – who vary in their illness severity, interest in consulting a doctor, preference for online services, and other characteristics – are matched randomly to nurses. In the model, the share of cases directed online by each nurse among all the cases that the nurse directed to consultations can be used as an instrumental variable for online consultations. Identification relies on simple and testable assumptions similar to those in Frandsen et al. (2023), and we show that these assumptions are satisfied in our setting. For example, we show that the instrument is uncorrelated with patient characteristics or other nurse characteristics (including nurse experience and the propensities to direct to any doctor or to make rare mistakes). We also explain why in our setting nurses have little scope to affect outcomes of patients that they direct to doctors, except through the choice of the consultation mode.

We focus on the IV estimates, which overcome the selection problem and generally show lower cost savings from online consultations than the OLS estimates. The IV estimates indicate that compared to in-person doctor consultations, online ones occur sooner and are shorter overall, with shorter patient-facing meeting times but longer administrative time for the doctor (e.g., to write prescriptions and notes after seeing the patient). Online consultations are similar to in-person consultations in their within-consultation outcomes, including rates of informative diagnosis, prescriptions, referrals to specialists, and patient satisfaction.

Turning to patient outcomes within 30 days of the nurse meeting (for ease of distinction, we call a patient's interaction with a nurse a "meeting" and a patient's interaction with a doctor a "consultation"), we find that online consultations have no significant effect on hospitalizations or prescription collection (a measure of adherence). However, we find that online significantly increases the rates of Emergency Department (ED) visits and doctor-booked in-person primary care follow-up doctor consultations. But looking at medium-term (week by week for 10 weeks) and longer-term (from 31 days to three years after) outcomes, we find no significant effects of online consultations on patient health outcomes.

Although online consultations do not adversely affect patients' longer-term outcomes, the short-term follow-ups (though possibly not all redundant) are costly to taxpayers. Whereas the online consultations themselves are three to four times cheaper than in person ones, the follow-ups eliminate most – if not all – the average savings. We show that this finding is robust to weighting by patients' likelihood of being in our sample and the sorting by nurses of sicker patients into having any doctor consultation.

At the same time, we find that less vulnerable patients (those without hospitalizations or ED visits from three years to a month before the nurse meeting) are unlikely to have follow-ups (e.g., in primary care or ED) after online consultations; for them, online's savings are around 40-60% compared to in person. This finding suggests that carefully sorting patients between online and in person can yield important savings for hybrid organizations.

Our findings also suggest that most patients find that online consultations are a good substitute for in-person consultations. Although we cannot precisely quantify the surplus to the patients, we find a plausible positive lower bound of the average valuation of online consultations above in-person even without taking into account some of online's advantages, such as consulting doctors sooner, reduced risk of contagion, and greater scheduling flexibility, including availability outside of regular working hours.

The main contribution of this paper is our examination of the trade-offs between online and in-person 1:1 service provision. This adds to the literature on hybrid work, which has transformed labor markets in recent years (Barrero et al. 2023; Bloom et al. 2015; Aksoy et al. 2022; Bloom et al. 2022; Goodman et al. 2019; Ertem et al. 2021).[2] Current research on remote or hybrid work focuses primarily on settings where the mode (online versus in person) changes only for workers (Bloom et al. 2015; Emanuel and Harrington 2023; Emanuel et al. 2023), without obvious implications for customers. In contrast, we study patient outcomes and taxpayer costs when both are directly affected by moving online. We also contribute to the literature by showing the importance of effective sorting of users across delivery modes—

[2]Barrero et al. (2023) show that the shift to working from home persisted after the Covid-19 pandemic; by mid-2023, 28% of paid workdays in the US were conducted from home (four times the 2019 rate and ten times the rate in the mid-1990s). They also show that in the first half of 2023, workers aged 20-64 in the healthcare and social assistance sectors worked from home 1.58 days per week, based on full-time work schedules.

in our case of vulnerable and less vulnerable ones — which can be important for unlocking online's cost savings.

Recent work has studied service provision, especially teaching, where both providers (teachers) and consumers (students) switched modes during the COVID-19 pandemic (Jack et al. 2023). However, the pandemic's impacts likely extend beyond merely shifting studies online.[3] In addition to this, settings where collaboration or peer effects are central (Emanuel et al. 2023; Agostinelli et al. 2022) differ substantively from the 1:1 service provision that we study.[4]

A nascent literature within health economics studies changes in access to (or relative price of) online healthcare (Zeltzer et al. 2023; Ellegård et al. 2021; Rabideau and Eisenberg 2022). Our paper differs by examining a setting in which assignment to online and in person takes place *after* patients have sought care. This allows us to shed light on online's effects, free from concerns that such changes might induce different patients (or the same patients under different symptoms) into care. Our approach also addresses the sorting of patients between modes by the provider. The differences between our OLS and IV results indicate that, on average, nurses sort simpler cases into online consultations, underscoring the usefulness of our identification strategy. However, we do not examine how the increased availability of online options affects the usage of (and sorting into) consultations. Instead, we focus on costs and downstream outcomes for patients who had already requested consultations.

Methodologically, we build on the literature using expert propensities as instruments (Kling 2006; Doyle Jr 2007; Anwar et al. 2012; Dahl et al. 2014; Aizer and Doyle Jr 2015; Dobbie et al. 2018; Bhuller et al. 2020; Bakx et al. 2020; Chan et al. 2022; Frandsen et al. 2023; Humphries et al. 2024). We use this approach to study a different research question, namely assessing the impact of online consultations, and use the weaker identification assumptions of Frandsen et al. (2023). Our work is also related to the literature studying IVs with multi-valued treatments, which are typically ordered (Angrist and Imbens 1995; Heckman and Urzua 2010) or unordered (Lee and Salanié 2018; Mountjoy 2022), where we differ by focusing on a semi-ordered IV model.

The remainder of the paper is organized as follows. Section 2 presents the institutional setting. Section 3 discusses the data sources and dataset construction, and Section 4 presents

[3]We study hybrid (online and in-person) healthcare that began before the COVID-19 pandemic and continues after it in the same mixed form. Our sample includes periods before and during the pandemic (including the lull of summer 2020) in a country where in-person visits continued throughout the pandemic. We also control for time effects.

[4]Carlana and La Ferrara (2021) study online 1:1 service provision (remedial tutoring) and find that it generates positive effects; however, they do not have an in-person comparison group.

our econometric model. Section 5 reports tests of instrument validity, our empirical findings on patient outcomes, and discussions of generalizability, costs, and patient heterogeneity. Section 6 concludes.

2 Institutional Setting

Assessing the impact of online consultations relative to in-person ones involves overcoming two main challenges. First, in many settings, primary care consultations are only in person, as was common in most countries before the COVID-19 pandemic, or only online, as observed in some countries during the pandemic.[5] To compare both types of consultations, we need to observe comparable patients in both delivery modes. Second, in settings with both online and in-person consultations, patient sorting across modes may be important. For example, patients might choose different modes for different symptoms, and healthcare providers may also sort patients between delivery modes based on their own criteria.

Our setting is helpful in addressing both challenges. To observe patients in both consultation modes, we focus on a large Swedish firm (that we refer to as "the firm" or "the provider"), which uses an increasingly common model of hybrid primary care, with both in-person and online doctor consultations (Cederberg 2022). This firm started providing online primary care in 2016 and hybrid primary care as early as 2019, before the onset of the COVID-19 pandemic. Although it still focuses mostly on online primary care, its hybrid model is available to patients who select it as their primary care provider, under national health insurance coverage.[6] We use novel data on online and in-person doctor consultations for patients who registered in four clinics: one that opened in Lund in southern Sweden in September 2019, and three that opened in the Stockholm area since September 2020. The data we use span 2019–2020, covering the period before the COVID-19 pandemic and the first two pandemic waves, as well as the summer lull between them. During this entire period, Sweden allowed in-person (as well as online) consultations.

This setting allows us to observe both consultation types and address the sorting between them. To see how, consider Figure 1, which illustrates the flow of patients who had registered with the firm. When a registered patient requests a consultation through a mobile phone

[5] Unlike most high-income countries, Sweden maintained a combination of online and in-person consultations (and many other services) even during the worst phases of the COVID-19 pandemic, never implementing a real lockdown.

[6] Primary care provision is publicly funded in Sweden and comprises both public (60%) and private (40%) providers. Every patient can choose a clinic, but many default to the clinic closest to their home. Once patients register with a clinic, their healthcare services are funded, mostly through capitation, by the national health insurance.

application, an algorithm determines whether a doctor consultation is immediately available, accounting for the symptoms the patient entered and the current waiting time for doctors. Usually, the algorithm assigns the patient directly to an online doctor consultation (we call this a "drop-in" consultation). However, during busy periods, some patients are instead directed to the next available online nurse, who (like the online doctors) may be based anywhere in Sweden.

The online nurse then makes two quick sequential decisions. First, the nurse decides whether to resolve the case without a doctor or to direct the patient to a doctor.[7] Second, if the nurse decides to direct to a doctor consultation, the nurse then decides whether this consultation should take place in person or online. In Section 4, we discuss factors that may affect nurses' decisions and explain how we overcome case sorting using variation nurses' propensities to direct patients across the two consultation delivery modes.

Swedish primary care physicians currently work both online and in person, since both private and public primary care clinics offer both delivery modes. The provider we study recruits doctors for both modes similarly, and these doctors are all paid hourly wages (as in other clinics), although they work from home when online and from clinics when in person. However, the effect we study, of moving consultations online, may depend on the identities of individual doctors who work online and in person. This would have been true even if we had randomly assigned patients to online and in-person consultations, provided that we did not alter the assignment of doctors' work modes. In practice, as discussed in Section 3, almost all the doctors we study worked at least some of the time online. Moreover, as we show below, (i) The sorting of doctors between delivery modes explains only a small fraction of the speed differences between online and in person, and (ii) Our findings on follow-ups are robust to controlling for observable doctor characteristics.

Before proceeding, we note a few more aspects of our setting. First, the healthcare service we study, whether online or in person, is covered by universal health insurance, with a small co-pay.[8] Second, the provider's mobile application allows doctors and patients to see

[7] We define a "case" as an online meeting between a patient and a nurse and its resulting treatment (either an online or in-person doctor consultation or no consultation). If the nurse decides (based on the patient's symptoms) that a consultation is needed, the nurse schedules that consultation, a step that we refer to as "directing the patient to a doctor consultation". If a consultation is not necessary, the nurse normally provides self-care advice and resolves the case. We observe no cases where nurses prescribe medicine, and they cannot refer the patient to an external specialist.

[8] During the sample period in the two regions we study, patients paid a fee (copay) of between SEK 200 (approximately USD 22) and SEK 250 for an in-person doctor consultation, and between SEK 100 and SEK 200 for an online consultation, up to a total annual ceiling of around 1,150 SEK (approximately 125 USD in 2020). The co-pay ceiling covers all healthcare visits, so a combination of a few PCP consultations and ED visits can bring a patient to the ceiling, after which they pay nothing for the rest of a rolling calendar

each other through video, unlike in typical phone conversations. Finally, we study patients with a broad range of demographics and conditions who chose a primary care provider with an online option; we discuss their representativeness of the broader population in Section 5.3, and adjust our cost estimates to plausibly represent the broader population of primary care patients.

3 Data

This section briefly outlines our data sources, the construction of our dataset, and our main outcomes and control variables, leaving the details to Section C of the Appendix.

3.1 Data Sources

We begin with a dataset that covers all primary care visits to a large healthcare provider in Sweden during the 24 months spanning 2019–2020. These include doctor consultations and nurse meetings, both in person and online. Most of this large sample consists of consultations with patients throughout Sweden who were registered with other providers for their in-person primary care consultations and only used this provider for online consultations. However, our analysis focuses primarily on patients who registered with the provider, since they receive in-person (as well as online) consultations from the provider.

We match to the provider's data additional data from Statistics Sweden and the Swedish National Board of Health and Welfare (*Socialstyrelsen*) spanning 2013–2022 and 2013-2023 respectively, which encompass three main components. First, the matched data cover healthcare provision outside the primary care provider, including inpatient and outpatient care, as well as collected prescriptions. Second, they contain demographic information, such as age, gender, and immigration status. Finally, the data include socioeconomic information, such as education and earnings, as discussed further in Appendix Section C.1.

3.2 Dataset Construction

To construct our dataset, we start with all ($\sim 240,000$) cases in which patients meet online nurses, and we impose sample restrictions, as described in Appendix Table B1. The first three restrictions ensure a strictly positive probability that each case is "at risk" of an in-person consultation. This is achieved by removing cases where patients were not yet registered at open in-person clinic as well as cases with specific conditions (chlamydia,

year. Minors and elderly were always exempt from any copay.

breastfeeding issues, COVID-19) or demographics (infants). We do this to ensure that the patient flows in our sample follow the pathways illustrated in Figure 1.[9] Further restrictions exclude nurses and centers involved in very few cases to ensure statistical power. We refer to the 8,907 resulting set of cases, which involve 62 individual nurses as the "nurse meeting sample" in Figure 1 (or "nurse sample" in brief).

Finally, as described in the last row of Appendix Table B1, we consider the subsample of the nurse sample that led to doctor consultations (in person or online). This leaves us with 4,664 cases, which we refer to as the "doctor consultation sample" in Figure 1 (or "doctor sample" in brief). Within this doctor sample, roughly 57% of the consultations are in person and 43% are online. These consultations are conducted by 400 individual doctors, of whom 338 are observed *within the doctor sample* with online consultations only. Of the remaining 62 doctors, 38 are observed both in person and online, and 24 are observed only in person within the doctor sample.[10] In Appendix Section C.4, we further explain other samples used in this paper.

3.3 Key Variables

Here we briefly describe the key variables in our data, leaving the definitions of variables to Appendix Table B2 and more detailed comments to Appendix Section C.6.

Outcome variables Since we have many outcome variables, we discuss them in detail in the results section. Most of the outcomes that we use are indicators, which reflects our focus on the extensive margin of healthcare use. This choice is motivated by two reasons. First, once a patient receives downstream treatment, their subsequent outcomes depend in part on that treatment and not only on the initial healthcare interaction. Second, this choice puts more weight on the general primary care patient population and less on individuals who are particularly intensive users of the healthcare system. When examining downstream outcomes, we typically focus on 30-day windows and (separately) at longer and shorter time periods for some key outcomes.

[9] For chlamydia cases, patients were sent a home test, and in breastfeeding-related cases, patients were directed to a breastfeeding consultant rather than a doctor. COVID-19 cases were managed through pathways that changed over time, adapting to shifts in testing availability and changing guidelines during the pandemic. Infants (children strictly younger than two years old) were also treated differently.

[10] However, since the firm's core business is online provision, almost all the doctors who work for it have some online experience. Therefore, of the 24 doctors, at least 17 had worked online in 2019–2020. These doctors held online consultations with patients who were either not directed by a nurse or had not registered with this firm as their in-person primary care provider.

Control variables In most regression specifications, we control for $\mathbf{BaselineFixedEffects}_i$, which includes a set of fixed effects for years × months (e.g., January 2020), days of the week (Monday, Tuesday, etc.), four-hour time blocks (midnight-4am, 4-8am, etc.) of the nurse meeting, and the primary care clinics at which patients are registered.

We also control for predetermined patient characteristics ($\boldsymbol{\psi}_i$), including age, age squared, and indicators for female, born outside Sweden, second-generation immigrant, born outside EU15 and Scandinavia, married, divorced, ineligible to marry (younger than 18), employed (ages 16-74), and not of working age (below 16 or above 74), as well as indicators for prior patient comorbidity and vulnerability.[11] These variables are measured in 2018, except for age-related variables, which are measured at the time of the nurse meeting. To these we add in some specifications fixed effects for patients' ICD (International Classification of Diseases, version 10) code groups, as determined by the nurses.[12]

Summary statistics for the doctor sample are reported in Table 1, which shows that the sample consists of cases with a broad range of patient demographics and nurse-set diagnosis (ICD-10) codes. We defer the discussion of the representativeness of this sample and the generalizability of our estimates to Section 5.3.

4 Model

This section outlines our econometric model of the assignment of patients to online and in-person doctor consultations. The model illustrates the identification problem: the potential sorting of cases into consultations and across modes based partly on unobservables, which biases OLS estimates of the effects of online delivery. The model also justifies our use of nurses' propensities to direct patients to online consultations (in all but the current meeting) as an instrumental variable, following the literature on expert propensities and especially the recent work by Frandsen et al. (2023), on which we build.[13] We differ from existing

[11]We measure 31 important comorbidities diagnosed in the rest of the healthcare system (inpatient and outpatient care registries) prior to this meeting, and do this with the Elixhauser comorbidity index as a starting point. Vulnerability measures previous serious healthcare utilization. Less vulnerable patients (58%) are those without hospitalizations or ED visits from three years to a month before the nurse meeting, and vulnerable patients have had at least one hospitalization or ED visit in this period.

[12]While these are technically not predetermined, we use them to proxy for patients' predetermined current condition (as opposed to the chronic comorbidity measures which are predetermined and measured in prior healthcare utilization). We have another variable that reflects patients' self-declared symptoms, but its classification is coarser and less informative and is more often missing.

[13]Frandsen et al. (2023) introduce the weaker assumptions of average monotonicity and average exclusion to replace the standard assumptions of monotonicity and exclusion in settings with expert propensities. Under these weaker assumptions (with independence and a first stage), they derive a causal LATE interpretation for IV, which is similar to the familiar one.

work by presenting a semi-ordered IV model, which divides the decision-making process into two parts. The first is an ordered decision: a doctor consultation is more intensive than no consultation. The second is unordered: online consultations may be arranged sooner and spare ill patients from having to travel, while in-person consultations allow physical examination.

4.1 Model Setup

As outlined in Section 2 and Figure 1, we focus on registered patients who request primary care consultations using the firm's mobile application and who are "at risk" of both types of consultations (in person and online). These patients' cases begin with an online meeting with a nurse. We assume and later verify that their assignment to the next available nurse is effectively (conditionally) random. We focus on patients, indexed by i, who are assigned to nurses, indexed by j.[14] We define j_i as the nurse assigned to patient i; I_j as the set of patients treated by nurse j, which consists of N_j patients; and I as the set of all patients. Each nurse briefly assesses every patient assigned to them and makes two sequential decisions: first, whether to direct the patient to a doctor consultation, and second, if they do direct the patient to a consultation, whether the consultation should be in person or online.

We assume that each patient has a level of illness, indexed θ_i, which causes them to request a doctor consultation.[15] Patients are also characterized by a vector of predetermined observable characteristics, $\boldsymbol{\psi}_i$; and interest in consulting a doctor, ϕ_i. We assume that $\phi_i = \theta_i + g(\boldsymbol{\psi}_i) + \zeta_i$, where ζ_i is mean 0 independent and identically distributed (i.i.d.) noise. We also assume that each patient has a preference $\tau_i > 0$ for an in-person (relative to an online) doctor consultation, such that $\tau_i = 1$ denotes indifference between in-person and online. The relationship between τ_i and the other patient parameters, including illness, is flexible, leading to sorting into online consultations that cannot be controlled for with observable characteristics.

We model the patient's utility as

$$U_i = \begin{cases} \phi_i & D_{ij}^0 = 1, D_{ij} = 1 \\ \phi_i \tau_i & D_{ij}^0 = 1, D_{ij} = 0 \\ 0 & D_{ij}^0 = 0, \end{cases} \tag{1}$$

where D_{ij}^0 is an indicator for patient i being directed to any consultation (after meeting nurse

[14]To economize on notation, we use the index i to denote patients and patient cases.

[15]Illness reflects the patient's "objective" need to see a doctor when they use the firm's app, which does not necessarily correlate strongly with underlying medical conditions, such as comorbidity.

j), and D_{ij} is an indicator for patient i being directed to an online consultation, as opposed to an in-person one (after meeting nurse j). $Y_i(d,j)$ denotes the potential outcome of patient i meeting nurse j, where d is an indicator for an online (versus in-person) consultation.[16] The outcome for patient i who met nurse j and was directed to a doctor can be written as $Y_{ij} = Y_i(1,j)\,D_{ij} + Y_i(0,j)\,(1 - D_{ij})$.

Turning to nurses, we assume that they decide whether to direct a patient to any consultation (versus no consultation) based on their perception of patient i's illness, θ_{ij}, where $\theta_{ij} = \theta_i + \eta_{ij}$, and η_{ij} is mean zero i.i.d. noise.

Nurses differ in their assessment of the value of online doctor consultations relative to in-person ones, which they consider when deciding the delivery mode, along with the patients' preferences for in-person consultations. Specifically, we define ρ_j as the tendency of nurse j to direct patients online, where $\rho_j > 0$. ρ_j varies across nurses, so that $\rho_j \neq \rho_{j'}$ for some j, j'. We assume that the utility of nurse j, who meets patient i, is

$$\widetilde{U}_j(i) = \begin{cases} 1_{\theta_{ij}>0} & D^0_{ij} = 1, D_{ij} = 1 \\ \frac{\tau_i}{\rho_j} 1_{\theta_{ij}>0} & D^0_{ij} = 1, D_{ij} = 0 \\ 1_{\theta_{ij}\leq 0} & D^0_{ij} = 0. \end{cases} \tag{2}$$

Since the nurses decide the treatment status of patients, patient i will have an online consultation ($D^0_{ij} = 1, D_{ij} = 1$) when $\theta_{ij} > 0$ and $\tau_i \leq \rho_j$; an in-person consultation ($D^0_{ij} = 1, D_{ij} = 0$) when $\theta_{ij} > 0$ and $\tau_i > \rho_j$; and no consultation ($D^0_{ij} = 0$) when $\theta_{ij} \leq 0$.[17]

4.2 Identification

Panel A of Appendix Figure A1 illustrates the treatment of patient i when nurses perceive illness precisely ($Var(\eta_{ij}) = 0$). In this case, only patients with $\theta_i > 0$ are directed to doctor consultations. There may be three types of directed patients. First, those with very strong preferences for in-person consultations ($\tau_i > \max(\rho_j)$), who never consult online. Second, those with very strong preferences for online consultations ($\tau_i \leq \min(\rho_j)$), who always consult online. Patients whose preferences for online versus in-person consultations are intermediate (($\min(\rho_j) < \tau_i \leq \max(\rho_j)$) respond to the instrument—their mode of consultation is determined by the nurse to whom they are (conditionally) randomly assigned. Panel B of Appendix Figure A1 shows that when nurses perceive patient illness imprecisely ($Var(\eta_{ij}) \neq 0$), the situation is similar except that some patients who should have consulted

[16] This notation can be naturally extended to denote sets of outcomes.

[17] Without loss of generality, we assume that nurses break ties between online and in-person consultations by assigning patients to online consultations.

a doctor based on θ_i do not, while others who should not have consulted end up having a consultation.

We define the propensity of nurse j to direct patients online, conditional on directing to any doctor, in the hypothetical scenario where the nurse had encountered the entire (realized) population of doctor sample patients as $\pi_j^{pop} \equiv \frac{\sum_{i' \in I} D_{i'j}}{\sum_{i' \in I} D^0_{i'j}}$.[18] We similarly define this propensity among the doctor sample patients whom nurse j actually met as $\pi_j \equiv \frac{\sum_{i' \in I_j} D_{i'j}}{\sum_{i' \in I_j} D^0_{i'j}}$. Finally, we define the instrument as nurse j_i's propensity to direct doctor sample patients online, leaving out patient i's meeting: $\pi_i \equiv \frac{\sum_{i' \in I_j; i' \neq i} D_{i'j}}{\sum_{i' \in I_j; i' \neq i} D^0_{i'j}}$.[19] We define for notational simplicity the observed values of these patients as $D_i \equiv D_{ij_i}$, $D^0_i \equiv D^0_{ij_i}$, $Y_i \equiv Y_{ij_i}$, and $\eta_i \equiv \eta_{ij_i}$.

To use π_i as an instrument for D_i, we specify conditions under which the (weaker) identification assumptions for an IV outlined by Frandsen et al. (2023) are satisfied. First, to satisfy the first stage, we require (sufficient) variation between nurses in ρ_j. To satisfy independence in the doctor sample, we rely on the (conditional) random assignment of patients to nurses and the orthogonality of nurse errors in the first decision (η_{ij}) to nurses' propensities to direct patients online. This allows us to write

Lemma 1. $\pi_i \perp \left\{Y_i\left(d, j_i\right), D_i | D^0_i = 1\right\}$

Proof. $\rho_{j_i} \perp \theta_i, \eta_i, \left\{Y_i\left(d, j_i\right), D_i\right\} \Rightarrow \pi_i \perp \theta_i, \eta_i, \left\{Y_i\left(d, j_i\right), D_i\right\}$
$\Rightarrow \pi_i \perp \left\{Y_i\left(d, j_i\right), D_i | \theta_i + \eta_i > 0\right\}$. □

Or, in other words, under our model's assumptions, the random assignment of patients to nurses results in a random assignment of patients to nurses in the doctor sample.

Third, our assumptions about nurse tendencies and decisions imply (strict) monotonicity within the doctor sample: $\forall j' \neq j$, either $D_{ij} \geqslant D_{ij'}$ for all i or $D_{ij} \leq D_{ij'}$ for all i, which in turn implies average monotonicity.

Finally, we assume that the instrument satisfies average exclusion:
$E[\sum_{j=1...J} \lambda_j (\pi_j^{pop} - \pi)\gamma_{ij}] = 0$, where $\lambda_j \equiv Pr(j_i = j)$, $\pi \equiv \sum_{j=1...J} \lambda_j \pi_j^{pop}$, and $\gamma_{ij} \equiv Y_i(d,j) - \overline{Y}_i(d)$, is nurse j's direct contribution to patient i's potential outcome.

The next section begins by providing evidence on the validity of these assumptions, and hence on the instrument's validity.

[18] "Population" here refers to the actual doctor sample, which is held fixed in this counterfactual.

[19] The instrument is implicitly also defined for patients who are not directed to a doctor, for whom it equals π_{j_i}.

5 Empirical Findings

We begin this section by discussing evidence on the validity of our model. We then discuss our main empirical findings on the effects of online consultations on patient outcomes and the generalizability of these findings. Finally, we discuss the implications of our findings for online's effects on costs and patient satisfaction, and how these differ between patient groups.

5.1 Instrument Validity

Appendix Figure A2 shows the variation in π_i. Most of the 62 nurses we analyze direct patients more frequently to in-person consultations, while some tend to recommend online consultations more often, resulting in a mean in-person consultation rate of around 57% in the doctor sample.

To study the instrument's validity, we begin by estimating first-stage regressions of D_i on π_i in the doctor sample:

$$D_i = \beta_{10} + \beta_{11}\pi_i + \mathbf{BaselineFixedEffects}_i'\beta_{12} + \boldsymbol{\psi}_i'\beta_{12} + \mathbf{ICD}_i'\beta_{12} + \epsilon_{1i}. \tag{3}$$

The vector $\mathbf{BaselineFixedEffects}_i$ includes a set of fixed effects for years $\times$ months (e.g., January 2020), days of the week (Monday, Tuesday, etc.), four-hour time blocks (midnight-4am, 4-8am, etc.) of the nurse meeting, and the primary care clinics at which patients are registered. The predetermined patient characteristics ($\boldsymbol{\psi}_i$), which are measured either in 2018 or at the time of the nurse meeting are age, age squared, and indicators for female, born outside Sweden, second-generation immigrant, born outside EU15 and Scandinavia, married, divorced, ineligible to marry, employed (ages 16-74), and not of working age, as well as indicators for prior patient comorbidity and vulnerability. To these we add in some specifications $\mathbf{ICD}_i$, fixed effects for patients' ICD (International Classification of Diseases, version 10) code groups, as determined by the nurses.

As Panel A of Table 2 shows, the first stage is precisely estimated and equals 0.66 with the full set of controls. The precision is similar when we use robust standard errors (s.e.) in our main specifications (following Abadie et al. 2023) or cluster the s.e. by nurse (as many previous papers on expert propensities do). In all specifications, the first-stage F-statistic exceeds 100, alleviating potential concerns about weak instruments, at least for outcomes that are available for all or almost all patients.

To establish average monotonicity, Panel B of Table 2 follows Frandsen et al. (2023)

and Bhuller et al. (2020) in reporting the first stage for different subsamples. The first stage is large and statistically significant when patients are broken down by some of our main controls (gender, age, immigrant status, comorbidity, and vulnerability), as well as an indicator for periods with low (or no) COVID-19 (versus the first and second COVID-19 wave) and two other indicators that measure education and income, which are available only for some of the sample. These estimates suggest that most groups of patients are represented among compliers. This is further confirmed in In Appendix Table A1, which uses a procedure similar to Frandsen et al. (2023) to compare compliers to the rest of the sample.

To examine independence, we proceed in the following steps. First, to test the (conditional) random assignment of patients to nurses, we regress the instrument, π_i, on patient characteristics, $\boldsymbol{\psi}_i$, in the nurse sample and report the p-value from a joint F-test of $\boldsymbol{\psi}_i = 0$. Panel A of Table 3 shows that the instrument is uncorrelated with patient characteristics in this sample, irrespective of controls. Second, to test the assumption that nurses with different propensities to direct online do not systematically differ in their propensity to direct to any doctor, we regress the instrument π_i on nurses' propensity to assign to any doctor, $\frac{1}{N_j}\sum_{i' \in I_j} D^0_{i'j}$. The estimates in Panel B of Table 3 show no significant correlation.[20] Third, to test whether the instrument is orthogonal to the characteristics of patients in the doctor sample, we repeat the test from Panel A but this time only in the doctor sample. The results in Panel C of Table 3 again show balance. Finally, Appendix Table A2 tests the balance of the different nurse characteristics on the patient characteristics for both the nurse sample (Panel A) and the doctor sample (Panel B), and the results are again consistent with random assignment.

We present three pieces of evidence to establish average exclusion. First, as Panel A of Table 4 shows, institutional rules circumscribe nurses' decisions in our setting. Unlike doctors, nurses cannot prescribe medications, refer patients to (external) specialists, or give patients sick notes.[21] These rules limit nurses' opportunities to affect the outcomes of patients that they direct to doctors, except by choosing the mode of doctor consultation. Second, in Panel B of Table 4 we show that the instrument is uncorrelated with various

[20] This finding also helps address a potential concern (related to that noted in Chan et al. 2022) that a low propensity to direct patients to an online consultation might reflect excessive caution on the part of less skilled nurses, who might also refer more cases to doctors.

[21] The nurses we study differ from "registered nurses", a professional category that exists in the US. Whereas US-based registered nurses can perform many doctors' tasks, the nurses we study are more restricted. While 17% of nurses in our sample are specialized "District Nurses" who have some limited prescribing rights, we observe no prescriptions from them in the sample.

measures of nurse skill, including experience, specialization, and propensity to make mistakes (Chan et al. 2022) and other variables, including language background and urban residence. Only the coefficient on nurses' urban residence is significant.[22] Finally, in Panel C of Table 4, we show that nurses have very little time to interact with patients whom they direct to doctors, with a mean patient-facing time of less than five minutes and a median of four minutes. Such short meetings leave little time to affect patient outcomes other than through the pathway we discuss in the model; even advising patients seems unlikely if the nurse directs the patient to a doctor. Panel B also shows that nurses' mean patient-facing time is about four times shorter than that of doctors, and their median is about three times shorter.[23]

More evidence on the validity of our identification strategy is discussed in Section 5.2.5, where we show that key health outcomes were uncorrelated with the instrument during each of the weeks leading up to the nurse meeting.

5.2 Effects of Online versus In-Person Doctor Consultations

Having shown evidence on the instrument's validity, we proceed to use the doctor sample to estimate our main specification:

$$Y_i = \beta_{20} + \beta_{21} D_i + \mathbf{Controls}_i^{'} \beta_{22} + \epsilon_{2i}. \tag{4}$$

As discussed in Section 4, D_i may be correlated with unobserved patient illness. We therefore focus on specifications where we instrument for D_i using π_i. The differences between the OLS and IV estimates may inform us whether, on average, sicker patients are sorted into online or in-person consultations. For brevity, we also usually focus on the regressions with all the controls, though in practice adding controls usually makes little difference.

5.2.1 Duration and Timing of Consultations

Panel A of Table 5 shows that online consultations take place sooner after the patient's request, and usually on the same day. In contrast, in-person consultations are typically held

[22] Given our limited sample size, the coefficient on nurses' mistake share is imprecise. But since it is negative, it is unlikely that nurses who direct more online are "worse" in a way that could explain higher follow-up rates after online consultations. Moreover, the magnitude is economically small in terms of standard deviations (see summary statistics in Table 1).

[23] To ensure comparability between the duration of the nurse meeting and doctor consultation, Panel B restricts the sample to patients for whom the patient-facing duration is observed for both, although this restriction does not matter much in practice.

two-three days after the nurse meeting, reflecting the need to find availability among the smaller set of doctors working in the nearby clinic.

Panel B shows that the total duration of online consultations is shorter, which may, along with the lower overhead, explain their lower cost; we investigate post-consultation costs in Section 5.4). But while the OLS estimates suggest that online consultations are almost two-thirds shorter, the IV estimates show that they are only one-third as short. This difference may be due to the sorting of sicker patients into in-person consultations, a problem that IV solves. The IV estimates thus give a more realistic and less optimistic view of the gains from online consultations.

Panels C and D of Table 5 decompose online's effect on the duration of doctor consultations into patient-facing and administrative times. As the IV estimates show, the patient-facing part of online consultations is much shorter, but the administrative time is longer. A possible interpretation of this finding is that during in-person consultations, doctors write notes and fill out forms while the patient is physically present, whereas online they perform these tasks after the patient has left the video meeting. Another interpretation, which is not mutually exclusive, is that doctors need time to consult notes or recuperate after consulting patients. Online, this could be recorded separately as administrative time, whereas in person this may be bundled with patient-facing time.

5.2.2 Within-Consultation Outcomes

Table 6 examines online's effect on four patient outcomes that are determined during the consultation. In Panel A, the OLS estimates suggest that the rate of informative diagnosis is higher online (which would be surprising if it had a causal interpretation), but sensibly the IV estimates show negative, though not significant estimates. In Panel B, the OLS estimates indicate that an online consultation is more likely to yield a prescription, while the IV estimates are smaller and are not statistically significant from zero.

In Panel C, the OLS estimates suggest that specialist referrals are much less common online, again consistent with healthier patients sorting online. In contrast, the IV estimates are small and not significant.[24]

Panel D shows estimates of patient satisfaction, an outcome available only for patients who scored the consultation, which is more commonly done online (see Appendix Table A3). The response rate online is likely higher because patients are more systematically reminded

[24] Due to differences across regions, we only observe whether patients are referred to specialists from the three clinics in the Stockholm Region and not from the clinic in Lund (Scania Region), so we estimate this regression for Stockholm patients only.

to score consultations online than in person. In other words, the estimates in Panel D are conditional on an outcome (patient scoring) and therefore should be treated with caution. In practice, satisfaction is not significantly different for online consultations.

5.2.3 Post-Consultation Outcomes

In contrast to the similarity of patient outcomes during in-person and online consultations, Table 7 shows significant differences between the two delivery modes in short-term (30-day) post-consultation outcomes.

Panel A shows that online consultations are more likely to be followed by visits to Emergency Departments or urgent care centers (summarized by the term ED). This is true for both the OLS and the IV estimates, but the IV estimates are larger. Our interpretation is that an online consultation is more likely to result in the patient, the doctor, or both concluding that the patient should consult with a doctor in person, perhaps because physical inspection is needed or as a precaution. If this happens, especially outside of regular work hours, it could lead to an ED visit that an in-person consultation would have avoided.

Panel B shows that the effects of online consultations on hospitalizations are not statistically significant, although the point estimates are positive (perhaps, in part, due to follow-ups from increased ED visits).

All the estimates in Panel C of Table 7, show that after online consultations, patients are significantly likelier to have additional primary care consultations within 30 days than after in-person consultations. The IV estimates suggest that about two thirds of online consultations (compared to approximately half of in-person consultations) are followed by additional primary care visits within 30 days. We note that the additional consultations are all with the same firm, which is responsible for the registered patients' primary care and is paid through capitation, as opposed to fee for service, and hence faces a cost to additional follow-ups. We discuss the roles of patients and doctors in initiating the follow-up consultations in primary care, and whether these follow-ups are online or in-person, in Section 5.2.4.

Panel D reports online's effect on the rate of patient prescription collection, a measure of patient adherence, which is rarely measured (Neiman et al. 2018). We find that this effect is small and statistically insignificant. We note, however, that this result comes with two caveats: it conditions on an outcome (receiving a prescription), and for that reason also relies on a weaker first stage.

To show the robustness of our findings on post-consultation outcomes, Appendix Table

A4, repeats the analysis in Table 7 but starts the 30-day count from the doctor consultation (rather than from the nurse meeting). The estimates in Appendix Table A4 are similar to those in Table 7.

Appendix Table A5 shows that the results in Table 7 are also robust to the inclusion of doctor characteristics, that is indicators for urban residence, top Swedish medical school graduation, whether the doctor is in specialty training and whether the doctor already has specialist qualification (with the omitted category being MD only), and whether the specialist training or specialist qualification is in the General Practice field, and the number of prior consultations with the firm before the earliest in-sample meeting.[25]

5.2.4 Drivers of Primary Care Follow-Ups

Appendix Table A7 examines the drivers of the increase in primary care follow-ups after online consultations. The table shows that this increase is largely explained by in-person doctor-booked follow-up consultations. The table also suggests that there may be a higher probability of a patient-initiated primary care follow-up visit, although the estimates are smaller and imprecise.

We think that there are two likely and mutually compatible explanations for our findings. First, our most likely explanation is that patients and doctors who talk to each other online are more cautious and book in-person follow-up consultations as a precaution, although we cannot be sure who pushed for these follow-ups and whether the caution was merited or excessive. Second, some follow-ups may also reflect patient requests to investigate health issues that the consultation did not cover. This, in turn, may be due in part to the fact that in a longer in-person consultation there is time to discuss several health issues, whereas in a shorter online consultation there is time only for one.

5.2.5 Patient Outcomes Over Different Time Horizons

In Figure 2, we report IV estimates separately for the weeks before and after the nurse meeting, where we define "week 0" as the seven-day period starting on the day the patient had the nurse meeting. There are two main takeaways from this figure. First, there are no significant differences in health outcomes in the weeks before the nurse meeting between patients assigned to nurses with differing online propensities, neither in levels nor in trends.

[25]Since 400 different doctors are included in the doctor sample, we do not have sufficient power to control for individual doctor fixed effects. However, Appendix Table A6, uses a larger sample to study doctor shifts, as discussed in Appendix C.4.2. The results show that doctors work almost twice as fast online, and only 15% of this speed difference is explained by individual doctor fixed effects.

Second, the figure provides a detailed view of what happens after the nurse meeting. Finally, follow-ups (both in-person doctor consultations and ED visits) typically occur within a week of the nurse meeting. Panel D shows that hospitalizations may increase slightly during the following week, possibly as a delayed consequence of the increased ED visits. However, as discussed above, for the 30-day period, this increase is not statistically significant.

In Appendix Table A8 we take a longer-term perspective. Panels A and B show that online consultations do not significantly affect the probability of ED visits or hospitalizations from 31 days to three years after the nurse consultations. Panel C similarly shows no significant effect on average employment status in the following years.

5.3 Generalizability of Our Findings

In this section, we examine the generalizability of our findings in two ways. First, we compare the characteristics of the cases in the doctor sample to those of a larger and more representative sample of primary care cases. Second, we examine whether, as the model predicts, the patients in the doctor sample are sicker than those who see a doctor without first seeing a nurse. The conclusions we draw affect the cost calculations we report in Section 5.4.1.

In Appendix Table A9, we compare the patients in the doctor sample to those in a more representative sample of primary care patients. Our comparison group consists of approximately 1.5 million PCP consultations — the universe of PCP consultations in 2019 in Scania, a region home to 13% of Sweden's population, which is similar to the entire country in its inhabitants' education and income.[26]

The results show that the doctor sample is younger and more urban and a bit more male than the Scania sample, and there are some differences in ICD codes. When discussing our cost estimates below, we use this sample of the universe of primary care doctor consultations (in person and online), which is described in Appendix Table A9 to construct weights that account for these observable differences. Appendix Section provides further details on the construction of the weights.

Next, we compare indirect evidence on the illness of the patients in the doctor sample to that of the patients in the nurse sample. Our model leads us to expect that the patients in the doctor sample are sicker, since they are the ones whom nurses directed to doctor consultations. Panel A of Appendix Table A10 shows that the patients in the doctor sample

[26] In Scania, the share of people aged 25-64 years with at least three years of post-high school education is 34.2%, while in Sweden as a whole it is 33.7%. Scania has a median annual income per adult of ∼326 thousand SEK, compared with the Swedish median of ∼ 342 thousand SEK (Ekonomifakta 2023).

who are directed to online doctors by nurses are about 2.6 times more likely to follow up with a PCP than patients who consult online doctors directly after contacting primary care (without nurse direction). Since both groups receive the same treatment (online doctor consultations), the difference probably reflects selection. We note, however, that there are no significant differences in ED visits or hospitalizations between the two groups. To account for our findings, we adjust some of our cost estimates in Section 5.4.1 by multiplying the fraction of PCP follow-ups by 1/2.6.

5.4 Cost Analysis

We now consider the difference between online and in-person consultations in costs, which largely fall on taxpayers, and in patient valuations.

5.4.1 Taxpayer Costs

The main payers of healthcare costs in Sweden are the taxpayers, while in other settings such costs might be borne by private firms or individuals. Nevertheless, the private provider we study has some incentives to limit downstream costs, since the payment model is based on capitation, which implies that the firm pays for at least part of primary care follow-ups. The firm is paid through capitation for the patients studied in this paper in Region Scania, which means that it gets a yearly payment from tax money for patients who are registered with it, and then faces a cost from additional primary care follow-ups. In Region Stockholm, primary care firms are paid through a combination of capitation and some fee for service, so the incentives for additional primary care visits are less clear. Additionally, in Region Stockholm, the primary care provider is penalized if a large share of their patients visits the ED, while they get a bonus if there is a low share. This system was not present in Scania during the study period and was implemented starting in 2022.

Appendix Table A11 reports our best estimates of what the public health insurer — and thus the taxpayer — pays for each treatment. The notes to this table and Appendix Section C.5 provide further details. Specifically, in-person doctor consultations (around 2000 SEK) are about four times more expensive than online consultations, which highlights online's potential to deliver significant cost savings. This large cost advantage may reflect the shorter durations of online consultations discussed in Section 5 and reduced overhead costs, since doctors work online from their homes and in person from clinics. At the same time, the table suggests that an increased incidence of follow-ups after online consultations could greatly reduce their actual cost savings. As discussed above, these follow-ups commonly include in-person doctor consultations, as well as rarer but more expensive ED visits and even rarer and costlier hospitalizations, the effect on which is imprecise.

In our regression analysis below, we report specifications with costs as outcomes in both logarithms and levels, since rare but costly events may matter for levels, even where there are significant proportional savings on some less expensive cases. We then present a non-parametric approach that explains how we reconcile the logs and levels results when they differ.

Table 8 reports estimates of online's effects on costs. Panel A shows that when we only consider the cost of the initial nurse meeting, the doctor consultation, and the prescriptions that result from it, online saves about 65% of the costs of in-person consultations. This result is almost unchanged in Panel B, where we use weighted regressions to reflect the representativeness of patient case characteristics. See Appendix Section C.6.3 for an explanation of the weights.

But Panel C shows that when we calculate the full cost of the patient's healthcare journey, including the cost of the initial doctor meeting, and any potential follow-up cost (which includes the first provision of any type of healthcare treatment within 30 days of the nurse meeting, also counting the first provision of additional PCP visits), a large share of online's savings are lost. There is some difference here between the IV estimates in logarithms (Column 3), which still suggest some savings from online consultations, and those in levels (Column 4), which suggest that any cost savings are small and statistically insignificant. To rationalize the difference between the two functional forms, we turn to Figure 3. Panel B of this figure shows that the large proportional savings suggested by the logarithmic specifications arise from consultations without expensive follow-ups. But the regressions in levels tell a more sobering story, where these savings are offset by rare and expensive cases with follow-ups. Thus, our preferred estimates suggest that overall, online's cost savings within our sample is around 7%.

The conclusion that follow-ups largely negate online consultation cost savings remains intact when we weight the regressions to reflect the representativeness of patient case characteristics (panel D of Table 8) and finally also adjust the frequency of in-person follow-up consultations to account for the nurse direction of sicker patients to doctor consultations (Panel E of Table 8 and C of Figure 3), as discussed in Section 5.3. However, as we discuss in Section 5.5 below, online consultations may still deliver important savings for a sub-population of patients that are unlikely to require follow-up care.

5.4.2 Patient Valuation of Online Consultations Relative to In-Person Ones

To shed light on patients' valuation of online consultations, we first examine whether they view them as substitutes for in-person consultations. Appendix Table A12 shows results for a sample of non-registered patients who used the drop-in service for online consultations. This sample is much larger than that of registered patients, which allows us to better study heterogeneity. We use results from a specific question that patients who have had online consultations were asked: did they view their online consultation as a replacement for an in-person consultation? The results should be interpreted with caution, since only around half of those asked replied to this question. This limitation notwithstanding, the table shows that about 95% of the respondents said that their online consultation was a substitute for an in-person consultation. Those who were less likely to consider them as a replacement were predominantly aged 70 and over, and first-generation immigrants from countries whose languages differ from Swedish and other Western European languages.

These survey data about views on whether online is a substitute, along with patients' satisfaction ratings of their online consultation on a scale from 1 to 5, and patients' actions (follow-up rates), help us bound from below the net patient valuation of an online consultation relative to an in-person consultation. In Appendix Table A13, we divide the doctor sample patients into three groups. We classify patients as "Positive" if they viewed the online consultation positively (based on both views on whether online is a substitute and their satisfaction rating) and have no follow-ups; as "Negative" if they either (i) view the consultation negatively or (ii) are neutral about the consultation but follow up after it; and as "Neutral" otherwise (for more details, please refer to Appendix Table A13 and its notes). Combining this classification with data on patient costs which are detailed in the same table, we conclude that, on average, patients derive a positive value from online consultations compared to in-person consultations.

We consider this small positive value a lower bound on patients' net valuation of online (relative to in person) consultations since it is difficult to quantify all online's gains. First, as shown in Section 5, online patients benefit from seeing doctors sooner. Second, online consultations offer convenience, as they allow patients to attend from their preferred location (e.g., home) and avoid traveling and waiting in a clinic. Third, online consultations offer greater availability outside of regular hours: 51% occur outside of regular medical office hours (8am–5pm on weekdays), compared to 28% out-of-hours for in-person consultations. Fourth, online consultations reduce the risk of contagion for patients and others, thus mitigating negative health externalities from in-person care (Neprash et al. 2021). Finally, as discussed, patients in the doctor sample are more likely to follow up because of the sorting by nurses of sicker patients into seeing doctors at all. For all these reasons, generalizing these patient net valuations to the broader Swedish patient population would likely show higher patient gains from online consultations than our lower bound suggests.

5.5 Patient Heterogeneity

This section explores heterogeneity in patient responses to online versus in-person consultations. We begin with a breakdown of online's effect by patient vulnerability and its implications for the organization of online primary healthcare and its ability to deliver cost savings. We conclude with a brief discussion of marginal treatment effect (MTE) estimates.

5.5.1 Heterogeneous Costs by Vulnerability

Our finding that follow-ups are an important factor in reducing online's cost savings also suggests a possible way forward: perhaps the propensity to follow-up care after online consultations is correlated with a history of such care?

To examine this, we divide the doctor sample patients into two groups of patients. We define patients as "more vulnerable" if they experienced at least one hospitalization or ED visit between 31 days and three years before meeting the online nurse; the rest of the patients we define as "less vulnerable".

The IV estimates in the last column of Appendix Table A14 suggest that for less vulnerable patients, online consultations' effects on 30-day follow-ups are considerably smaller than their counterparts for more vulnerable patients, which are reported in Appendix Table A15. Specifically, the estimates for more vulnerable are about three times larger for doctor-booked in-person primary care revisits are about three times larger and four times larger for ED visits; for both outcomes, only the estimates for the more vulnerable patients are statistically significant. Since splitting the sample reduces precision, we revisit the question of whether the two groups of patients differ significantly to the next table, where we compare costs.

As Appendix Table A16 shows, the differences by patient vulnerability affect taxpayer costs. Panels A-C show that for less vulnerable patients, online's cost savings are large (around 40-60%) and significant, since there are few follow-ups after online for this patient group. In contrast, Panels D-E show that there are no significant savings from sending vulnerable patients to online consultations, and in fact there may be dis-savings although the estimates are admittedly imprecise. Despite this lower precision, we formally reject the equality of the IV estimates in Panels B and E.

This message is reinforced in Figure 4. For less vulnerable patients, costs are generally low, and even lower online than in person, due to few follow-ups. More vulnerable patients are more likely to have follow-ups, and since these are more common after online consultations, sending them to in-person consultations may be cheaper in expectation.

More generally, our findings suggest that cost-effective provision of 1:1 services requires providers to understand the needs, preferences, and behavior of different groups of consumers in response to evolving delivery modes, and design their hybrid offering accordingly. Switching 1:1 services online may be a good idea for some groups of customers and a bad idea for others.

5.5.2 Marginal Treatment Effects

Frandsen et al. (2023) note that identifying MTEs in a setting with expert propensities requires, in addition to the assumptions discussed above, strict monotonicity and strict exclusion. To test which outcomes satisfy these assumptions, we implement their (more powerful) semi-parametric test, giving equal weight to the two components of their test, as we discuss in more detail in Appendix Table A17. Of the seven main outcomes we test, strict monotonicity and exclusion are satisfied for three: total consultation duration and hospitalization and new patient visit to primary care provider within 30 days. We follow Mogstad et al. (2018) in estimating MTEs for these three outcomes, using the Stata package by Andresen (2018), and we reject significant heterogeneity in terms of resistance to the treatment for two outcomes, but patients with higher unobserved resistance have significantly shorter meetings online.

6 Conclusion

Online delivery is now possible for many 1:1 services, such as banking/financial advice, tutoring/teaching, therapy, and healthcare. Online platforms offer potential savings and convenience, yet the trade-offs for providers and consumers when transitioning these services online are not well-understood. To the best of our knowledge, this paper is the first to study the effects of online versus in-person 1:1 services in a setting where consumers have already opted for the service and where sorting between the two delivery modes is addressed. Our focus is on healthcare, specifically primary care consultations, where cost pressures are rising and ensuring quality is important.

Our findings suggest that online consultations are more readily available as they are scheduled sooner, and they save time since they are shorter overall. Despite these differences, within-consultation rates of diagnosis, prescription, specialist referral, and patient satisfaction in online consultations are similar to those in in-person consultations.

However, patients are more likely to follow up with ED visits and PCP consultations (especially in person) shortly after online consultations. These follow-ups could suggest concerns from doctors, patients, or both that some aspects of care could not be addressed online. Nevertheless, longer-term outcomes are similar, indicating that the initial increase in follow-ups does not adversely affect the overall outcome of care.

While the cost of the online consultations themselves is about a quarter of the cost of in-person consultations, the increased frequency of expensive short-term follow-ups after online consultations eliminates most of online's mean cost savings. But our results suggest that directing more vulnerable patients (who are less likely to follow up) to in-person consultations and less vulnerable ones to online settings could save costs. We find that patients generally benefit from online, and we calculate a lower bound on their net valuation of online consultations relative to in-person ones.

Taken together, our findings inform decisions whether to provide 1:1 services online or in person, and to whom. Finding the right mix of online and in person is an important challenge for hybrid organizations, which encompass a large and growing number of providers worldwide.

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Table 1. Summary Statistics for Key Variables in the Doctor Sample

	Mean	SD	Min	Max	Observations
Key model variables					
Doctor consultation was online	0.43	0.49	0	1	4,664
Nurse propensity to online π_i (Instrument)	0.43	0.12	0.24	1	4,664
Proxies for fixed effect controls					
Nurse meeting was on a weekend	0.17	0.38	0	1	4,664
Nurse meeting was from 8am-8pm	0.87	0.33	0	1	4,664
Patient registered at clinic in Stockholm	0.52	0.50	0	1	4,664
Patient demographic controls (measured in 2018)					
Female	0.49	0.50	0	1	4,664
Age	35.0	13.8	2	87	4,664
Born outside Sweden	0.30	0.46	0	1	4,663
Second-generation immigrant	0.089	0.29	0	1	4,663
Born outside EU15 and Scandinavia	0.24	0.43	0	1	4,663
Urban Residence	0.87	0.33	0	1	4,660
Married	0.27	0.45	0	1	4,532
Divorced	0.10	0.31	0	1	4,532
Not eligible to marry (age<18)	0.090	0.29	0	1	4,664
Employed (ages 16-74)	0.72	0.45	0	1	4,529
Not of working age	0.058	0.23	0	1	4,664
Comorbidity	0.29	0.46	0	1	4,664
Vulnerability	0.42	0.49	0	1	4,664
Nurse-set ICD group controls					
Infectious	0.023	0.15	0	1	4,651
Endocrine, nutritional, metabolic	0.0084	0.091	0	1	4,651
Mental and behavioural	0.021	0.14	0	1	4,651
Nervous system	0.0080	0.089	0	1	4,651
Eye and adnexa	0.0090	0.095	0	1	4,651
Ear and mastoid process	0.072	0.26	0	1	4,651
Circulatory system	0.025	0.16	0	1	4,651
Respiratory system	0.029	0.17	0	1	4,651
Digestive system	0.025	0.15	0	1	4,651
Skin and subcutaneous tissue	0.035	0.18	0	1	4,651
Musculoskeletal, connective	0.19	0.39	0	1	4,651
Genitourinary system	0.049	0.22	0	1	4,651
Symptoms (cough, rash, etc.)	0.37	0.48	0	1	4,651
Injury or poisoning	0.042	0.20	0	1	4,651
Health status factors	0.091	0.29	0	1	4,651
Other	0.0069	0.083	0	1	4,651
Any hospitalization within 30 days	0.0094	0.097	0	1	4,664
Any ED visit within 30 days	0.048	0.21	0	1	4,664
New visit to primary care provider within 30 days	0.40	0.49	0	1	4,050
Other variables					
Nurse propensity to direct to any doctor	0.54	0.092	0.28	0.85	4,664
Nurse "mistake" share	0.076	0.037	0	0.25	4,664
Patient university educated (age>22)	0.58	0.49	0	1	3,396
Patient's annual income (in thsnd. SEK, age>20)	328.4	299.2	0	5301	3,759
Time period with low COVID-19 spread	0.49	0.50	0	1	4,664

Notes: This table presents summary statistics for key variables in the doctor sample (N=4,664). The variables refer mostly to the controls used in the main regressions (see Appendix Table B2 for descriptions).

Table 2. First Stage and Average Monotonicity

A. First stage

	Online consultation (D_i)		
	(1)	(2)	(3)
Instrument (π_i)	0.78	0.69	0.66
	(0.055)	(0.059)	(0.058)
	[0.053]	[0.056]	[0.055]
Patient characteristics and fixed effects		✓	✓
Nurse-set ICD group			✓
Observations	4,664	4,528	4,515
K-P F-statistic	198	138	133
Clustered K-P F-statistic	214	151	148
Baseline mean	0.43	0.43	0.43

B. Average monotonicity

	Female	Male	Age > median	Age ≤ median
Instrument (π_i)	0.73	0.67	0.67	0.72
	(0.085)	(0.081)	(0.083)	(0.082)
Fixed effects	✓	✓	✓	✓
Observations	2,299	2,365	2,246	2,418
First-stage K-P F-statistic	74	68	67	77
Baseline mean	0.45	0.40	0.42	0.43

	Born outside EU15 and Scandinavia	All other	Any comorbidity	No comorbidities
Instrument (π_i)	0.76	0.69	0.85	0.64
	(0.12)	(0.068)	(0.11)	(0.070)
Fixed effects	✓	✓	✓	✓
Observations	1,140	3,523	1,371	3,293
First-stage K-P F-statistic	43	103	64	84
Baseline mean	0.41	0.43	0.44	0.42

	Vulnerable	Less vulnerable	Low COVID-19 spread	All other
Instrument (π_i)	0.62	0.76	0.67	0.72
	(0.091)	(0.076)	(0.10)	(0.071)
Fixed effects	✓	✓	✓	✓
Observations	1,982	2,682	2,298	2,366
First-stage K-P F-statistic	46	100	43	103
Baseline mean	0.45	0.41	0.41	0.45

	University educated	Not university educated	Annual income > median	Annual income ≤ median
Instrument (π_i)	0.72	0.66	0.80	0.58
	(0.090)	(0.11)	(0.089)	(0.094)
Fixed effects	✓	✓	✓	✓
Observations	1,975	1,421	1,879	1,880
First-stage K-P F-statistic	63	39	82	37
Baseline mean	0.39	0.45	0.40	0.43

Notes: Panel A reports coefficients from regressions using the doctor sample. Panel B reports the first stage of the IV in different sub-samples of the doctor sample. The median age in the sample is 33, while the median annual income (for patients who are at least 21 years old) is 309,800 SEK. We restrict university education indicator to patients who are at least 23 years old. For descriptions of all the variables, please see the main text and the Appendix (especially Appendix Table B2). The F-statistic is the Kleibergen-Paap F-statistic. The baseline mean is the mean of the dependent variable for in-person doctor consultations. Robust standard errors are in parentheses. In panel A, robust standard errors in brackets are clustered by nurse.

Table 3. Instrument Independence

A. Balance of instrument, π_i, on patient characteristics (nurse sample)

Joint test on:						
Demographics	✓	✓	✓	✓	✓	✓
Comorbidity and Vulnerability			✓	✓	✓	✓
Nurse-set ICD group					✓	✓
Conditional on fixed effects		Yes		Yes		Yes
Joint test p-value	0.50	0.88	0.31	0.61	0.24	0.78
Observations	8,634	8,634	8,634	8,634	8,604	8,604

B. Balance of propensity to direct online, π_i, on nurse propensity to direct to any doctor

Propensity to direct to doctor	0.065	0.11
	(0.18)	(0.17)
Temporal Fixed Effects		✓
Observations	8,907	8,907
Baseline mean	0.43	0.43

C. Balance of instrument, π_i, on patient characteristics (doctor sample)

Joint test on:						
Demographics	✓	✓	✓	✓	✓	✓
Comorbidity and Vulnerability			✓	✓	✓	✓
Nurse-set ICD group					✓	✓
Conditional on fixed effects		Yes		Yes		Yes
Joint test p-value	0.38	0.51	0.37	0.44	0.13	0.29
Observations	4,528	4,528	4,528	4,528	4,515	4,515

Notes: Panels A and C show instrument balance tests using the nurse sample and the doctor sample. Joint tests and their p-values are reported in both panels are of the patient demographics (ψ_i). Panel B shows the correlation between the nurse propensity to direct patients to online doctor consultations, π_i, with the propensity to direct to any doctor (in-person or online) using the nurse sample, where the second column includes temporal fixed effects for 4-hour blocks, weeks, months and years. The standard errors in Panel B are clustered by nurse, since the regressions essentially use nurse-level variation. The baseline mean is the mean of the dependent variable for in-person doctor consultations.

Table 4. Average Exclusion

A. Tasks that doctors and nurses are allowed to perform

	Doctors	Nurses
Prescribe medications	✓	
Refer to (external) specialist	✓	
Write sick notes for patients	✓	
Advise patients on self-care	✓	✓

B. Instrument regressed on nurse characteristics

	Instrument (π_i)	
District Nurse	0.013	0.0012
	(0.034)	(0.036)
Urban Residence	-0.067	-0.061
	(0.030)	(0.030)
Speaks non-EU15 Language	0.046	0.032
	(0.051)	(0.054)
Experience within Provider	0.000010	0.000016
	(0.000016)	(0.000016)
Nurse Mistake Share	-0.27	-0.35
	(0.46)	(0.45)
Years Since Graduation		-0.0020
		(0.0013)
Temporal fixed effects	✓	✓
Sample:	Doctor	Doctor
Observations	4,664	4,569

C. Nurse meetings are short (and shorter than doctor consultations)

		Quartiles			
	Mean	Q_{25}	Q_{50}	Q_{75}	Count
Nurse patient-facing time	4.7	2.5	4	6.1	4,267
Doctor patient-facing time	20.0	4.2	12.6	30.1	4,267

Notes: In Panel A we outline tasks that doctors and nurses are allowed to perform when seeing patients. In Panel B we regress the instrument on nurse characteristics and the standard errors are clustered by nurse, since the regression in this panel essentially use nurse-level variation. There are 62 unique nurses in the doctor sample and the detailed descriptions of the nurse characteristics can be found in the Appendix table B2. In Panel C we show the difference in the meeting duration between doctor consultations and nurse meetings (in minutes) in the doctor sample.

Table 5. Online's Effect on Timing and Duration of Doctor Consultations

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Days between nurse meeting and doctor consultation						
Online consultation (D_i)	-2.30	-2.30	-2.35	-3.15	-2.73	-2.77
	(0.065)	(0.067)	(0.069)	(0.34)	(0.41)	(0.43)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	2.4	2.5	2.5	2.4	2.5	2.5
B. Total consultation duration (in minutes)						
Online consultation (D_i)	-25.8	-25.7	-26.1	-12.6	-15.0	-14.9
	(0.62)	(0.64)	(0.66)	(3.52)	(3.99)	(4.14)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,512	4,382	4,369	4,512	4,382	4,369
First-stage K-P F-statistic				194	133	129
Baseline mean	39.8	39.7	39.7	39.8	39.7	39.7
C. Patient-facing part of the consultation (in minutes)						
Online consultation (D_i)	-26.8	-26.8	-27.1	-22.6	-23.0	-22.8
	(0.44)	(0.46)	(0.48)	(2.17)	(2.48)	(2.56)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,343	4,220	4,208	4,343	4,220	4,208
First-stage K-P F-statistic				200	138	134
Baseline mean	32.3	32.2	32.2	32.3	32.2	32.2
D. Administrative part of the consultation (in minutes)						
Online consultation (D_i)	1.32	1.43	1.31	6.32	6.48	6.36
	(0.34)	(0.34)	(0.35)	(1.94)	(2.26)	(2.33)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,332	4,211	4,199	4,332	4,211	4,199
First-stage K-P F-statistic				198	136	133
Baseline mean	7.2	7.2	7.2	7.2	7.2	7.2

Notes: This table reports estimates of regressions using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the control variables, please see the main text and the appendix (in particular Appendix Table B2). Fixed effects indicate year×month, 4-hour blocks, day of the week, and clinics where the patients were registered. The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table 6. Online's Effect on Within-Consultation Outcomes

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Doctor set an informative diagnosis						
Online consultation (D_i)	0.035	0.038	0.028	-0.12	-0.15	-0.12
	(0.013)	(0.014)	(0.014)	(0.075)	(0.090)	(0.088)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.68	0.68	0.68	0.68	0.68	0.68
B. Patient received a prescription						
Online consultation (D_i)	0.15	0.15	0.15	-0.011	0.023	0.058
	(0.013)	(0.014)	(0.014)	(0.070)	(0.082)	(0.083)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.21	0.21	0.21	0.21	0.21	0.21
C. Doctor gave a specialist referral (Stockholm only)						
Online consultation (D_i)	-0.092	-0.094	-0.096	-0.035	-0.0015	-0.016
	(0.010)	(0.011)	(0.011)	(0.057)	(0.070)	(0.068)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	2,419	2,333	2,324	2,419	2,333	2,324
First-stage K-P F-statistic				82	58	63
Baseline mean	0.12	0.12	0.12	0.12	0.12	0.12
D. Patient satisfaction score (5 is best)						
Online consultation (D_i)	-0.012	-0.025	-0.040	-0.074	-0.24	-0.26
	(0.042)	(0.047)	(0.049)	(0.26)	(0.34)	(0.33)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,466	1,429	1,423	1,466	1,429	1,423
First-stage K-P F-statistic				53	29	31
Baseline mean	4.71	4.70	4.70	4.71	4.70	4.70

Notes: This table reports estimates of regressions using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and the appendix (in particular Appendix Table B2). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table 7. Online's Effect on Patient Outcomes Within 30 Days After the Nurse Meeting

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Any ED visit within 30 days						
Online consultation (D_i)	0.016	0.013	0.015	0.10	0.11	0.11
	(0.0065)	(0.0067)	(0.0072)	(0.037)	(0.045)	(0.047)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.042	0.042	0.042	0.042	0.042	0.042
B. Any hospitalization within 30 days						
Online consultation (D_i)	0.0037	0.0036	0.0027	0.021	0.023	0.025
	(0.0029)	(0.0030)	(0.0032)	(0.014)	(0.017)	(0.018)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.008	0.008	0.008	0.008	0.008	0.008
C. New visit to primary care provider within 30 days						
Online consultation (D_i)	0.096	0.10	0.11	0.17	0.29	0.31
	(0.016)	(0.016)	(0.017)	(0.090)	(0.11)	(0.11)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				147	96	90
Baseline mean	0.360	0.360	0.360	0.360	0.360	0.360
D. Patient collected prescription within 30 days (conditional on getting a prescription)						
Online consultation (D_i)	-0.0067	-0.0034	-0.00083	-0.013	-0.0064	0.0029
	(0.016)	(0.018)	(0.019)	(0.12)	(0.15)	(0.15)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,286	1,247	1,244	1,286	1,247	1,244
First-stage K-P F-statistic				32	20	22
Baseline mean	0.920	0.918	0.918	0.920	0.918	0.918

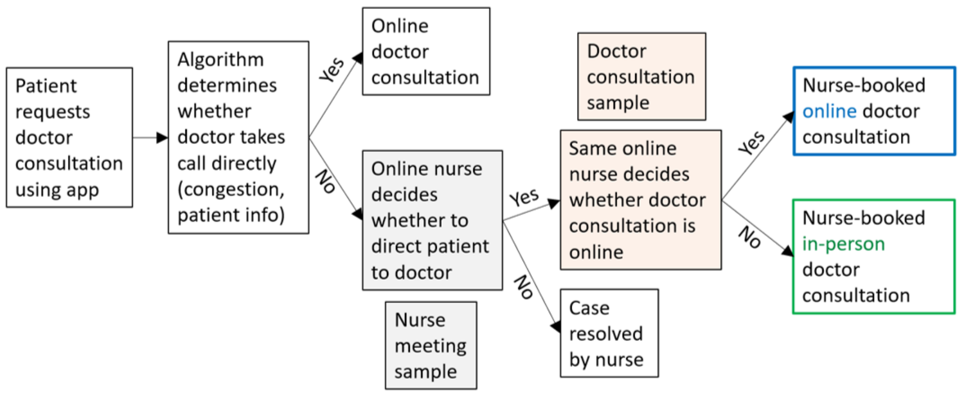
Notes: This table reports estimates of regressions using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. ED definition includes hospital associated EDs and urgent care center visits. For a description of the variables, please see the main text and the appendix (in particular Appendix Table B2). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table 8. Online's Effect on Taxpayer Costs (SEK)

	OLS		IV	
	Logs	Levels	Logs	Levels
A. Initial consultation costs				
Online consultation (D_i)	-1.02	-1474.0	-1.04	-1491.1
	(0.0026)	(2.63)	(0.015)	(15.6)
First-stage K-P F-statistic			133	133
Observations	4,515	4,515	4,515	4,515
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.64	-0.64	-0.65	-0.64
B: Same as in Panel A but weighted to reflect primary care patient characteristics (see note)				
Online consultation (D_i)	-1.01	-1459.9	-1.06	-1502.5
	(0.0048)	(4.80)	(0.025)	(25.7)
First-stage K-P F-statistic			54	54
Observations	4,512	4,512	4,512	4,512
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.63	-0.63	-0.65	-0.65
C. Overall treatment costs				
Online consultation (D_i)	-0.68	-1158.0	-0.53	-220.8
	(0.020)	(119.0)	(0.12)	(668.2)
First-stage K-P F-statistic			133	133
Observations	4,515	4,515	4,515	4,515
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.49	-0.34	-0.41	-0.065
D. Same as in Panel C but weighted to reflect primary care patient characteristics (see note)				
Online consultation (D_i)	-0.71	-1189.1	-0.33	1055.2
	(0.035)	(192.3)	(0.21)	(1274.9)
First-stage K-P F-statistic			54	54
Observations	4,512	4,512	4,512	4,512
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.51	-0.35	-0.28	0.31
E. Same as in Panel D but adjusted for PCP follow-up probability (see note)				
Online consultation (D_i)	-0.78	-1304.4	-0.56	521.4
	(0.033)	(191.2)	(0.18)	(1258.3)
First-stage K-P F-statistic			54	54
Observations	4,512	4,512	4,512	4,512
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.54	-0.40	-0.43	0.16

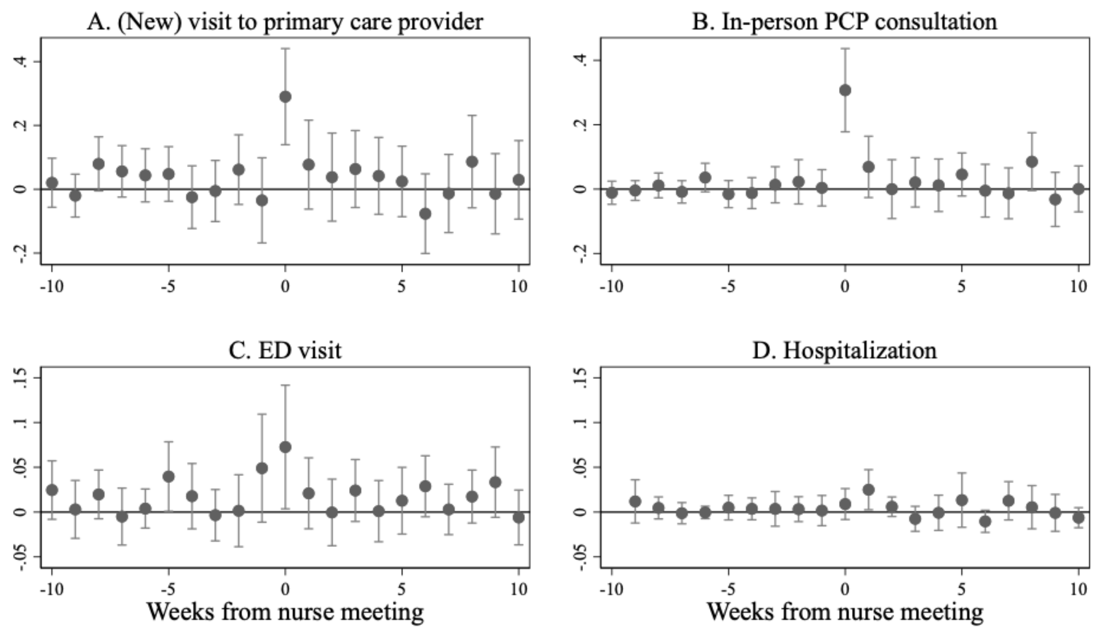
Note: This table reports estimates of regressions using specification (4) with the full set of controls in the doctor sample, where the outcomes are measures of taxpayer costs. Panels D and E use weights that reflect general primary care patient characteristics. These weights are the inverse of the fitted values from a regression that pools both columns of Appendix Table A9, after having removed potential double counts of online meetings, and uses probit to estimate the probability of being in the doctor sample. Panel E multiplies the probability of a PCP in person follow-up by 0.386 to reflect the selection done by nurses of patients to see a doctor at all, as per the analysis of Appendix Table A10.

Figure 1. Assignment of Registered Patients to Online versus In-Person Consultations



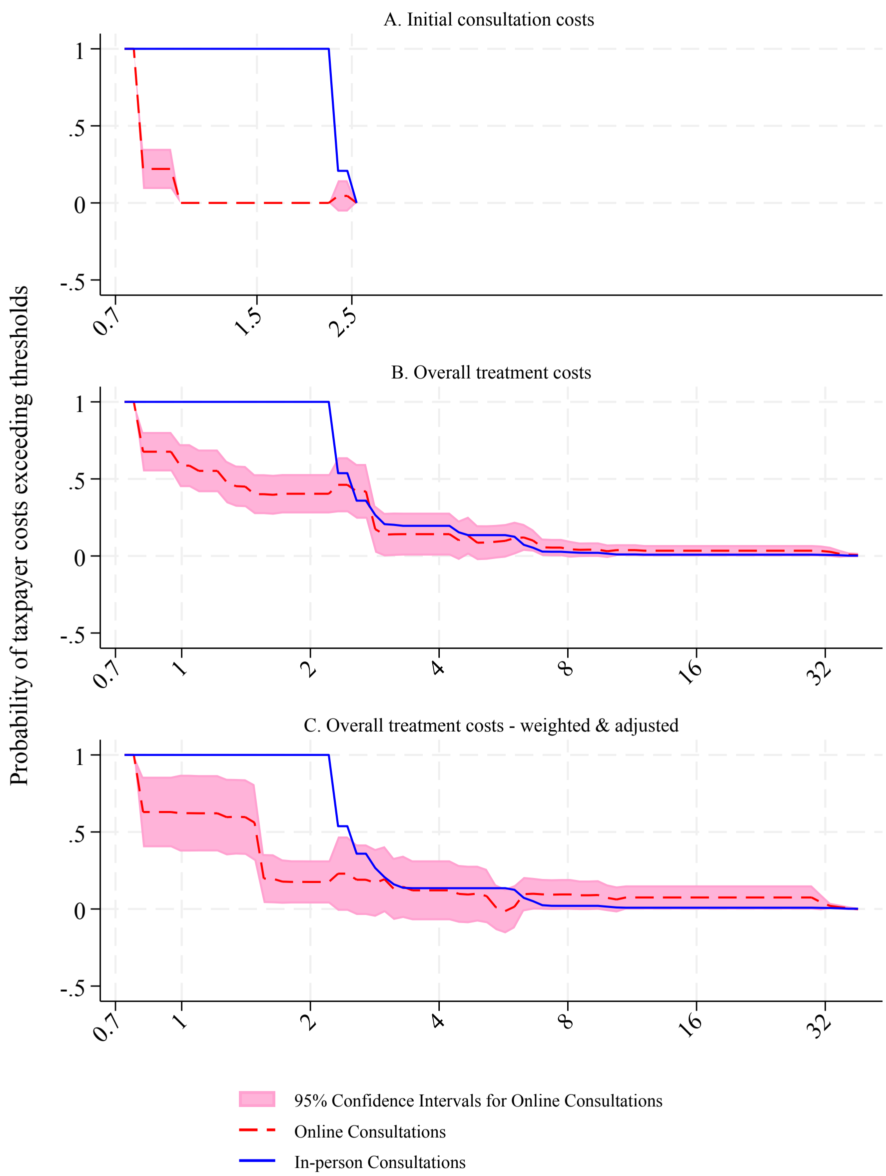
Notes: This figure shows the flows of patients registered with the healthcare company. Cases in the box with a gray background are defined as the "nurse meeting sample" (or "nurse sample" for short), and cases in the box with an orange background are defined as the "doctor consultation sample" (or "doctor sample" for short). We define a case as an online meeting between a patient and nurse and its resulting treatment (either an online or in-person doctor consultation or no consultation).

Figure 2. Patient Outcomes During the Weeks Before and After the Nurse Meeting



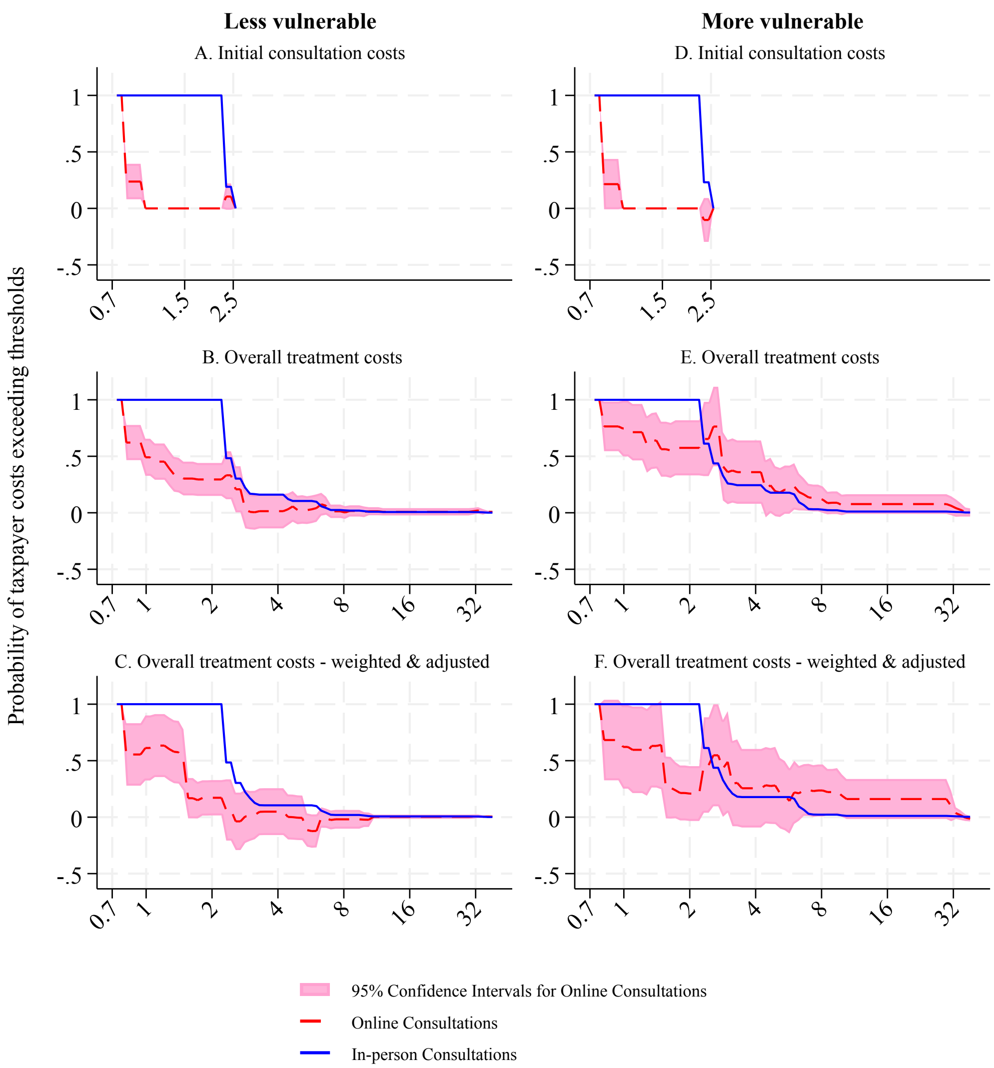
Notes: This figure shows estimated effects of an online doctor consultation 10 weeks before and after the nurse meeting. Each of the estimates in each panel is based on a separate regression using our main IV specification in the doctor sample with full controls (baseline fixed effects, demographics, comorbidity and vulnerability, and indicators of nurse-set ICD group). "Week 0" shows the effect for the seven days starting with the patient's nurse meeting, "week 1" for the following week, "week –1" for the preceding week, etc. In Panels A and B, the (new) visit to the primary care provider and in-person PCP consultation are indicators for any visit or consultation that the patient had in the respective time period, excluding the consultation that the patient was directed to. In panel D, there were no hospitalizations in week -10, therefore we observe a missing point in the figure. For variable descriptions, see the main text and appendix (in particular Appendix Table B2). Additionally, the confidence intervals are at the 95% level and constructed using robust standard errors.

Figure 3. Online's Effect on the Distribution of Taxpayer Costs ('000 SEK)



Notes: This figure presents the probabilities that taxpayer costs (in thousands of SEK) exceed the thresholds shown on the x axis. The estimates are taken from repeating specifications similar to Column (4) of Panels A, C, and E of Table 8 but using indicators for ln(costs) exceeding different thresholds, at intervals of 0.05. The first sub-figure shows costs due only to the online nurse consultation, the subsequent online or in-person doctor visit and the (mean) prescription cost. The second and third subfigures add costs of emergency department visits, hospitalizations, urgent care visits, and additional primary care consultations with nurses and doctors, up to the first cost of each type occurring within a month. The third subfigure adjusts costs and uses weights as in Panel E of Table 8.

Figure 4. Online's Effect on the Distribution of Taxpayer Costs ('000 SEK) by Patient Vulnerability



Notes: This figure presents the probabilities that taxpayer costs (in thousands of SEK) exceed the thresholds shown on the x axis. Sub-figures A, B, and C, which report costs for less vulnerable patients correspond to Column (4) Panels A, B, and C of Appendix Table A16 but using indicators as described in the Note to Figure 3. Sub-figures D, E, and F show the costs for more vulnerable patients, and correspond to Column (4) Panels D, E, and F of Appendix Table A16.

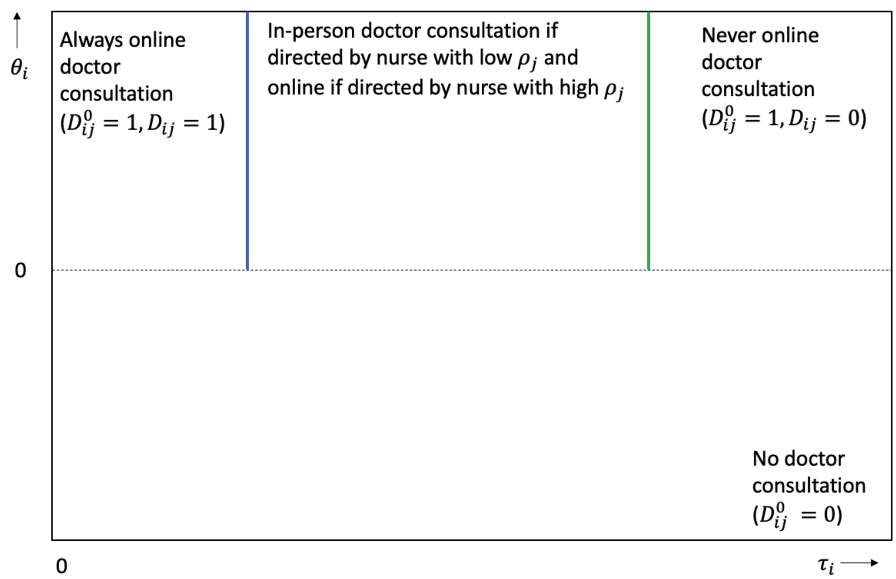
Online Appendix

Online versus In-Person Services: Effects on Patients and Providers

A Appendix Figures and Tables

Figure A1. Patient Sorting in the Model

A. When the nurses perceive illness precisely $(Var(\eta_{ij}) = 0)$



B. When the nurses perceive illness imprecisely $(Var(\eta_{ij}) \neq 0)$

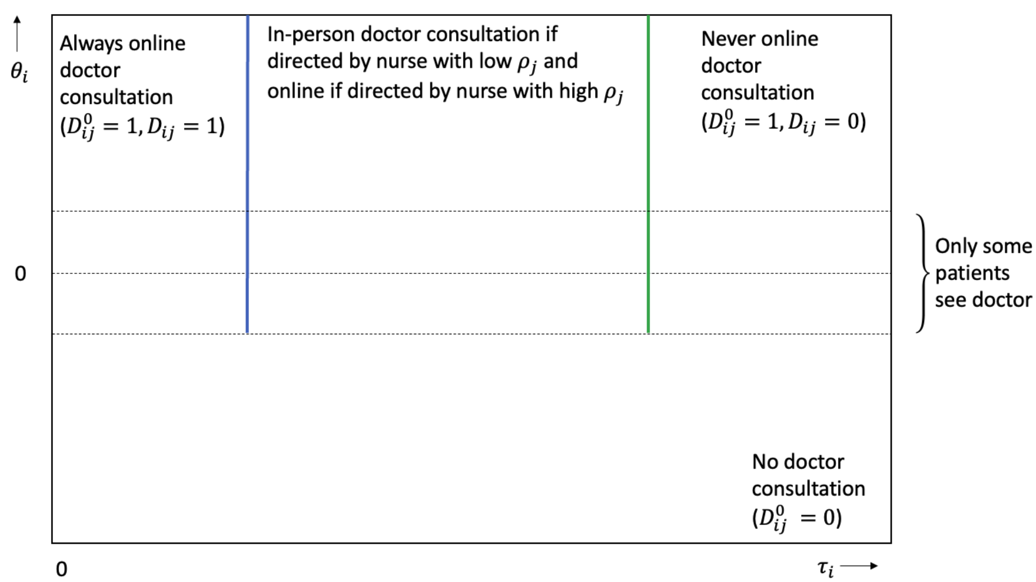
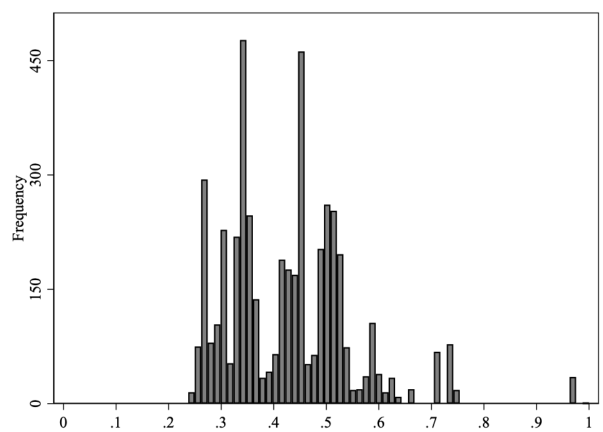


Figure A2. Distribution of the Instrument



Notes: This figure shows the distribution of the instrument π_i (the nurse's leave-one-out propensity to direct patients to online consultations as a share of all consultation the nurse directs to) in the doctor sample.

Table A1. IV Complier Characteristics

	(1) Sample mean	(2) Complier mean
Patient Demographics		
Female	0.49	0.47
Age	35.0	32.8
Born outside EU15 and Scandi.	0.24	0.26
Urban Residence	0.87	0.83
Married	0.27	0.14
Divorced	0.10	0.085
Ineligible to marry	0.090	0.12
Employed (ages 16-74)	0.72	0.70
Not of working age	0.058	0.045
Comorbidity	0.29	0.30
Vulnerability	0.42	0.36
Nurse-set ICD group		
Infectious	0.023	0.0069
Endocrine, nutrit., metabolic	0.0084	-0.000092
Mental and behavioural	0.021	0.028
Nervous system	0.0080	0.017
Eye and adnexa	0.0090	0.0086
Ear and mastoid process	0.072	0.023
Circulatory system	0.025	0.011
Respiratory system	0.029	-0.0065
Digestive system	0.025	0.025
Skin and subcutaneous tissue	0.035	0.057
Musculoskeletal, connective	0.19	0.071
Genitourinary system	0.049	0.030
Symptoms (cough, rash, etc.)	0.37	0.50
Injury or poisoning	0.042	0.037
Health status factors	0.091	0.18
Other	0.0069	0.0074
Other variables		
University educated	0.58	0.67
Annual income (in thsnd. SEK)	328.4	404.0

Notes: This table characterizes the complier population in the doctor sample (N=4,664). We follow the procedure described in Frandsen et al. (2023) and present in Column (2)—for some pre-determined characteristic X_i—the estimate of $\frac{E[\omega_i X_i]}{E[\omega_i]}$, where ω_i is the weight given to case i by the IV. Column (1) shows the mean of X_i in our sample for comparison. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2).

Table A2. Nurse Characteristics Regressed on Patient Characteristics

	Instrument (π_i)	District Nurse	Urban Residence	Speaks non-EU15 Language	Experience within Provider	Years Since Graduation	Nurse Mistake Share	Propensity to Redirect
A. Balance test on the nurse sample								
Patient Characteristics								
Female	-0.0016	-0.0031	-0.0061	0.0045	-11.9	-0.28	0.00044	0.0016
	(0.0024)	(0.0079)	(0.011)	(0.0063)	(15.5)	(0.20)	(0.00077)	(0.0020)
Born outside Sweden	0.0012	0.00041	0.044	0.027	19.5	0.045	-0.000086	-0.00037
	(0.0052)	(0.019)	(0.025)	(0.016)	(35.4)	(0.47)	(0.0018)	(0.0045)
Second-generation immigrant	-0.0011	-0.0040	-0.0019	0.0090	24.5	0.16	0.00096	-0.0021
	(0.0040)	(0.013)	(0.018)	(0.011)	(26.0)	(0.34)	(0.0013)	(0.0034)
Born outside EU15 & Scandi.	0.0015	-0.011	-0.020	-0.027	-33.7	0.32	0.0000015	-0.00066
	(0.0056)	(0.020)	(0.026)	(0.016)	(37.1)	(0.50)	(0.0019)	(0.0048)
Married	-0.0025	0.0012	0.013	-0.000059	-30.5	0.068	0.00061	-0.0039
	(0.0034)	(0.012)	(0.015)	(0.0092)	(22.2)	(0.29)	(0.0011)	(0.0028)
Divorced	-0.0072	-0.0074	0.0081	-0.013	-46.7	0.33	-0.000080	0.0021
	(0.0048)	(0.016)	(0.022)	(0.013)	(31.9)	(0.40)	(0.0016)	(0.0040)
Ineligible to marry	0.0035	-0.0085	0.0067	0.0048	50.3	-0.41	0.0028	0.0035
	(0.0062)	(0.021)	(0.028)	(0.018)	(40.1)	(0.52)	(0.0021)	(0.0051)
Employed (ages 16-74)	0.000013	-0.0012	-0.011	-0.0048	6.57	0.13	-0.00030	-0.0029
	(0.0031)	(0.010)	(0.014)	(0.0082)	(20.1)	(0.26)	(0.0010)	(0.0025)
Not of working age	-0.0049	-0.015	-0.040	0.0032	-49.7	-0.027	-0.00017	-0.0084
	(0.0075)	(0.025)	(0.034)	(0.022)	(49.0)	(0.64)	(0.0024)	(0.0063)
Age	-0.00024	-0.00054	-0.0022	0.00094	1.93	-0.041	0.000035	-0.000047
	(0.00055)	(0.0019)	(0.0025)	(0.0015)	(3.60)	(0.047)	(0.00018)	(0.00047)
Age^2	0.0000031	0.0000038	0.000024	-0.0000099	-0.011	0.00043	-0.00000011	0.0000022
	(0.0000066)	(0.000023)	(0.000030)	(0.000018)	(0.043)	(0.00055)	(0.0000021)	(0.0000055)
Comorbidity	-0.0026	-0.0041	-0.0030	-0.0054	23.8	0.18	-0.00026	0.0026
	(0.0027)	(0.0089)	(0.012)	(0.0071)	(17.7)	(0.23)	(0.00086)	(0.0022)
Vulnerability	-0.0042	-0.00010	-0.0088	0.0026	-15.3	0.13	0.0013	-0.0015
	(0.0025)	(0.0082)	(0.011)	(0.0066)	(16.0)	(0.21)	(0.00081)	(0.0020)
Observations	8,634	8,634	8,634	8,634	8,634	8,454	8,634	8,634
Baseline mean	0.43	0.17	0.50	0.10	471.53	12.75	0.08	0.54
Joint test p-value	0.61	0.99	0.63	0.89	0.60	0.89	0.76	0.54
B. Balance test of nurse characteristics in the doctor sample								
Patient Characteristics								
Female	-0.0020	0.0047	0.0028	0.0017	-23.7	-0.74	0.0012	0.0015
	(0.0035)	(0.011)	(0.015)	(0.0086)	(21.5)	(0.27)	(0.0011)	(0.0027)
Born outside Sweden	-0.010	-0.0092	0.074	0.029	10.4	0.26	0.0026	0.0082
	(0.0073)	(0.026)	(0.034)	(0.021)	(47.9)	(0.62)	(0.0026)	(0.0060)
Second-generation immigrant	0.0070	-0.021	0.0036	0.021	-19.0	-0.31	0.0014	0.0000048
	(0.0064)	(0.019)	(0.026)	(0.017)	(36.7)	(0.47)	(0.0020)	(0.0050)
Born outside EU15 & Scandi.	0.013	-0.0083	-0.035	-0.036	-24.8	0.60	-0.0031	-0.0078
	(0.0078)	(0.027)	(0.036)	(0.022)	(50.2)	(0.66)	(0.0027)	(0.0063)
Married	-0.0072	-0.027	-0.024	-0.019	-21.8	0.19	0.00023	-0.0023
	(0.0048)	(0.015)	(0.020)	(0.011)	(29.8)	(0.38)	(0.0015)	(0.0038)
Divorced	-0.0065	-0.024	-0.031	-0.018	-68.6	0.25	-0.0012	0.0047
	(0.0066)	(0.021)	(0.029)	(0.017)	(41.0)	(0.51)	(0.0021)	(0.0051)
Ineligible to marry	0.00060	-0.0028	0.00044	0.013	105.3	-0.65	-0.00096	0.0053
	(0.0099)	(0.032)	(0.044)	(0.028)	(65.7)	(0.74)	(0.0032)	(0.0075)
Employed (ages 16-74)	-0.0053	-0.0032	-0.0085	0.00034	14.1	0.25	0.00056	0.00089
	(0.0046)	(0.014)	(0.019)	(0.011)	(27.6)	(0.35)	(0.0014)	(0.0034)
Not of working age	-0.0011	-0.057	0.0013	-0.010	-157.8	0.29	0.0045	-0.00089
	(0.012)	(0.039)	(0.054)	(0.035)	(78.9)	(0.93)	(0.0039)	(0.0095)
Age	0.00025	-0.00077	-0.0032	-0.0014	-1.20	0.0097	-0.00024	-0.00017
	(0.00083)	(0.0027)	(0.0037)	(0.0022)	(5.28)	(0.065)	(0.00027)	(0.00067)
Age^2	-0.0000032	0.000013	0.000050	0.000024	0.042	-0.00012	0.0000030	-0.00000022
	(0.0000097)	(0.000032)	(0.000043)	(0.000026)	(0.061)	(0.00075)	(0.0000031)	(0.0000078)
Comorbidity	-0.0058	-0.0069	0.0032	0.0078	13.8	0.020	0.00032	0.0024
	(0.0038)	(0.012)	(0.017)	(0.0099)	(24.4)	(0.30)	(0.0012)	(0.0030)
Vulnerability	0.00089	-0.0064	-0.018	-0.0033	5.24	0.36	0.000047	-0.0071
	(0.0036)	(0.011)	(0.015)	(0.0090)	(22.4)	(0.28)	(0.0011)	(0.0028)
Observations	4,528	4,528	4,528	4,528	4,528	4,436	4,528	4,528
Baseline mean	0.45	0.17	0.47	0.11	401.44	12.45	0.08	0.54
Joint test p-value	0.44	0.44	0.38	0.51	0.41	0.04	0.52	0.18

Notes: Panels A and B show balance tests using the nurse and doctor samples using robust standard errors. Joint tests and their p-values are reported in both panels and always exclude fixed effects. All the regression are conditional on out baseline fixed effects, which are: year × month, four-hour blocks, day of the week, and the clinic where the patient was registered. The detailed descriptions of the nurse characteristics can be found in the table B2.

Table A3. Probability of Patient Answering the Satisfaction Survey

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
Online consultation (D_i)	0.21	0.22	0.22	0.16	0.23	0.23
	(0.014)	(0.014)	(0.015)	(0.073)	(0.086)	(0.089)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.2	0.2	0.2	0.2	0.2	0.2

Notes: This table presents the estimated probability that the patient answers the satisfaction survey in the doctor sample. The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A4. Online's Effect on Patient Outcomes Within 30 Days After the Doctor Consultation

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Any hospitalization within 30 days						
Online consultation (D_i)	0.0037	0.0037	0.0030	0.024	0.028	0.030
	(0.0029)	(0.0030)	(0.0032)	(0.014)	(0.018)	(0.018)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,660	4,524	4,511	4,660	4,524	4,511
First-stage K-P F-statistic				198	138	133
Baseline mean	0.008	0.008	0.008	0.008	0.008	0.008
B. Any ED visit within 30 days						
Online consultation (D_i)	0.019	0.016	0.018	0.11	0.11	0.12
	(0.0064)	(0.0067)	(0.0072)	(0.037)	(0.045)	(0.047)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,660	4,524	4,511	4,660	4,524	4,511
First-stage K-P F-statistic				198	138	133
Baseline mean	0.039	0.039	0.040	0.039	0.039	0.040
C. New visit to primary care provider within 30 days						
Online consultation (D_i)	0.096	0.10	0.11	0.17	0.30	0.32
	(0.016)	(0.016)	(0.017)	(0.090)	(0.11)	(0.11)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,046	3,935	3,922	4,046	3,935	3,922
First-stage K-P F-statistic				147	97	90
Baseline mean	0.360	0.359	0.360	0.360	0.359	0.360
D. Patient collected prescription within 30 days (conditional on getting a prescription)						
Online consultation (D_i)	-0.0069	-0.0039	-0.00100	-0.015	-0.0084	0.00075
	(0.016)	(0.018)	(0.019)	(0.12)	(0.16)	(0.15)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,284	1,245	1,242	1,284	1,245	1,242
First-stage K-P F-statistic				31	19	21
Baseline mean	0.920	0.918	0.918	0.920	0.918	0.918

Notes: This table reports estimates of regression coefficients using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A5. Robustness to Table 7: including Doctor Characteristics

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Any ED visit within 30 days						
Online consultation (D_i)	0.019	0.018	0.020	0.15	0.16	0.17
	(0.0083)	(0.0085)	(0.0091)	(0.054)	(0.069)	(0.069)
Doctor characteristics	✓	✓	✓	✓	✓	✓
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				129	84	86
Baseline mean	0.042	0.042	0.042	0.042	0.042	0.042
B. Any hospitalization within 30 days						
Online consultation (D_i)	0.0074	0.0079	0.0065	0.032	0.036	0.037
	(0.0041)	(0.0041)	(0.0042)	(0.022)	(0.027)	(0.027)
Doctor characteristics	✓	✓	✓	✓	✓	✓
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				129	84	86
Baseline mean	0.008	0.008	0.008	0.008	0.008	0.008
C. New visit to primary care provider within 30 days						
Online consultation (D_i)	0.062	0.079	0.086	0.17	0.37	0.39
	(0.020)	(0.020)	(0.021)	(0.13)	(0.17)	(0.17)
Doctor characteristics	✓	✓	✓	✓	✓	✓
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				98	60	60
Baseline mean	0.360	0.360	0.360	0.360	0.360	0.360
D. Patient collected prescription within 30 days (conditional on getting a prescription)						
Online consultation (D_i)	-0.022	-0.024	-0.020	-0.031	-0.040	-0.026
	(0.019)	(0.021)	(0.022)	(0.16)	(0.21)	(0.21)
Doctor characteristics	✓	✓	✓	✓	✓	✓
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,286	1,247	1,244	1,286	1,247	1,244
First-stage K-P F-statistic				23	13	15
Baseline mean	0.920	0.918	0.918	0.920	0.918	0.918

Notes: This table reports robustness checks to Table 7 and using the same specifications but adding controls for doctor characteristics, including indicators for urban residence, top Swedish medical school graduation, whether the doctor is in specialty training and whether the doctor already has specialist qualification (with the omitted category being MD only), and whether the specialist training or specialist qualification is in the General Practice field, and the number of prior consultations with the firm before the earliest in-sample meeting. The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, i. For a detailed description of the variables, please see the main text and appendix (in particular Appendix Table B2). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A6. Doctor Consultations per Hour in Online and In-Person Doctor Shifts

	Shift incl. all breaks			Shift excl. all breaks		
	(1)	(2)	(3)	(4)	(5)	(6)
Shift was online	1.88	1.94	1.68	2.34	2.47	2.00
	(0.078)	(0.078)	(0.12)	(0.084)	(0.084)	(0.15)
Time fixed effects		✓	✓		✓	✓
Doctor fixed effects			✓			✓
Observations	78,413	78,413	78,413	78,413	78,413	78,413
Baseline mean	1.81	1.81	1.81	2.88	2.88	2.88

Notes: This table reports regressions using the doctor shift sample, which consists of consultations with both registered and non-registered patients collapsed to the doctor×day level. A shift starts with the start of the first consultation and ends with the end of the last consultation within a calendar day. Breaks are times in between the consultations. For the construction of the doctor shift sample and the shift variables, please see Appendix Section C.4.2. Time fixed effects include year×month and day of the week fixed effects. The baseline mean is the mean of the dependent variable for in-person doctor shifts, and robust standard errors are in parentheses.

Table A7. Online's Effect on Primary Care Use Within 30 Days of the Nurse Meeting

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Doctor booked a revisit within 30 days						
Online consultation (D_i)	0.10	0.10	0.11	0.18	0.24	0.25
	(0.012)	(0.012)	(0.013)	(0.070)	(0.084)	(0.088)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				147	96	90
Baseline mean	0.11	0.11	0.11	0.11	0.11	0.11
B. Doctor booked an in-person revisit within 30 days						
Online consultation (D_i)	0.097	0.10	0.11	0.21	0.26	0.27
	(0.010)	(0.011)	(0.012)	(0.064)	(0.076)	(0.079)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				147	96	90
Baseline mean	0.07	0.07	0.07	0.07	0.07	0.07
C. Doctor booked an online revisit within 30 days						
Online consultation (D_i)	0.0042	0.0012	-0.0011	-0.031	-0.016	-0.016
	(0.0065)	(0.0068)	(0.0069)	(0.034)	(0.042)	(0.044)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				147	96	90
Baseline mean	0.04	0.04	0.04	0.04	0.04	0.04
D. Patient initiated follow-up visit which took place within 30 days						
Online consultation (D_i)	0.040	0.050	0.054	0.064	0.15	0.16
	(0.014)	(0.015)	(0.016)	(0.079)	(0.097)	(0.10)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,050	3,939	3,926	4,050	3,939	3,926
First-stage K-P F-statistic				147	96	90
Baseline mean	0.25	0.25	0.25	0.25	0.25	0.25

Notes: This table reports estimates of regression coefficients using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). Panels A, B, and C show estimates on whether the doctor booked a follow-up consultation for the patient within 30 days, which we determine by matching the doctor consultation with the revisit. Panel D shows estimates on whether the patient contacted the primary care provider to book another meeting within 30 days. The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A8. Online's Effect on Long-Term Outcomes

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Any ED visit in 30 days - 3 years after the nurse meeting						
Online consultation (D_i)	0.016	-0.0017	-0.0045	0.091	0.077	0.084
	(0.014)	(0.015)	(0.015)	(0.077)	(0.089)	(0.093)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.375	0.377	0.376	0.375	0.377	0.376
B. Any hospitalization in 30 days - 3 years after the nurse meeting						
Online consultation (D_i)	0.017	0.012	0.010	0.049	0.084	0.088
	(0.0095)	(0.0096)	(0.010)	(0.052)	(0.060)	(0.062)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,664	4,528	4,515	4,664	4,528	4,515
First-stage K-P F-statistic				198	138	133
Baseline mean	0.106	0.106	0.107	0.106	0.106	0.107
C. Average employment status from 2020 to 2022						
Online consultation (D_i)	-0.023	-0.012	-0.013	-0.12	-0.081	-0.088
	(0.0098)	(0.0091)	(0.0095)	(0.052)	(0.055)	(0.057)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	4,361	4,228	4,215	4,361	4,228	4,215
First-stage K-P F-statistic				192	136	131
Baseline mean	0.838	0.840	0.840	0.838	0.840	0.840

Notes: This table reports estimates of regression coefficients using specification (4) for different outcomes in the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). Note that the outcomes in all panels indicate events occurring at least a month after the consultation (see Table 6). The longest duration patients can be observed after 30 days from the doctor consultation is about three years and one month. The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A9. Comparison of Doctor Sample Patients to Those in a Wider Sample of PCP Consultations

	(1) Doctor sample	(2) Scania sample
Patient demographics		
Female	0.49	0.59
Age	33.0	49.5
Urban Residence	0.87	0.39
ICD codes		
Infectious	0.023	0.034
Endocrine, nutritional, metabolic	0.0084	0.051
Mental and behavioural	0.021	0.084
Nervous system	0.0080	0.020
Eye and adnexa	0.0090	0.016
Ear and mastoid process	0.072	0.051
Circulatory system	0.025	0.084
Respiratory system	0.029	0.100
Digestive system	0.025	0.037
Skin and subcutaneous tissue	0.035	0.057
Musculoskeletal, connective	0.19	0.11
Genitourinary system	0.049	0.056
Symptoms (cough, rash, etc.)	0.37	0.18
Injury or poisoning	0.042	0.047
Health status factors	0.091	0.051
Other	0.0069	0.026
Observations	4,664	1,515,402

Notes: This table presents summary statistics for doctor consultations from the Scania sample in 2019 and the doctor sample. The Scania sample consists of all PCP visits in Scania, a region in southern Sweden where 13% of the Swedish population lives. The ICD codes are based on letter-level codes and we use the same letter groupings from the nurse-set ICD group controls for the doctor sample. For the Scania sample, we also use the same letter groupings, but base it on the doctor consultation as opposed to the nurse meeting. The variables report patient age based on 2018 for the doctor sample and 2019 for the Scania sample. More information on the Scania sample can be found in Appendix Section C.4.

Table A10. Comparison of Patients Directed to Online Consultations (in Doctor Sample) to Patients Who Consulted Online Doctors Without First Meeting Nurses

	OLS			
	(1)	(2)	(3)	(4)
A. Doctor booked an in-person revisit within 30 days				
Consultation is in online doctor sample	0.083	0.15	0.19	0.14
	(0.0092)	(0.015)	(0.033)	(0.019)
Patient characteristics and fixed effects		✓	✓	✓
ICD code			✓	
Symptom ID				✓
Observations	22,100	21,542	21,462	21,293
Dependent variable mean	0.089	0.088	0.088	0.088
B. Any ED visit within 30 days				
Consultation is in online doctor sample	0.0095	-0.0025	0.016	-0.012
	(0.0055)	(0.013)	(0.021)	(0.015)
Patient characteristics and fixed effects		✓	✓	✓
ICD code			✓	
Symptom ID				✓
Observations	25,057	24,405	24,320	24,142
Dependent variable mean	0.050	0.051	0.051	0.051
C: Any hospitalization within 30 days				
Consultation is in online doctor sample	0.0018	0.00092	-0.0076	-0.0019
	(0.0026)	(0.0060)	(0.0088)	(0.0066)
Patient characteristics and fixed effects		✓	✓	✓
ICD code			✓	
Symptom ID				✓
Observations	25,057	24,405	24,320	24,142
Dependent variable mean	0.011	0.011	0.011	0.011

Notes: This table shows descriptive OLS regressions based on the doctor sample (limited to online consultations) merged with drop-in consultations limited to the same restrictions as described for the doctor sample. We compare the nurse-directed online doctor patients to patients who were directed to online doctors without a nurse (‘"drop-ins"’). The controls for the online doctor sample are based on the nurse meeting and on the doctor consultation for the drop-in patients. Fixed effects include year × month, four-hour blocks, day of the week, and the clinic where the patient was registered. Patient characteristics include age,age, age squared, and indicators for female, born outside Sweden, second-generation immigrant, born outside EU15 and Scandinavia, married, divorced, ineligible to marry, employed (ages 16-74), and not of working age, as well as indicators for prior patient comorbidity and vulnerability. The ICD-10 code for the online drop-in sample is based on the nurse meeting, while the ICD-10 code for the drop-in consultations builds on the doctor consultation. Robust standard errors are in parentheses.

Table A11. Details of Taxpayer Costs (SEK)

	Cost estimates (SEK)	How cost is calculated	Year	Source
Primary care in-person doctor consultation	2,002	Average cost in 2019/2020 (National estimates)	2019/2020	Vård- och omsorgsanalys (2022)
Primary care online doctor consultation	500	Out-of-region compensation for digital care services	2019/2020	Vård- och omsorgsanalys (2022)
Primary care online nurse consultation	275	Recommendation on remuneration for digital healthcare services to healthcare providers.	2020	Sveriges Kommuner och Regioner (SKR)
Primary care in-person nurse consultation	614	Average cost in 2022 (Scania Region of Sweden)	2,022	Vård- och omsorgsanalys (2022)
Prescription	196	Average cost to the region for a prescription among patients in our analysis sample	2019/2020	Own calculations using data obtained from Socialstyrelsen (National Board of Health and Welfare)
Emergency Department visit	3,494	The amount is calculated as the weighted average cost of an urgent care visit and an emergency department visit, with weights based on their frequency in our sample.	2019/2020	Södra Regionsvårdsnämnden (2020) and egion Stockholm (1177.se)
Specialist visit	3,931	The median cost of a doctor's visit across various specialties in Northern Sweden	2018	Norra sjukvårdsregionförbundet (NRF)
Hospitalisation	28,487.5	There are four cost components of hospitalization costs: the one-time admission fee (Intagning, vårdavdelning), admission costs (including doctor consultations)(Intagning, läkarinsats), daily medical care costs (including doctor consultations)(Läkarinsats per vårddag), and daily nursing care costs (Omvårdnadsdag). The average length of stay is three days, so costs (excluding initial admission-related expenses) are multiplied by three. Since care intensity varies across units, the final cost is calculated by taking the median total cost for a three-day hospitalization across all units.	2020	Own calculations using price list obtained from Södra Sjukvårdsregionen Southern Healthcare Region of Sweden)

Notes: This table reports taxpayer costs for 2019 and 2020 and adds background information to the cost table (Table 8). The in-person PCP taxpayer costs are estimated in the following way: national average for 2019–2020: 0.5×1838 SEK $+ 0.5 \times 2166$ SEK $= 2002$ SEK. There are no fixed total fees and reimbursement is based on a mix of capitation and some service fee. ED visits are also calculated in a similar fashion: Average costs in Southern Sweden, $(3,963$ SEK $+ 4,020$ SEK$) * 0.5 = 3,991.5$ SEK. Urgent care center visits are asummed to cost the same as regular primary care center visits as per the information provided— "Without an EU card, you must pay the full cost of the care yourself. [...] An appointment with a doctor at a healthcare centre or a visit to the urgent care centre costs SEK 2,093.(**?**)"— therefore we base our analysis on 2019/2020 costs, 2002 sek per visit. See Appendix Section C.5 for more information and sources regarding the cost table.

Table A12. Patient Views on Whether Online Consultation Was a Replacement to In Person

	Patient answered that online consultation is a replacement for an in-person one				
	(1)	(2)	(3)	(4)	(5)
Comorbidity	-0.003				-0.003
	(0.001)				(0.001)
Vulnerability	-0.001				-0.002
	(0.001)				(0.001)
Female		0.011			0.011
		(0.001)			(0.001)
Age 10-19		-0.002			0.001
		(0.001)			(0.001)
Age 20-29		-0.006			0.003
		(0.001)			(0.002)
Age 30-39		-0.003			0.010
		(0.001)			(0.002)
Age 40-49		-0.002			0.010
		(0.001)			(0.002)
Age 50-59		-0.009			0.002
		(0.001)			(0.003)
Age 60-69		-0.021			-0.009
		(0.003)			(0.003)
Age 70 and over		-0.040			-0.029
		(0.005)			(0.006)
In education			-0.000		0.004
			(0.001)		(0.002)
Primary school education			-0.011		-0.008
			(0.001)		(0.002)
Short high-school			-0.016		-0.012
			(0.002)		(0.002)
University (less than 3 years)			-0.004		-0.003
			(0.001)		(0.001)
University (3 years or more)			-0.005		-0.005
			(0.001)		(0.001)
Second-generation immigrant				-0.014	-0.014
				(0.001)	(0.001)
Immigrant (born within EU15 or Scandinavia)				-0.011	-0.009
				(0.002)	(0.002)
Immigrant (born outside EU15 and Scandinavia)				-0.032	-0.030
				(0.001)	(0.001)
Observations	456,498	456,202	434,144	437,023	433,878
Dependent variable mean	0.95	0.95	0.95	0.95	0.95

Notes: This table reports the correlation of patient characteristics to survey responses on whether their online consultation replaced an in-person one. This analysis is based on a larger sample of online doctor consultations with patients not registered at one of the firm's in-person clinics and who were directed to an online doctor (not a nurse) when requesting an appointment. We use this sample because the survey question was only asked in online consultations. Positive answers to the survey are coded as 1, "Don't know" responses as 0.5, and negative responses as 0. Consultations related to chlamydia or COVID-19 are dropped. The baseline for the age bins is children aged 0–9, and for the education variables, the baseline is high school education. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). Robust standard errors are in parentheses.

Table A13. Calculation of Lower Bound on Patient Net Valuation of Online Consultation

A: Defining groups of patients in terms of positive or negative net valuation

Revealed preference score based on follow-ups

This score is -1 if patient followed up with PCP or ED within 7 days of doctor consultation and 0 otherwise.

Survey response score

Patient's satisfaction rating of the consultation	Patient sees the online consultation as a replacement for an in-person consultation		
	Yes	Unsure or unanswered	No
5 or 4	1	1	0
3 or not answered	1	0	-1
1 or 2	0	-1	-1

Sign of patient valuation of online consultations net of in-person consultations

Sign of net valuation	Follow up score plus Survey response score	Share
Positive	> 0	0.30
Negative	< 0	0.16
Neutral	0	0.53

B: Descriptives of Online Patient Groups

	Satisfied	**Unsatisfied**	**Uncertain**
Age	32	34	32
Female	0.49	0.58	0.52
Urban residence	0.86	0.89	0.84

C: Primary Care Doctor Visit Costs for Patients (SEK)

	In-Person	**Online**	**Calculation**
Fees	225	150	Average fees in Stockholm and Scania
Lost income	284.47	73.51	Average hourly income × (travel, waiting and consultation time)
Travel costs	192.23	0	Fuel and parking costs
Total	701.7	223.51	

D: Lower Bound of Net Valuation of Online Doctor Meeting compared to In-Person to the Average Patient

Lower bound on patient net valuation of online consultation

Value = Satisfied Patient Share × (Patient total cost of in-person doctor visit - Patient total cost of online doctor visit)

+ Unsatisfied patient share × (- Patient total cost of online doctor visit)

Value (SEK) =	$0.3044 \times (701.7 - 223.51) + 0.1575 \times (-223.51)$	**110.36**

Notes: This table reports the calculation of a lower bound on mean patient valuation of online consultations net of in-person ones. This bound is calculated as described in detail in Appendix 5.4.2. Panel A defines the indicator, Panel B reports the mean age, gender, and urban status of patients in each category, and Panel C illustrates the lower bound on the net valuation. Patient costs are discussed in Appendix C.5

Table A14. Outcomes for Less Vulnerable Patients (With no ED and no Hospital Visit from Three Years to 30 Days Prior to Nurse Visit)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Doctor booked an in-person revisit within 30 days						
Online consultation D_i	0.11	0.12	0.12	0.13	0.16	0.16
	(0.014)	(0.015)	(0.016)	(0.078)	(0.092)	(0.093)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	2,358	2,259	2,252	2,358	2,259	2,252
First-stage K-P F-statistic				104	68	69
Baseline mean	0.11	0.11	0.11	0.11	0.11	0.11
B. Any emergency department visit within 30 days						
Online consultation D_i	0.0064	0.0044	0.0033	0.047	0.051	0.053
	(0.0076)	(0.0080)	(0.0086)	(0.040)	(0.048)	(0.048)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	2,684	2,566	2,559	2,684	2,566	2,559
First-stage K-P F-statistic				136	94	97
Baseline mean	0.038	0.038	0.038	0.038	0.038	0.038
C. Any hospitalization within 30 days						
Online consultation D_i	0.00095	0.00062	0.00038	-0.0037	-0.0033	-0.0042
	(0.0032)	(0.0034)	(0.0040)	(0.011)	(0.015)	(0.015)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	2,684	2,566	2,559	2,684	2,566	2,559
First-stage K-P F-statistic				136	94	97
Baseline mean	0.01	0.01	0.01	0.01	0.01	0.01

Notes: This table reports coefficients from regressions using the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). The sample is restricted to patients who had no ED or hospital visit three years before the nurse meeting, excluding 30 days prior (57% of doctor sample). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A15. Outcomes for More Vulnerable Patients (With at Least One ED or Hospital Visit from Three Years to 30 Days Prior to Nurse Visit)

	OLS			IV		
	(1)	(2)	(3)	(4)	(5)	(6)
A. Doctor booked an in-person revisit within 30 days						
Online consultation D_i	0.076	0.089	0.10	0.36	0.45	0.50
	(0.016)	(0.017)	(0.018)	(0.12)	(0.15)	(0.16)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,692	1,680	1,674	1,692	1,680	1,674
First-stage K-P F-statistic				44	30	24
Baseline mean	0.11	0.11	0.11	0.11	0.11	0.11
B. Any emergency department visit within 30 days						
Online consultation D_i	0.026	0.025	0.030	0.19	0.21	0.23
	(0.011)	(0.011)	(0.012)	(0.074)	(0.091)	(0.099)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,980	1,962	1,956	1,980	1,962	1,956
First-stage K-P F-statistic				64	45	39
Baseline mean	0.062	0.063	0.063	0.062	0.063	0.063
C. Any hospitalization within 30 days						
Online consultation D_i	0.0067	0.0065	0.0050	0.064	0.070	0.073
	(0.0053)	(0.0050)	(0.0050)	(0.034)	(0.041)	(0.044)
Patient characteristics and fixed effects		✓	✓		✓	✓
Nurse-set ICD group			✓			✓
Observations	1,980	1,962	1,956	1,980	1,962	1,956
First-stage K-P F-statistic				64	45	39
Baseline mean	0.01	0.01	0.01	0.01	0.01	0.01

Notes: This table reports coefficients from regressions using the doctor sample (see the main text for a discussion). The instrument in the IV specifications is the leave-one-out propensity to direct patients to online consultations, π_i. For a description of the variables, please see the main text and appendix (in particular Appendix Table B2). The sample is restricted to patients who had any ED or hospital visit three years before the nurse meeting, excluding 30 days prior (43% of doctor sample). The baseline mean is the mean of the dependent variable for in-person doctor consultations. The first-stage K-P F-statistic refers to the Kleibergen-Paap F-statistic, and robust standard errors are in parentheses.

Table A16. Online's Effect on Taxpayer Costs by Patient Vulnerability (SEK)

	OLS		IV	
	Logs	Levels	Logs	Levels
Less vulnerable patients				
A. Initial consultation costs [N=2,557]				
Online consultation (D_i)	-1.02	-1471.4	-1.03	-1473.6
	(0.0035)	(3.55)	(0.018)	(18.5)
First-stage K-P F-statistic			97	97
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.64	-0.64	-0.64	-0.64
B. Overall treatment costs [N=2,557]				
Online consultation (D_i)	-0.71	-1257.5	-0.75	-1294.2
	(0.026)	(148.0)	(0.13)	(634.4)
First-stage K-P F-statistic			97	97
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.51	-0.39	-0.53	-0.41
C. Overall treatment costs - weighted & adjusted (see note) [N=2,555]				
Online consultation (D_i)	-0.82	-1287.4	-0.81	-1778.0
	(0.033)	(225.9)	(0.17)	(595.8)
First-stage K-P F-statistic			37	37
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.56	-0.41	-0.55	-0.57
More vulnerable patients				
D. Initial consultation costs [N=1,958]				
Online consultation (D_i)	-1.02	-1478.3	-1.06	-1524.3
	(0.0038)	(4.00)	(0.026)	(28.2)
First-stage K-P F-statistic			39	39
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.64	-0.64	-0.65	-0.66
E: Overall treatment costs [N=1958]				
Online consultation (D_i)	-0.63	-1043.7	-0.15	1634.9
	(0.032)	(191.0)	(0.24)	(1543.2)
First-stage K-P F-statistic			39	39
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.47	-0.29	-0.14	0.45
F. Overall treatment costs - weighted & adjusted (see note) [N=1,957]				
Online consultation (D_i)	-0.70	-1196.8	-0.22	3436.7
	(0.055)	(287.3)	(0.35)	(2848.5)
First-stage K-P F-statistic			20	20
($Cost_{online}$ - $Cost_{in-person}$) / $Cost_{in-person}$	-0.50	-0.34	-0.20	0.96

Note: This table reports estimates of the effect of online consultations on taxpayer costs by vulnerability of the patients. A patient is considered more vulnerable if they had any ED or hospital visit from three years to 30 days prior to their nurse meeting. Panels C-F use weights that reflect primary care patient characteristics. These weights are the inverse of the fitted values from a regression that pools both columns of Appendix Table A9 and uses probit to estimate the probability of being in the doctor sample.

Table A17. Tests of Strict Monotonicity and Strict Exclusion and MTE Summary

Outcomes	From	Strict monotonicity/exclusion conditional on: Full set of controls	Significant heterogeneity in MTEs	Only average monotonicity/exclusion
Total consultation duration	Table 5, B	✓	Yes	
Doctor set an informative diagnosis	Table 6, A			✓
Patient received a prescription	Table 6, B			✓
Any ED visit within 30 days	Table 7, A			✓
Any hospitalization within 30 days	Table 7, B	✓	No	
New visit to primary care provider within 30 days	Table 7, C	✓	No	
Doctor booked an in-person revisit within 30 days	Table A7, B			✓

Notes: In this table, we study treatment effect heterogeneity by estimating marginal treatment effects (MTEs). Estimating MTEs allows us to recover heterogeneous treatment effects for observable subpopulations and across patients' unobserved propensity to online consultations. However, the method requires much stronger assumptions than we have elsewhere argued for. To successfully estimate MTEs, we must assume strict monotonicity and exclusion for our instrument; elsewhere, we only assume average monotonicity and exclusion. Therefore, we first present the results of a semi-parametric test for strict monotonicity and exclusion proposed by Frandsen et al. (2023) – the test is defined in relation to an outcome, so we present the results separately for some of our most important patient outcomes. Column 1 shows whether the test fails to reject strict monotonicity/exclusion at the 95% level, conditional on our fixed effects. Column 2 shows whether the test fails to reject strict monotonicity/exclusion at the 95% level, conditional on our complete set of controls, which includes our standard set of fixed effects, demographic controls, a comorbidity indicator, and nurse-set ICD groups. Column 4 indicates whether average monotonicity and exclusion are the only valid assumptions. The Frandsen et al. (2023) test consists of two components: (1) whether the nurse assignment has significant explanatory power and (2) whether the implied treatment outcomes are unreasonably large. The test is implemented through the Stata package *testjfe*. In our implementation, we choose the parametric form through cross-validation (implemented in the package) and specify that the test's two components are given equal weight. Note that the instrument tested through this test differs slightly from the one we use in our analysis. We use an unconditional leave-one-out nurse propensity estimate, whereas the package estimates the propensity without leave-one-out and conditional on the specified controls. Also note that, according to testing by Frandsen et al. (2023), our sample size—and in particular, the number of observed cases per nurse—is on the lower limit for the test to perform accurately. Finally, with the test results in hand, we estimate MTEs for the outcomes that passed. In Column 3, we condense the MTE results by presenting the outcome of a test of observable heterogeneity – which can be interpreted as a test of whether the treatment effect varies across observable patient characteristics. We can not reject that the treatment effects are the same across patient characteristics for any outcome. The MTEs were estimated through the *mtefe* Stata package. In our implementation, we have trimmed 0.5% of the treated and untreated subsamples with the sparsest support. In practice, this means removing some propensity scores close to 0 or 1 with limited common support.

B Appendix: Sample and Variables

Table B1. Sample Restrictions

	Directed in-person	Directed online	Not directed	Total
Cases (each is an episode where a patient is handled by an online nurse)	4,460	50,987	185,674	241,121
	(1.8)	(21.1)	(77.0)	(100.0)
+ Keep only cases with registered patients whose clinics are open	2,993	2,592	8,535	14,120
	(21.2)	(18.4)	(60.4)	(100.0)
+ Remove cases related to chlamydia, breastfeeding, or COVID-19	2,945	2,375	5,112	10,432
	(28.2)	(22.8)	(49.0)	(100.0)
+ Remove cases with infants (children strictly younger than two years old)	2,931	2,327	4,957	10,215
	(28.7)	(22.8)	(48.5)	(100.0)
+ Remove cases associated with clinics that have very few observations	2,924	2,246	4,773	9,943
	(29.4)	(22.6)	(48.0)	(100.0)
+ Remove cases where nurses directed less than 20 patients to a doctor				
→ **Nurse sample**	2,670	1,994	4,243	8,907
	(30.0)	(22.4)	(47.6)	(100.0)
+ Cases directed to a doctor				
→ **Doctor sample**	2,670	1,994		4,664
	(57.2)	(42.8)		(100.0)

Notes: This table shows the number of cases (which are observations in the doctor sample) as we apply sample restrictions for our analysis. The columns show the different case pathways: the nurse can direct the patient to either an in-person or online consultation. In parentheses, we show the percentage split between the pathways. Additionally, each row in the table adds another restriction, with the first row showing the total number of cases, defined as a care episode where an online nurse starts seeing a patient. We first restrict the same to cases with patients registered at one of the primary care provider's in-person care clinics, where the clinic was open for consultation. This requirement ensures that patients have a greater than zero probability of being directed by the nurse to both an online or in-person doctor consultation. A clinic is open for consultations when the first nurse directs a patient there for an in-person visit. We then remove cases where the patient's symptom is related to chlamydia, breastfeeding, or COVID-19 as patients with these symptoms follow special care paths. For the same reason, we remove cases with children strictly younger than two years old (see Appendix Section C.4). We also remove cases associated with clinics that have very few observations, leaving us with cases linked to four clinics in Stockholm and Lund. Last, we only consider cases where the nurse had at least 20 cases after imposing the previous restrictions. With this restriction, we define what we refer to as the "nurse sample". If we further only focus on cases where the nurse directed a patient to a doctor, we are left with 4,664 cases (observations), which we refer to as the "doctor sample".

Table B2. Variable Descriptions

Variables	Descriptions
Outcome variables	
Days between nurse meeting and doctor consultation	This variable denotes the number of calendar days between the nurse meeting and doctor consultation.
Total consultation duration	This variable denotes the total consultation duration in minutes.
Patient-facing part of the consultation	This variable denotes the patient-facing consultation duration in minutes.
Administrative part of the consultation	This variable is made up of the total consultation time minus the patient-facing consultation time in minutes.
Doctor set an informative diagnosis	An indicator that the ICD-10 code is neither in "R" (symptoms such as cough or rash) nor in "Z" (health status factors) categories.
Patient received a prescription	An indicator for patients that received a prescription.
Patient collected prescription	An indicator that the patient in the prescription data picked up a prescription we tied to the primary care consultation.
Doctor gave a specialist referral	An indicator that the doctor consultation resulted in a specialist referral. Due to differences across regions, this outcome is defined only for patients in Stockholm.
Patient satisfaction score	This variable denotes the patient's score of the consultation on a 1-5 scale based on a voluntary post-consultation patient survey. The best score is 5.
Any hospitalization	An indicator that the patient had an inpatient hospitalization.
Any ED visit	An indicator that the patient had an outpatient acute care visit. Our ED definition includes hospital associated EDs, specialty emergency clinics (e.g., psychiatric clinics), as well as minor injury emergency clinics and urgent care center visits. About 70% of the EDs in our sample are hospital associated.
New visit to primary care provider	An indicator that the patient had a second visit to the primary care provider. A new visit is a new meeting or consultation with a nurse or doctor. We have excluded visits with psychologists and visits in which the patient and clinician may have not interacted, e.g., visits labelled "tests ordered" and "prescription renewals".
Patient answered that online consultation is a replacement for an in-person one	This variable denotes the patient's response to a post-online consultation survey asking the patients whether the online consultation replaced an in-person consultation (see e.g., Appendix Table A12). Positive responses are coded as 1,"Don't know" responses as 0.5, and negative responses as 0.
Patient answered satisfaction score	An indicator that the patient gave a response to a post-online consultation survey asking the patients whether the online consultation replaced an in-person consultation. See e.g., Appendix Table A3 for the probability that patients answered the satisfaction survey.
Doctor booked a revisit	An indicator for a (matched) primary care follow-up consultation with the provider booked by the clinician. Revisits can be limited to only in-person or only online revisits. See Appendix Section C.3 for details on the matching.
Patient initiated follow-up visit	An indicator that the patient, rather than a clinician, initiated the primary care follow-up visit with the provider.

Table B2. Variable Descriptions (Continued)

Variables	Descriptions
Shift length (including all breaks)	This variable denotes doctors‘ online or in-person shifts in hours. The start of a shift is the start of the first consultation, and the end of the shift is the end time of the last consultation. All breaks are included. Consultations that extend beyond midnight are removed. See Appendix Section C.4.2 for details on the definitions of shifts.
Shift length (excluding all breaks)	This variable denotes doctors‘ online or in-person shifts in hours. The start of a shift is the start of the first consultation, and the end of the shift is the end time of the last consultation. All breaks are removed. Consultations that extend beyond midnight are removed. See Appendix Section C.4.2 for details on the definitions of shifts.
Average employment status	This continuous variable ranges from 0 to 1 and denotes the average employment status across the years 2020, 2021 and 2022, for patients aged 18-64 in 2022. It is calculated as the mean of up to three dummy variables (1 for employed, 0 for non-employed). For most meetings, we use the mean of November 2020, 2021, and 2022, but for meetings held from 1 October 2020 onwards, we use the mean of November 2021 and 2022.Data for 2023 is unavailable as our dataset only extends through 2022.
Taxpayer costs	
Initial consultation costs	This variable represents the costs of the initial nurse meeting, the follow-up online or in-person doctor consultation, and the associated prescription costs attributed to the taxpayer.
Overall treatment costs	This variable represents the costs incurred after online or in-person doctor visits occurring within 30 days of the nurse meeting attributed to the taxpayer. These costs include initial consultation costs plus indicators for any visits to the emergency department, specialists, or urgent care centres, as well as any hospitalization and prescription costs. Appendix Table A11 presents the details of each of the mentioned cost items
Fixed effects	
Time of day, 4h blocks	Indicators for four-hour time windows: 12am-4am; 4-8am; 8am-12pm; 12pm-4pm; 4pm-8pm; 8pm-12am during which the nurse meeting was held.
Day of the week	Indicators for the days of the week (e.g., Monday, Tuesday) during which the nurse meeting was held.
Provider center	Indicators for each of the four provider centers and non-registered patients.
Year×month	Indicators for particular months, e.g., September 2019 during which the nurse meeting was held.
Time period with Low COVID-19 spread	An indicator for low COVID-19 spread, which is the case for consultations before March 11, 2020, and between July 6, 2020 and October 24, 2020.

Table B2. Variable Descriptions (Continued)

Variables	Descriptions
Patient characteristics	
Female	An indicator for the gender of the patient. Female patients are denoted by 1, male patients by 0.
Age	This variable denotes the age of the patient in 2018. An interaction of age is additionally included in the controls.
Urban residence	An indicator for whether the patient resides in an urban area as defined by the Swedish Agency for Economic and Regional Growth (Tillväxtverket).
Born outside Sweden	An indicator for whether the patient is a first-generation immigrant, that is, the patient was born outside of Sweden.
Second-generation immigrant	An indicator for whether the patient is a second-generation immigrant born in Sweden, whose both parents were born outside Sweden.
Born outside EU15 & Scandinavia	An indicator for whether the patient was born outside the EU15 countries and Scandinavia. EU15 refers to the time when the EU had only 15 members. See also Appendix Section C.1.2.
Married and Divorced	Indicators for civil status of the patient in 2018 and if the patient is eligible to marry or divorce in 2018. Married or divorced is denoted by 1, not married or divorced by 0. Patients strictly below 18 are not eligible to be married or divorced. See also Appendix Section C.1.2.
Employed (ages 16-74)	An indicator for employment; it is equal to 1 for those aged 16-74 who work and 0 for those who do not work, regardless of their age.
Not of working age	Indicator for whether the patient is of working age. Patients strictly younger than 16 and strictly older than 74 are not considered of working age. See also Appendix Section C.1.2.
Comorbidity	An indicator for whether the patient had any comorbidity from 2013-2018 in our specialist (inpatient and outpatient) data, based on the Elixhauser comorbidity index (see Appendix Section C.6.1).
Vulnerability	An indicator of previous serious healthcare utilization. Patients are classified as "more vulnerable" if they had at least one hospitalization or ED visit between 31 days and three years before meeting the online nurse; otherwise, they are "less vulnerable." Vulnerability is denoted by 1 if the patient is more vulnerable and 0 if the patient is less vulnerable.
Socioeconomic characteristics	
Education	This variable is based on the education the patient had in 2018. It is presented in two formats, either as an indicator or as a factor variable. The indicator "University educated" is defined only for patients age 23 and over to ensure they have had the time to complete their education (e.g., in Appendix Table 2, panel B). The factor variable includes "In education" defined for individuals strictly below age 16, and other education categories for patients aged 16 and over (e.g., in Table A12). See also Appendix Section C.1.2.
Annual income	This variable denotes the total individual annual income in 2018 for patients age 21 and above. See also Appendix Section C.1.2.

Table B2. Variable Descriptions (Continued)

Variables	Descriptions
Nurse-related variables	
Nurse-set ICD group	This categorical variable uses the letter level disease group category of the ICD-10 code set by the nurse who redirected the patient to the doctor consultation in the doctor sample. ICD-10 code letters that occurred less than 30 times are included in category "Other."
Nurse "mistake" share	This variable focuses on the patients that the nurse did not direct to a doctor consultation. The mistake share is the fraction of those non-directed patients who visited an ED or were hospitalized within 30 days of the nurse meeting. This variable is computed as the leave-one-out mistake share at the nurse level and standardized.
Nurse characteristics	
District nurse	An indicator for the nurse being specialized as a district nurse, which is a 1.5 year additional training on top of the nurse education. A district nurse specialty for a nurse is similar to a general practice specialty for a medical doctor, as well as having an additional emphasis on organizing primary care work.
Speaks non EU15 languages	An indicator for whether a nurse speaks one of the fifteen EU languages
Experience within provider	This variable is a count of the meetings within the provider the nurse has before their earliest meeting in our sample.
Years since graduation	This variable denotes the difference between the meeting year and the clinician's graduation year, capturing the nurse's overall experience beyond the provider.
Urban residence	An indicator for whether the nurse resides in an urban area as defined by the Swedish Agency for Economic and Regional Growth (Tillväxtverket).
Doctor characteristics	
Graduated from a top medical school	An indicator for whether a doctor obtained their degree from a top medical school in Sweden.
Is a GP	An indicator for whether a doctor is a general practitioner
In specialist training	An indicator for whether a doctor is training to become a specialist.
Completed specialist training	An indicator for whether a doctor has completed their specialist training.
Seniority and Specialty	A set of indicators for whether the doctor is a general practitioner, is a specialist, or in training to become a specialist.
Speaks non EU15 languages	An indicator for whether the doctor speaks one of the fifteen EU languages
Urban residence	An indicator for whether the doctor resides in an urban area as defined by the Swedish Agency for Economic and Regional Growth (Tillväxtverket).
Experience within provider	This variable is a count of the meetings within the provider the doctor has before their earliest meeting in our sample.

C Data Appendix

C.1 Data Sources

Our analysis is primarily based on consultation-level data from the start of 2019 to the end of 2020 from a Swedish private primary healthcare provider to which we refer as "the firm" or "the provider". The firm offers in-person and online medical consultations to patients at the primary care level. For all patients, we obtain matched administrative individual-level panel data from Statistics Sweden's Integrated Database for Labour Market Research (LISA) from 2013 to 2022. Visit-level healthcare panel data for all specialist care between 2013 and 2023 come from the Swedish National Board of Health and Welfare (Socialstyrelsen), and they include all inpatient and outpatient care (e.g., a hospital stay or a specialist visit) except primary care, since primary care data (other than prescriptions) are not collected nationwide in Sweden. Finally, prescription collection data from 2013 to 2023 are obtained from Socialstyrelsen as well. These data include picked-up prescriptions from all types of healthcare (i.e., inpatient, outpatient, and primary care).

All datasets are proprietary and confidential and were accessed after obtaining approval from the Stockholm Regional Ethics Council (2018, number 2108/2318-31) and the Swedish Ethics Authority (2019, number 2019-06062). Additionally, Statistics Sweden and Socialstyrelsen carried out their own confidentiality assessments before approving the sharing of data. Statistics Sweden matched all datasets, anonymized the personal identifiers, and then only shared an anonymized version of the data.

C.1.1 Primary Care Provider Data

The firm's above-mentioned data on primary care online and in-person consultations form the backbone of the data we analyze. The firm began operating in 2016 as an online healthcare provider, but since 2019, it has extended its offering to include in-person doctor consultations. These consultations were rolled out at different times for different locations, with services first offered in Lund (a city in the Scania Region) and then expanded to different areas in and around Stockholm. In our analysis, we rely on the observed opening date, which is the date of the first logged in-person doctor consultation at the clinic. This allows us to focus on patients who are "at risk" of being directed to either in-person or online consultations.

For each patient meeting or consultation, we have data on the exact the exact start time, the type of meeting (e.g., a nurse meeting or a doctor consultation), whether it was in person or online, and what the patient fee was. Any patient in Sweden can use the firm's online care, regardless of which primary care provider they are registered with for in-person primary care. Patients can change their registered clinics at will without incurring a fee.

The clinics that patients can register with include clinics of both private and public primary care providers. Private providers contract with the public health insurance, so patients pay the same low fees for a given service irrespective of whether they use a public or private provider. For the patients who registered with the firm we study, we know which in-person clinic each patient chose to register with.

The data also include information on the duration of meeting and consultations, detailing both the patient-facing time spent by the clinician (whether a nurse or doctor) and the total duration of the consultation; the difference between the two is due to administrative work related to that meeting or consultation. We also have data on the provider's internal code for the symptom that the patient provides when initially seeking care through the provider's mobile app. This app is the primary channel for seeking care.

Finally, we also know the consultation "type"; this is an internal categorization of consultations depending on whom the patient met (e.g., "nurse meeting" or "psychology meeting"), whether it was booked ahead of time (e.g., "drop-in" or "doctor booked revisit"), and its purpose (e.g., "prescription renewal" or "test ordered"). We are primarily concerned with the sequence of meetings and consultations starting with a "nurse meeting" and resulting in a "doctor booked revisit" (booked by the nurse; see Appendix Section C.3 for more details).

For the consultation outcomes, we have data on the clinician's diagnosis and whether the patient received any prescription. The patient diagnosis is in the form of an ICD-10-SE code with four to five characters. Because we do not have data from the provider on what was prescribed, we use the prescription registry data from Socialstyrelsen. For the Stockholm-based clinics, we also have data on whether the doctor referred the patient to a specialist.

C.1.2 Demographic and Socioeconomic Data

To complement the primary care data, we use demographic and socioeconomic micro-data on patients from Statistics Sweden, drawn from the Integrated Database for Labour Market Research (LISA). This panel dataset provides information on individual annual income, educational attainment, municipality, immigration background, employment status, and civil status (married, unmarried, divorced, widowed). The variables are provided at the patient-year level. Income is annual, working status is measured at the end of October each year, education attainment is measured at the end of the year's spring semester, and immigration background is constant across years. The remaining variables are measured at the end of each year.

To ensure that the control variables are predetermined, we use the 2018 values for the demographic and socioeconomic variables; where there were missing values for 2018, we instead use the 2017 values (and for education, go back to 2016 to fill more missing values).

The only variable that we measure on a rolling basis is patient age, for which we use the age as recorded at the date of each nurse meeting.

Demographic controls in the main regressions include patient gender, patient age, indicators for migrant background, married and divorced dummies, working dummy, and indicators for age ineligibility to be married or divorced (below age 18) or working (below age 16 and above age 74). Table 1 provides summary statistics of these controls as well as of other variables.

C.1.3 Specialist Care Data

Non-primary healthcare data are obtained from Socialstyrelsen (The National Board of Health and Welfare) and cover 2013–2023. These data are divided into inpatient and outpatient care. Inpatient care covers cases where patients were hospitalized. Outpatient care includes ED visits and other non-primary care visits to clinics, such as planned specialist consultations.

The inpatient and outpatient datasets contain the diagnoses that the patients were given at the healthcare appointment in the form of ICD-10 diagnostic codes, with a precision of three characters. Both datasets provide the visit date and for hospitalizations also the discharge date.

C.1.4 Prescription Data

The prescription data, spanning 2013–2023, are obtained from Socialstyrelsen (The National Board of Health and Welfare) and include all the prescriptions that patients collected during this period. Each collected prescription is recorded on a separate observation line, meaning that multiple observations may reflect a single pharmacy visit. Additionally, the dataset provides information about the prescribing organizations. This includes codes for the prescribing clinic, the type of care from which the prescription was issued (e.g., psychiatric, primary care, or pediatric), and the specialization of the prescribing clinician.

C.2 Clinician Data

In addition to the patient data, we have data on clinicians from 2016—2022, which was provided by Statistics Sweden. The data on each clinician (i.e., nurse or doctor) consists of clinician background information such as the year and municipality where the medical or nursing license was obtained, and the municipality where the clinician resides. We use this data to define the characteristics of nurses and doctors described in Table B2.

We also have data about clinicians from the healthcare firm's records, including the specialization of the nurse and doctor, and for doctors, the seniority level such as whether they are in specialty training or have already received their specialist qualification.

C.3 Matching Nurse Meetings to Doctor Consultations

Here we describe the method we use to match nurse meetings to subsequent doctor consultations. We start by considering each doctor consultations that was booked by a clinician, following a direction made during an initial (originating) meeting with a clinician at the firm (online or in person). This originating meeting can be of any type, e.g., nurse meeting, drop-in, or psychologist visit. When matching to an originating meeting, we consider only meetings in the 30 days before the doctor consultation.

We use two strategies to find the initial meeting, where the first strategy takes precedence over the second. In the first strategy, we match the doctor consultation with a preceding meeting that has the same "symptom" label specified by the patient when seeking care. This label usually follows the patient automatically in a care episode with multiple visits. However, sometimes the symptom is relabeled in clinician-booked follow-ups as a "revisit" or "phone triage". In these cases, we use our second strategy where we allow the clinician-booked follow-up visit to match the closest (in the sense of timing) preceding meeting with the firm in the preceding 30 days.

Our matching strategy allows for multiple potential matches. As mentioned, matches using the first strategy are always prioritized over those found using the second. But two other conflicts may arise. First, a doctor consultation may match with more than one potential originating meeting in the first strategy. To resolve this issue, we prioritize matches in which the window between the clinician-booked follow-up visit and the originating meeting is as short as possible. Second, two different doctor consultations may match with the same preceding meeting. In such cases, conflicts are resolved by prioritizing earlier clinician-booked follow-ups over later ones, which ensures that the matched meetings and consultations are in a chronological sequence.

C.4 Defining the Samples

C.4.1 The Doctor Sample and the Nurse Sample

Appendix Table B1 shows how our two primary samples are created. We define a "patient case" (or "case") as an online meeting between patient i and nurse j and its resulting "treatment" (either an online or in-person doctor consultation or no consultation). Our analysis focuses on patient cases from 2019-2020, each of which starts with an online nurse meeting. As the first row of the table shows, there were 241,121 cases in total. We narrow down this set to focus on cases that we can analyze using the strategy laid out in the paper.

To do so, we exclude "drop-in" visits where patients are directly matched to doctors when seeking care. Visits are also excluded if the healthcare firm has categorized them as pertaining to a different care path. Specifically, these are visits to psychologists; prescription renewals, which can take place without a patient meeting; visits where patients were given automatic recommendations by the system for pediatricians or doctors speaking specific languages, or for a revisit; consultations where patients booked appointments with specific doctors; consultations where patients chose specific appointment times instead of the next available time slot; and visits for ordered tests.

The table also shows how we sequentially construct our main samples. We impose five conditions on the cases. The first three ensure that in every case we study, the patient is "at risk" of being directed to an in-person consultation as well as an online one. The first removes patients not registered with this firm as their primary care provider, who generally cannot access in-person care at the firm's clinics. We also remove cases with registered patients that took place before their clinic has opened for in-person consultations. We also exclude patients with a few specific conditions or symptoms (chlamydia, breastfeeding issues, and COVID-19) as well as infants (children strictly younger than two at the time of meeting the nurse). These patients follow care pathways that differ from those outlined in Figure 1. For chlamydia cases, patients were sent a home test, and in breastfeeding-related cases, patients were directed to a breastfeeding consultant rather than to a doctor. COVID-19 cases were managed through pathways that changed over time, adapting to shifts in testing availability and changing guidelines during the COVID-19 pandemic. The final conditions are imposed to limit our sample to cases where we have sufficient statistical power. We refer to the 8,907 resulting cases handled by 62 nurses as the "nurse meeting sample" in Figure 1 (or "nurse sample" in brief).

In the last row of Appendix Table B1, we further restrict ourselves to the cases that resulted in either in-person or online doctor consultations. This leaves us with 4,664 cases, referred to as the "doctor consultation sample" in Figure 1 (or "doctor sample" in brief).

C.4.2 Doctor Shift Sample

To study doctors' consultation speed as we do in Appendix Table A6, we define a larger sample of doctor consultations that took place both in person and online, and involved unregistered patients as well as registered patients. Our motivation for creating this larger sample is that during online shifts, doctors work not only with the patients in our main analysis sample and also (mostly) with patients outside of that sample. To study the doctors' speed, we need to consider all the patients they consult. We exclude from this sample prescription renewals, which are almost all (over 99.9%) online and do not involve meeting patients. We also exclude the ordering of tests, since we have no record of their start or end time.

We further remove 13,909 consultations (1.1%) where: (i) durations were missing, (ii) the consultations started on one day and ended after midnight (since we use calendar days to define shift limits), or (iii) the doctors had both in-person and online consultations on the same day. To avoid unrealistically short durations (or the few measured with with negative durations), we winsorize the minimum consultation duration to the first percentile of the duration time distribution (2.58 minutes). Ultimately, the "doctor shift sample" is based on 1,269,163 individual doctor consultations.

These consultations are then collapsed into what we define as "shifts", where each shift involves an individual doctor working on one calendar day. Each shift begins at the start of the first consultation and ends at the end with the time of the last consultation. The times in between patient consultations are defined as breaks and are cleaned to have only positive values. Breaks longer than one hour make up 1.63% of the sample. We do not know whether these intervals represent actual breaks, waiting time for the next patient, work on prescription renewals or similar, or periods when the doctor is not working. We therefore define two different shift measures that either include all inter-consultation times or excludes them. Each shift is either fully online or fully in person. The doctor shift sample includes 2,046 in-person doctor shifts and 76,367 online doctor shifts involving a total of 731 doctors. Of these, 127 in-person shifts and 306 online shifts each consist of only one consultation.

C.4.3 Scania Primary Care Sample

We have data on all primary care visits, both private and public, in Scania, a region in southern Sweden where 13% of the country's population resides. These data cover the period from 2013-2019. To restrict the analysis to doctor consultations, we drop meetings that are not with a doctor, are conducted over the telephone (not online), or are marked as acute.[27] To get as close as possible to the doctor sample restrictions (see Appendix Table B1), we also limit ourselves to consultations where the patients were at least two years old. The resulting "Scania sample" is used in Appendix Table A9 to compare the representativeness of the doctor sample to a wider sample of primary care consultations with doctors. The ICD-10 codes in this sample are based on the PCP consultations with doctors, while the ICD-10 codes in the doctor sample are based on the initial nurse meetings.

C.5 Cost Calculations

We consider two different types of costs: those incurred by the taxpayer and those incurred by the patients. Taxpayer costs consist of costs to the insurer, in our case the public health insurance. In Table 8 and Appendix Table A16, we approximate the taxpayers' costs for

[27] Only around 1% of the consultations in the Scania data are marked as acute.

online and in-person doctor consultations and their downstream outcomes. The costs are denoted in Swedish krona (SEK); the average exchange rate in 2020 for SEK to USD is 1 SEK = 0.11 USD (Riksbank 2024).

The taxpayer cost estimates are drawn from the sources listed in Appendix Table A11. For the costs of online consultations, we use the public payers' recommended reimbursement for online doctor consultations in cases where the consultation was not under capitation. This was 500 SEK in 2019 (Vård- och omsorgsanalys 2022, p. 127) as well as in 2020 (Södra sjukvårdsregionen 2020, p. 91). The taxpayer costs for prescriptions are included in our prescription dataset provided by Socialstyrelsen. We compute the average cost of a prescription within our timeframe and use it as the prescription cost in our regressions. We estimate the costs of the remaining items using the available price lists from the administrative regions' (the healthcare payers) reports. The cost of an ED visit is calculated as the weighted average of an urgent care visit cost and emergency department visit cost, and these costs in turn are based on the estimates from the report (Södra sjukvårdsregionen 2019, 2020, p. 47). Costs are weighted by visit frequency in our sample (0.75 for emergency department visits and 0.25 for urgent care). An ED visit costs 3,991.5 SEK and an urgent care visit 2,002 SEK, resulting in a weighted average cost of 3,494 SEK. Specialist visit costs are estimated using the median cost from the Northern healthcare region's 2018 price list, and hospitalization costs are calculated by summing the medians of the average costs over the four components of hospitalization—admission costs: the one-time admission fee, admission costs, daily medical care costs times average length of stay and daily nursing care costs times average length of stay. All these cost items were provided by the Southern Healthcare Region. Admission costs and daily medical care costs also include doctor consultation costs. The average length of stay is three days in our sample.

We also estimate patient costs and use them in Appendix Table A13. The average fee for a primary care visit with a doctor is taken from Region Stockholm and Scania because the majority of our sample patients are located in these regions. Patients between the ages of 18 and 85 (73.49% of our sample) have to pay a co-pay/visit fee in Stockholm Region, while patients between the ages of 20 and 85 (67.67% of our sample) have to pay a fee in Scania.[28] The average percentage of paying patients over these two regions is 70.58%. The fee for paying patients was 225 SEK in person (the mean of 250 SEK for Stockholm and 200 SEK for Scania) and 150 SEK online (the mean of 100 SEK for Stockholm and 200 SEK for Scania) in 2023.

The patient time cost estimates are the product of patient time spent in (or getting to and from) a consultation, multiplied by the mean hourly wage of private sector workers in

[28]Patients who have reached the deductible ceiling do not have to pay until the next year, but we do not consider this.

Sweden: 178.5 SEK/hour in January 2020 (SCB 2024). The waiting time in the doctor's office for in-person consultations is 30 minutes, based on Ekman (2018), and 15.3 minutes for online, based on our full data with registered and unregistered patients. The online waiting time is restricted to online doctor consultations without missing values, negative values, or waiting time values above 60 minutes. The meeting durations are 32.2 minutes for in-person and 9.4 minutes for online consultations as calculated using the estimates from from panel C of Table 5.

Transport costs include commuting by car, public transport, biking, and walking, along with the respective probabilities of each mode being chosen (Rosberg and Enström 2019). We use the average time and frequency of commuting to work to estimate the likelihood of a patient using a particular mode of transport to the doctor's office. The commuting costs by car for primary care are based on fuel costs, transport fees, the commuting time, and parking fees. The average time to primary care is 11.71 minutes one way and 23.42 minutes round trip after including frequencies of commuting types. We assume a mean tempo of 60km/h for the fuel cost and a fuel use of 0.5 liter/km. The fuel price of 16.03 SEK/liter is taken from January 1, 2020 (Circle K 2024), and the fuel cost is calculated for a 20-minute drive to the doctor and back. We calculate the fuel costs and multiply it by the probability of 57% that patients use their car to get to work. Parking fees close to the city center in Stockholm during the day were 15 SEK/hour in 2020 (Stockholms stad 2020). We weight these fees by the patient-facing consultation time and multiply them by the probability that patients would go by car.

We assume it takes 5 minutes for patients to find a parking spot before the doctor's appointment and 5 minutes after (including the walking distance to the doctor's office). The transport fee for Stockholm in 2020 is a single ticket for 37 SEK, valid for 75 minutes (Trafikförvaltningen 2020), which we multiply by the probability that the patient takes public transport to the appointment (24%). We also assume that patients do not buy two tickets due to time constraints for their appointment.

The total cost to a patient of an in-person doctor consultation is 714.2 SEK, including 99.42 SEK for travel time, 284.47 SEK for meeting time, and 192.23 SEK for journey costs. For online meetings, the cost is 147.09 SEK, consisting of 73.51 SEK for meeting time and the fees.

We also calculate heterogeneous costs for more or less vulnerable patients in Appendix Table A16. The cost estimates for these patients are calculated in the same way as those in Table 8 but instead using probabilities from Appendix Table A15 for the follow-ups for more vulnerable patients and from Appendix Table A14 for less vulnerable patients.

C.6 Construction of Variables

C.6.1 Patient Comorbidity

Throughout the paper, we often control for whether a patient has any important comorbidity. This means that they have one of several diagnoses from prior healthcare in the national registries maintained by Socialstyrelsen.[29] The comorbidities are defined as 31 families of ICD-10 diagnosis codes. We assign patients a comorbidity if they were diagnosed with any of the ICD-10 codes in each family during any inpatient or outpatient care appointment or hospitalization between 2013 and 2018.

The list of 31 comorbidities (ICD-10 code families) is: Congestive Heart Failure; Cardiac Arrhythmias; Valvular Disease; Pulmonary Circulation Disorders; Peripheral Vascular Disorders; Hypertension, Uncomplicated; Paralysis; Other Neurological Disorders; Chronic Pulmonary Disease; Diabetes, Uncomplicated; Diabetes, Complicated; Hypothyroidism; Renal Failure; Liver Disease; Peptic Ulcer Disease Excluding Bleeding; AIDS/HIV; Lymphoma; Metastatic Cancer; Solid Tumor Without Metastasis; Rheumatoid Arthritis/Collagen Vascular; Coagulopathy; Obesity; Weight Loss; Fluid and Electrolyte Disorders; Blood Loss Anemia; Deficiency Anemia; Alcohol Abuse; Drug Abuse; Psychoses; Depression; Hypertension, Complicated.

This list of comorbidities is taken from the Stata command *elixhauser* written by Stagg et al. (2015). However, we have adapted their code to our setting. Our data on patients' medical records from outside of the online firm only contain three-character ICD-10 codes while the *elixhauser* command is written with four-character ICD-codes in mind. Therefore, we expand the families of ICD-10 codes to include the three-character parent of any four-character code contained in the implementation of Stagg et al. (2015). For example, the family Pulmonary Circulation Disorders was defined by Stagg et al. (2015) as the ICD-10 codes "I26", "I27", "I280", "I288", and "I289"; in our implementation, the family is defined by the ICD-10 codes "I26", "I27", and "I28". Our definition will include a broader set of diagnoses. Another example is that while in Stagg et al. (2015), the family Chronic Pulmonary Disease would specify the four-character code J684 "Chronic diseases in the lungs caused by gases, steam, or chemicals", in our implementation, the Chronic Pulmonary Disease family will contain any "diseases in the lungs caused by gases, steam, or chemicals" (J68). The most common comorbidities in our sample are Depression, Alcohol Abuse, Drug Abuse, Chronic Pulmonary Disease and Cardiac Arrhythmias which make up 36% of the comorbidities.

[29] In other words, we do not measure comorbidities assessed in primary care, which are held separately by the 21 regions and not in the national registries.

C.6.2 Patient Satisfaction with Online Care

Patient satisfaction with online is measured using patient survey responses as well as their "revealed preference" actions, as we report in Appendix Table A13.

The patients' survey responses are based on how they respond to two questions. First, how they rate the quality of the consultation on a scale from 0 to 5, which can be left unanswered. Second, how the respond when asked whether they agree that the online consultation was a replacement to an in-person consultation, where the possible answers are Yes, No, and Don't Know, and again the patient does not have to answer.

The "action" component of satisfaction measures whether the patients followed up with primary care providers or EDs within the seven days after the online consultation.

We classify patients as having "positive" satisfaction if (i) they did not follow up and (ii) either ranked the meeting quality highly and did not say that it was not a replacement for in-person; or did not rank the meeting poorly and said that it was a replacement for online. Patients with positive satisfaction make up 30.44% of the doctor sample.

We classify patients as having "negative" satisfaction from online if they belong in one of two groups. The first includes patients with follow-ups, except those who (i) gave a high rating and did not answer no to replacement; or (ii) said that the consultation was a replacement for and did not rate the meeting poorly. The second group includes those who did not follow but either: (i) rated the meeting poorly and did not say that it was a replacement; or (i) said the meeting was not a replacement and did not rate it highly. Patients with negative satisfaction from online make up 15.75% of the doctor sample.

Lastly, we classify patients as having "neutral satisfaction" if they are neither positive nor negative about online. This group makes up 53.81% of the doctor sample.

C.6.3 Representativeness Weights

To make our cost estimates more representative of the broader population of Swedish primary care cases, we define sample weights using observable characteristics, comparing the doctor sample to the Scania sample. The Scania data contain all primary care doctor consultations in the Scania region of Sweden during 2019 and 2020, and we restrict it in ways similar to our main data. We append the doctor sample to the Scania dataset and remove the potentially double counted online care meetings from the Scania data to avoid double counting. We then estimate a probit regression of an indicator that a case is in our doctor sample on the following patient characteristics: age, gender and urban residence.[30] After the estimation, we take the inverse of the fitted values for each observation, divide it by the sum of the

[30] We do not use ICD codes here as that would possibly put large weights on categories with very few observations, which would reduce the precision of the weighted regressions.

weights in our sample and scale it to the total Swedish population in 2020 (10,379,295), as reported by Statistics Sweden.

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