In Sickness and In Health: Motivating Improved Healthcare Using Holistic Patient Contracts

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Abstract

We investigate whether restructuring the implicit contract between primary care doctors and patients can improve healthcare delivery and outcomes. In most healthcare systems, the doctor-patient relationship is organized around reactive care: providers respond to patient-initiated complaints rather than systematically managing underlying health, leading to inefficiently delayed diagnosis and treatment. We study an intervention that shifts this relationship, having doctors and chronically-ill patients jointly develop explicit "care plans" specifying mutual responsibilities and proactive health goals, without any formal enforcement mechanism. Using a randomized trial across the universe of Estonian primary care clinics using national health insurance records, we show that this relational contracting intervention increased screening, diagnosis, and treatment of chronic conditions by approximately 10%, and, among patients earlier in their disease progression, reduced annualized mortality by approximately 20%. Effects

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are concentrated precisely where theory predicts: among patients with conditions that are difficult to self-detect but which are highly responsive to early treatment. Patients at higher risk, by contrast, showed no mortality declines. The results demonstrate that health systems can achieve substantial gains by formalizing proactive care relationships, even without top-down accountability mechanisms, and suggest that relational contracting approaches may be broadly applicable to improving frontline service delivery.

1 Introduction

Effective primary healthcare requires high-quality curative care, but as the global burden of chronic and non-communicable diseases grows, it increasingly requires the early and effective identification and management of underlying long-term health issues between acute care episodes (Nishtar et al., 2018). However, the implicit cornerstone of the provider-patient relationship in primary healthcare has been the responsiveness of healthcare providers to patient signals of acute ill-health. A well-known problem that this creates is the lack of attention to prevention or early detection of conditions that are not yet presenting acute symptoms (Kenkel, 2011; Fineberg, 2013; Rose, 1992).[1] Inadequate prevention and delayed detection lead to worse health for patients, higher costs for healthcare systems, and foregone economic benefits for society, yet they remain neglected by multiple actors within the health system.[2]

The care relationship between doctors and patients may offer a critical opportunity for intervention in situations where timely identification and management of underlying health issues requires a more personal and structured understanding of an individual patient's overall health.[3] For some conditions, optimal treatment frequently begins well before a patient raises acute symptomatic concerns or even experiences notable discomfort. An under-researched approach to improving primary care is reshaping the "relational care contract" between provider and patient, in order to improve the joint effort equilibrium in early detec-

[1]Patients covered by health insurance may underinvest in prevention since they do not bear the full financial costs of future treatment (Cutler and Zeckhauser, 2000; Zweifel and Manning, 2000; Fang and Gavazza, 2011; Zhou et al., 2017). Providers may neglect prevention if they are compensated more for curative procedures than for preventive actions (Chandra, Cutler and Song, 2011; Alexander, 2020).

[2]Policymakers seek to avoid this neglect of prevention in several ways. First, primary care providers may be compensated in ways which shift focus away from curative care, such as capitation, or may be directly incentivized, such as through quality bonuses, to provide specific preventive services (Kane et al., 2004; Town et al., 2005). Intermediaries such as insurance companies or health maintenance organizations may also be financially incentivized to prioritize prevention in their patient population through per patient rather than per procedure payment or reimbursement schemes. However, despite these efforts healthcare systems continue to significantly underprovide prevention services (Hanson et al., 2022), and more broadly allocate care across patients inefficiently (Chandra and Staiger, 2020).

[3]Recent evidence has emphasized the importance of the quality of service delivery by health providers (Das and Hammer, 2005; Doyle, Ewer and Wagner, 2010; Currie and MacLeod, 2017; Chen, 2021; Card, Fenizia and Silver, 2023; Das and Do, 2023; Posso, Saravia and Tamayo, 2024), specifically in the areas of effective doctor-patient communication (Freimuth and Quinn, 2004; Schoenthaler et al., 2012; Young et al., 2017; Becker et al., 2021), diagnosis (Abaluck et al., 2016; Currie and MacLeod, 2020; Chan, Gentzkow and Yu, 2022; Conner et al., 2022), and supporting patient adherence to relevant prescription medications (Iizuka, 2012; Curtis et al., 2013; Koulayev, Simeonova and Skipper, 2017; Simeonova, Skipper and Thingholm, 2024). High-quality evidence on experimental and causal interventions to stimulate relational behaviors to improve service delivery is scarce (Rowe et al., 2018).

tion (by the provider) and prevention (by the patient). For example, the joint co-development of an explicit contract for 'holistic' care between doctors and patients could enumerate proactive health monitoring, check-ins, medication adherence, and lifestyle modification. Such a relationship might encourage more effective communication, planning and prevention between doctors and patients, inducing greater screening, diagnosis, and treatment, before a patient would self-identify as being in acute ill-health.[4]

It may be natural to wonder why, if relational contracting is clearly beneficial, it is not already widely implemented. In many health systems, agency problems inherent in system organization (such as fee-for-service payment for primary care physicians) may limit incentives to adopt this approach. But even where payers and providers have more aligned incentives, this paper demonstrates that (1) health systems may be in fact forgoing important benefits for some patients by not trying to foster new forms of doctor-patient relationships, but that (2) that this approach may not be universally beneficial; rather it may be most effective for a subset of patients who are early on in the development of chronic conditions. We show that modest changes to the structure of the provider-patient relational contract through explicit co-developed 'care plans' can have large impacts over a short period of time by increasing effort in primary care utilization, diagnostic testing, and medication prescription. By contrast, we show that the same intervention has no effect on acute conditions (heart attack and stroke), and that despite similar improvements in diagnosis and care among individuals with more advanced disease progression, there are no corresponding mortality reductions for them.

We do this by implementing a uniquely situated, large-scale experimental evaluation of explicit provider-patient 'care plan' contracts for more holistic primary care. At the core of this Enhanced Care Management (ECM) intervention, chronically-ill patients were identified through Estonian national insurance records. During the program, patients and their doctors filled out a 'care plan' template together, identifying key themes in the patient's health and agreeing on proactive areas of action to be taken by both parties. They then had regular check-ins on progress towards the commitments they made in the contract.[5] The ECM

[4] One strand of the health economics literature focuses on aligning incentives within health systems by using (or improving) explicit contracts between health system purchasers and health providers (Hanson et al., 2022; de Walque and Kandpal, 2022). However, these approaches overlook the relational contracting that takes place between doctors and patients themselves.

[5] The intervention evaluated in this paper relates to medical research on 'patient contracts' and to a lesser extent on 'shared decision-making' processes. Reviews of the associated research within medicine have typically concluded that existing evaluations are small-scale and provide insufficient measurement to effectively evaluate the impacts of such interventions Bosch-Capblanch et al. (2007); Desroches (2010); Gallagher et al. (2022); Montori et al. (2023). As such, this paper builds on the nascent work on related ideas in the medical

program thereby attempted to shift patient care from an implicit 'reactive' focus on salient ailments to an explicit contract between the patient and doctor based on a forward-looking and broader 'holistic' conception of welfare of the patient (Kurowski et al., 2017). This has dual potential effects on the relationship between doctors and their patients, analogous to the "twin problems of clarity and credibility" at the core of relational contracting (Gibbons and Henderson, 2011). First, it widens the lens of focus during medical consultations to a more extensive set of domains of patient health, similar to parties working through a comprehensive set of contract stipulations. Second, explicitly writing down a care plan helps to organize and strengthen the (informal) accountability regime across both sides of the patient-doctor relationship.

However, no system of formal accountability was put in place to deter deviation from the care plan or incentivize adherence to it, by either the doctor or the patient.[6] Rather, the care plan intervention attempts to use the process of contracting itself to shift the relationship of doctor and patient, investigating how changes in relational contracting affect healthcare provision and patient outcomes (Blader et al., 2015; Blader, Claudine and Prat, 2019; Cuevas and Zuñiga, 2021; Macchiavello, 2022; Macchiavello and Morjaria, 2023; Simeonova, Skipper and Thingholm, 2024). As such, this paper explores the intersection of how innovations in (relational) contracting affect economic behaviors, and an understanding of how contracting in healthcare interactions helps to determine patient outcomes.[7] Through heterogeneity analysis of downstream mortality using our pre-registered stratified randomization by baseline severity of illness (Daniels et al., 2024), it further identifies medical and informational boundary conditions on the effectiveness of such interventions.

For this study, we worked with the single-payer Estonian Health Insurance Fund (EHIF) to identify and randomly enroll at-risk patients at participating primary care clinics nationwide in the ECM program. This setting has several unique advantages. First, given Estonia's single-payer system, we observe the entire eligible population of primary care providers and the entire care-seeking population covered by EHIF. Second, Estonian primary care providers are private for-profit entities and are therefore behaviorally responsive; in addition, they maintain complete billing records of care activities. Third, in the Estonian context, people

literature.

[6]Since patient welfare is unpredictable and influenced by numerous factors beyond the scope of the healthcare system, there are severe limits on top down forms of provider accountability for holistic care for patient outcomes.

[7]The intervention is analogous to a management intervention, the most comparable of which in a medical setting is the application of checklists in relational contracting settings (Bosk et al., 2009; Singer and Vogus, 2013; Jackson and Schneider, 2015; Semrau et al., 2017; Martinez et al., 2020; Tietschert et al., 2024).

register with family doctors and there is little patient movement or selection across providers, and these physicians are regulated to have roughly similarly-sized patient populations. As a result, we are able to work with a broad range of clinics from across the country to randomize patient enrollment *within* clinics, assigning 1,781 of participating providers' 5,056 eligible patients to treatment and the rest to control, producing internally valid estimates of the program impact.[8]

Using the universe of Estonian national health insurance records, which cover 95% of the population (Habicht et al., 2023), we are able to track the impacts of the program through screening and treatment channels to impacts on hospitalization and two-year all-cause mortality. By precisely tracking the content of care, including screening, diagnosis, and prescriptions, we are able to identify significant changes in the care provided by doctors in response to program enrollment. These changes are especially notable given that the intervention targeted patients who already had multiple chronic conditions and as such, were heavy users of the health system. The share of ECM patients receiving core diagnostic tests is 3 to 5 percentage points higher than for control patients at the same clinics. This leads to corresponding increases in diagnosed conditions and prescription provision. For ECM patients, formal diagnosis of heart failure increases by 10% (+3p.p.); hyperlipidemia by 25% (+10p.p.); and overweight by 40% (+6p.p). Similar results are observed for prescriptions of medications treating key chronic conditions, such as statins.

We then assess downstream impacts on health outcomes of ECM patients. We focus on hospitalization and mortality as the most significant health events. For ECM-assigned patients, the incidence of any inpatient hospitalization declined by 2.1 percentage points over the period, or an eight-percent decline relative to a control risk of 25.5%, though this effect is only marginally significant (p=0.068). Leveraging our stratified randomization based on each doctor's assessment of whether a patient's risk level corresponded to their being 'mild to moderately ill' or 'severely ill', we are further able to assess health outcomes for both groups separately. We see suggestive reductions in hospitalization for both groups, although these are imprecisely estimated. However, we detect reductions in mortality for mild-risk patients only, with severe-risk patients closely tracking the mortality rates of control patients. The reductions in mortality for mild-risk patients are substantial: We estimate an approximately

[8] We are also able to compare the outcomes of these patients to the universe of similar patients across the health system to qualify our estimates of the effects of the intervention. This is discussed further in Appendix Table F.10, where we investigate bounds on potential selection biases – as about half of randomized-to-treatment providers did not ultimately participate – and spillover effects to control patients, as we observe improvements in control patients at participating providers relative to all others, and attempt to rule out the possibility that our within-provider estimates arise from effort re-allocation among the patient population.

20% annual decline (−1.3 percentage points against a control risk of 3.2% over the full two year period). We interpret these results as ECM generating a better overall quality of life for patients, but with a limited ability to extend lifespan for patients whose health was already severely compromised.

These sizable impacts indicate the potential power of restructuring relationships through care "contracts" within healthcare. As the global community makes further progress on reducing infectious diseases and other drivers of premature mortality, non-communicable or chronic diseases such as diabetes, hypertension, and cardiovascular diseases have come to account for over 70% of deaths worldwide (WHO, 2020).[9] These shifts in population health imply major new demands on the health system, as patients with multiple and advancing chronic conditions typically require more care, from multiple levels of the health system, over extended periods of time. Yet in many countries, primary health systems are not well-prepared to face these challenges. The results from ECM hint at the potential of a more proactive and comprehensive primary care model for complex patients, inspired by relational contracting approaches.

The rest of the paper is organized as follows. Section 2 presents a conceptual framework for differentiating between reactive and holistic approaches to patient care. Section 3 provides background to the setting, care plan intervention, and RCT design. Section 4 lays out the data and analytical approach used. Section 5 presents the results, and Section 6 concludes with a discussion of the implications of our findings.

[9]Noncommunicable diseases, also known as chronic diseases, are broadly defined as health conditions or diseases that are of long duration (for example, lasting 1 year or more) and require ongoing medical attention or limit activities of daily living or both. WHO (2023) states that roughly three-quarters of all global fatalities are due to non-communicable diseases, and this proportion is rising. High and middle income countries in particular have faced rapidly rising burdens of chronic disease, including as improving social conditions and advanced medical treatments enable populations to survive into old age. In these populations, co-occurrence of multiple chronic illness, also known as multi-morbidity, is also growing. For example, 60% of the adult population in the US and over 91% of the population above the age of 65 have two or more morbidities (King, Xiang and Pilkerton, 2018), while in the European Union (EU), 20-40% of the population have been diagnosed with at least one chronic illness, of which 25-50% have multiple chronic conditions (Rijken et al., 2014). In the case of Estonia, hypertension is the most common illness for the oldest age cohorts, followed by chronic pain associated with arthritis (Jürisson et al., 2021). This rise in multi-morbidity is in part a result of population aging, and can lead to premature mortality, high expenditure on inpatient and ambulatory services, and reduced functionality and quality of life (Van den Akker et al., 1998; Walker, 2007; Gijsen et al., 2001).

2 A conceptual model of holistic versus reactive care

A simple conceptual framework illustrates the approach of holistic care programs, the full exposition of which is provided in the Appendix. A vector of stochastic latent variables, h_{ki}, characterize patient i's health across each of k domains. Optimally, for any health domain, treatment should begin at $h_k < h_k^*$. Patients only observe stochastic realizations of h_{ki}. At threshold $E[h_{ki}] < \hat{h_k}$, a patient identifies that their health level requires treatment independent of a doctor's diagnostic test. For a cost, c, a doctor can run a diagnostic test to assess the true value of h_{ki}. The doctor must choose when to invest c into a diagnostic test.

In reactive care, suppose the doctor assigns the ex-ante value (before diagnostic tests) of h_{ki} to the population average. In most domains, $E[h_k] > h_k^*$, and the average member of the population does not need treatment. Doctors wait for patients to signal that $h_k < h_k^*$, which happens when $E[h_k] < \hat{h_k}$. However, this is a sub-optimal level of treatment for the population. The issue in this case is that without further information the doctor does not know who in the population should be targeted for costly diagnostic tests. As a result, doctors make systematic errors in test targeting (Mullainathan and Obermeyer, 2022). The social costs of this sub-optimal treatment are borne by the patient and wider society rather than by any individual doctor.

Relational care "contracts", in which a program of care is outlined in greater detail than previously undertaken, motivate doctors to invest c in diagnostics for more patients for three reasons. The first is that communication to fill in the broad range of stipulations that must be covered in the contract act as a new technology for efficiently generating a patient profile. The characteristics of that profile, x, allow the doctor to identify more precisely when $E[h_k|x] < h_k^*$. Second, the repeated interactions of doctor and patient allow both actors to relationally 'reward' the other by maintaining high effort and engagement when they perform their agreements over stipulations, leading to a broader set of potential outcomes of any strategic game. This incentivizes the doctor to invest more in diagnostics for a particular patient, and for the patient to adhere to any treatment recommendations.

The care contracts create a stronger architecture for a repeated game: a reference point that defines mutual expectations and makes deviations observable; with scheduled follow-ups natural checkpoints for accountability (MacLeod, 2007). Ordinarily, both the provider and the patient adhere to an equilibrium in which both put 'low' effort into the diagnosis and management of non-communicable diseases (including avoiding lifestyle modification) based on self-fulfilling expectations about the other's behavior. Care contracts may move those relationships to a high-effort equilibrium. Importantly, no formal enforcement mechanism is required; both doctor and patient can informally 'punish' deviations by reducing effort in subsequent interactions, making sustained high effort incentive-compatible. This relational logic suggests that care plans may be particularly effective when doctor-patient relationships are ongoing (as opposed to episodic emergency care) and when both parties can observe each other's effort over time.

This framework generates predictions about which health conditions and patient types should benefit most from holistic care interventions. In particular, the largest effects should occur for conditions where the 'diagnostic gap' $(h_k^* - \hat{h_k})$ is large – that is, for people who are in the early stages of devloping chronic conditions that are difficult for patients to self-detect but for which early diagnosis and treatment substantially alter disease trajectories. For example, early stage hyperlipidemia and pre-diabetes are largely asymptomatic conditions where patients rarely signal a need for testing, yet early detection using accurate blood panels enables early intervention (statins, lifestyle modification) that is highly effective at reducing downstream cardiovascular risk (Davidson et al., 2021). In contrast, acute events like stroke or myocardial infarction produce clear symptoms that trigger diagnosis regardless of proactive care engagement. At the patient level, this logic implies that individuals earlier in their disease progression should also show larger impacts; those with milder conditions that may not yet present such salient symptoms should benefit more than patients with advanced disease burdens.[10]

3 Estonian health system context and the ECM intervention

3.1 The Estonian health system

Estonia's 1.3 million people have a life expectancy close to the European average, though with significant inequality in health outcomes (OECD, 2021). For example, men die 8.5 years earlier than women, the third largest gender gap in life expectancy in Europe. Similarly, there are wide variations across regions, localities and households in disease burden. As in many countries, Estonia has an increasing prevalence of non-communicable diseases. 50% of

[10]It is in this case that the information value of a diagnostic test is most valuable since patient experience and therefore patient signals are a poor predictor of the distance of true health to h_k^*.

the population has at least one chronic illness, and multi-morbidity is a growing problem, with 71% of over 45-year olds having more than one chronic illness (World Bank, 2015). The Estonian government has estimated that chronic disease accounts for more than 40% of the loss in total disability adjusted life years (DALYs) in the country (University of Tartu, 2004).

Estonia's health system is based on a national single-payer insurance model anchored in the independent Estonian Health Insurance Fund (EHIF). EHIF's mandate and insurance model covers virtually the whole of the population and is funded through the country's social health insurance system (Sotsiaalministeerium, 2012).[11] Primary care is provided by approximately 800 independent private for-profit family doctors who contract directly with EHIF (Atun et al., 2016), roughly 70% of whom work in a solo practice clinic (Kurowski et al., 2015). All Estonians covered by EHIF are assigned to a private family doctor. Having reformed its Soviet-era "polyclinic" model of primary healthcare to one based on private family doctors, national primary healthcare policy works through EHIF's regulation of, and reimbursements to, these private clinics (Habicht, Kasekamp and Webb, 2023).[12]

Much of healthcare in Estonia is free at point-of-use for patients covered by EHIF's insurance, or requires a minimal co-pay. Doctors are primarily paid by EHIF through a combination of a base allowance (13% of provider income in 2021), annual capitation fees per patient (€5-11 per person, 48%), and fees for service related to a specific 'episode of care' (24%).[13] The model allocates substantial responsibility for the quality of healthcare services to independent doctors. The centrality of EHIF as a medium of payment for healthcare in Estonia implies that their governance and regulation over what services should be offered to patients are taken seriously, but ultimately practice quality remains a product of the incentives facing the providers. It also ensures a relatively consistent application of healthcare policies across providers. However, the disaggregated nature of delivery itself means that there is substantial room for variation in the quality of healthcare delivery that is a product of the activities of individual doctors.

[11] Approximately 1.5% of the population are not registered within the EHIF system.

[12] Additional reforms included introduction of the pay-for-performance Quality Bonus Scheme (QBS) to incentivize preventive care provision in 2006, expansion of nurse services, establishment of a digital health system to enable digital access to health services such as prescriptions, lab tests and health records in 2008, and adoption of primary healthcare development plans which increased service provision by primary health care providers and focuses on chronic illness management and improving care continuity (Atun et al., 2016; Habicht and van Ginneken, 2010; Koppel et al., 2008).

[13] The remaining 16% is made up of allowances for patient distance, nursing support, and the variable QBS payment. Outside of primary care, EHIF is also liable for the payment of tertiary costs, such as in- or out-patient episode at a tertiary health institution.

Among the population of interest for this study – older patients with multiple chronic conditions – we observe relatively regular contact between care providers and patients at baseline. Engagement with a patient's primary doctor in-person or by phone occurs roughly once a quarter, with the patient also seeing, and having a separate call with, the nurse once a year.[14] Patients in this group have approximately 3 outpatient episodes of care annually, and a one-in-six chance of experiencing an inpatient episode within a year. As such, these patients are already relatively heavy users of the healthcare system. Alongside a set of standardized screenings undertaken by their doctor (specified by national primary care and screening guidelines), the implicit contract in these consultations is that a patient requests assistance for a specific ailment and cooperates by undertaking the course of treatment that the doctor prescribes.

3.2 Enhanced Care Management (ECM) intervention

Between 2021 and 2023, EHIF piloted a system for chronically ill patients that attempted to shift the nature of patient-doctor interactions towards a more holistic treatment approach.[15] The core goal of the Enhanced Care Management (ECM) program is to improve the overall quality of care provided to vulnerable patients, including by increasing the use of preventive care, improving coordination of care across health system levels, and increasing patient involvement in proactive care. These elements can improve patient health and quality of life, and may reduce the need for curative medical services. For example, supporting patients with type 2 diabetes to improve their diet and increase physical activity in ways that they are most likely to take up may limit further deterioration in their health. Similarly, detecting the need for prescription statins can reduce the threat of cholesterol-related health complications.

The ECM intervention consists of coaching family doctors and their teams to develop holistic care and proactive outreach plans for chronically ill patients (World Bank, 2022). The core of

[14] Amongst OECD nations, Estonia is towards the bottom third of the ranking in intensity of patient consultations with doctors, but similar to other Scandinavian countries (OECD, 2021).

[15] An initial pilot of the ECM program was first conducted in 2017 with 10 providers, focused on patients with multiple chronic conditions including cardiovascular disease (CVD), hypertension, diabetes, and elevated blood lipids and other conditions. A non-experimental evaluation of the pilot showed that providers made 40% more calls to patients; were 11% more likely to have patients on appropriate statin prescriptions; had patients 25% less likely to be hospitalized for CVD-related conditions; and were 11% more likely to follow up within 30 days in the event of an acute CVD incident (Kurowski et al., 2017). This pilot was conducted with a purposely-selected group of 10 doctors who were expected to be highly motivated early adopters, limiting the possibility of inference about the causal impact of the program, or its likely effectiveness at scale. It was co-designed by EHIF, the World Bank, and Harvard University's Ariadne Labs. Pilot clinics were excluded from the current study.

the ECM intervention is the development of a relational ‘care plan’ for each enrolled patient that outlines the joint responsibilities of doctor and patient, and sets achievable, time-bound targets for care. The ECM care plans can be seen as a form of ‘contract’ between the doctor and patient, and might include improved tracking of tests and referrals, follow-up by doctors or their teams after hospital discharges, tracking of medication adherence, monitoring of patients between clinic visits, and greater focus on clinical quality.[16] Appendix B describes the ECM program in more detail and presents examples of such care plans from the trial.

A survey of doctors implementing the scheme indicated that the vast majority of doctors discussed the care plans with patients once every three months, and a fifth of clinic teams discussed the care plan with the patient once a month.[17] All care teams reported that they had done multiple follow-ups of some kind. These discussions included assessments of patients’ self-management goals, reviewing information from specialist care visits, and updating targets and treatments in response.[18]

An assessment of the care plans by EHIF staff implies that they were tailored to patient’s individual health needs, with 93% of plans assessed as satisfactory or above in terms of being tailored ‘to the needs of the individual patient’.[19] 83% of care plans had an explicit action plan to achieve the goals set.[20] Together, these statistics imply that ECM was successfully rolled out in participating clinics. When asked what the most effective element of the ECM program was in the survey, 91% of doctors stated it was the construction of the care plan. 94% of doctors felt that patients enrolled in ECM followed the practices and guidelines in their care plans ‘easily’ or only ‘with some difficulty’. 78% of doctors stated that they had observed differences in the behavior of ECM patients and 74% believed they had observed changes in their ECM patient’s physical health.[21]

[16] The broader ECM program includes four elements: identifying high-risk patients through risk stratification, developing care management plans by the primary care doctor in consultation with the patient, proactively linking care providers together, and developing a team approach between patients and their caregivers. ECM reflects global primary care reforms that aim to focus the health system’s attention on high-risk groups and improve the continuity of care for these patients (Peikes et al., 2018). Appendix B provides a comprehensive description of the ECM intervention, including the four key elements, provider training, care plan design, and the scope of the program.

[17] More details on the survey of doctors can be found in the appendix.

[18] Very few doctors reported coordinating with social care services, indicating that any impacts of ECM are driven by changes in medical behaviors.

[19] More details on the care plan assessments can be found in the appendix.

[20] The same assessment reported that 82% of care plans addressed the patient’s health holistically, 93% of plans were ‘easy to grasp and understandable from the patient’s point of view’, and 93% had information relevant to the patient.

[21] In the same survey, 94% of doctors stated that they were motivated to continue using the ECM approach after the pilot ended.

3.3 Randomization approach

We worked with EHIF to implement a randomized control trial of ECM, as specified in our pre-analysis plan (Daniels et al., 2024).[22] A random sample of 93 out of 375 eligible clinics were invited to be part of ECM, while 282 clinics were randomized into what we will refer to as 'pure control;' i.e. doctors in these clinics had little to no exposure to ECM. After discussions around the requirements of the scheme and eligibility assessments of patients, 56 of the original 93 clinics enrolled, with 72 doctors from these 56 clinics (and their lists of patients) making up our study sample. Among the 72 doctors that agreed to participate, 5,056 patients were identified as eligible for inclusion in the ECM program by EHIF according to pre-set rules using administrative data. 1,970 individuals were classified as facing severe risk to their health, and the remaining 3,086 individuals were classified with mild to moderate risk.

We then followed the randomization protocol outlined in Figure 1.[23] For each doctor, up to 25 individuals were included in ECM after this risk stratification. Fewer than 25 individuals were included into the ECM treatment group only when the doctor had fewer than 25 eligible patients; this occurred in 3 out of 72 cases (Figure D.2b). For all other providers, the 25 patients were subject to stratified randomization into ECM treatment.[24]

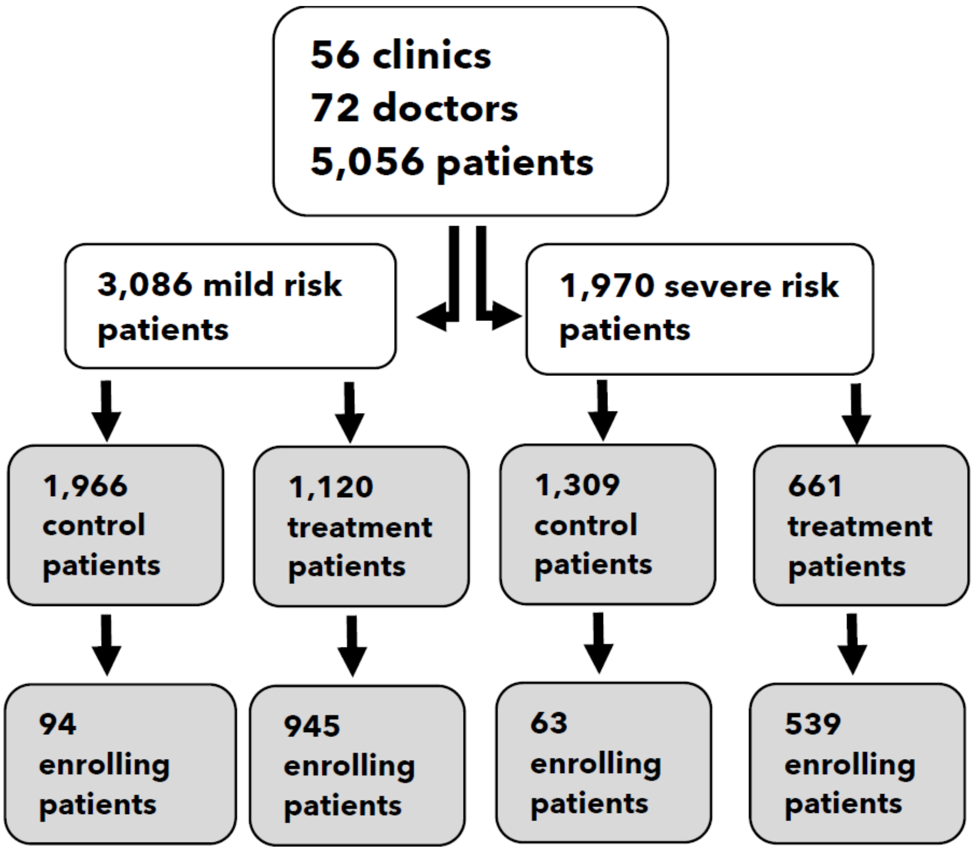
This approach resulted in 661 severe risk patients enrolled in ECM, of whom 539 (81.1%) eventually participated in the formulation of a care plan. Similarly, it resulted in 1,121 mild to moderate risk patients enrolled in ECM, of whom 945 (84.2%) eventually formulated a care plan with their doctor. Contamination by the control groups was rare, with only 157 cases in which an individual who had been assigned to the "ECM control" group participating in the ECM program, most of whom enrolled only in the last months of the observation period. The main results in this paper are analyzed as intent-to-treat outcomes based on initial treatment assignment with fixed effects for doctor-risk strata groups (effectively, comparing assigned-to-treatment and assigned-to-control patients within each risk level for each doctor). Corresponding treatment-on-the-treated (instrumental variables) estimates are reported as

[22] Appendix G documents all deviations from the pre-analysis plan, including changes in sample size and timeline due to provider attrition and pandemic-related disruptions.

[23] A fuller elaboration of the sampling process from the Estonian population to our final study sample is illustrated in Figure D.1.

[24] Though it was felt important to separately identify the impact of ECM on these risk groups, stratification based on risk-type complicates our ability to undertake analysis of hypertension, the medical guidelines for which denote distinct approaches for different risk-levels, making it challenging to undertake a coherent analysis across patients in different risk groups.

Figure 1: Within-provider patient stratification, randomization, and compliance



complementary to this core analysis.

4 Data and statistical approach

4.1 Data

To assess the impacts of ECM on the nature of healthcare and on broader patient health, we track patient treatment and outcomes over time using EHIF's administrative records. Since EHIF is liable for reimbursing providers for every episode of care, every billable activity undertaken within the formal health system is recorded within EHIF's records.[25] We merged these billing records over a 14 year period spanning 2009 until 2023 across eight health care services categories: primary health care, day care, outpatient care, outpatient nursing care, outpatient rehabilitation care, inpatient care, inpatient nursing care, and inpatient rehabilitation care. For each type of care, we obtained the International Classification of Disease (ICD) codes of diagnoses related to the episode and the procedures or treatments provided. The summary of the key outcomes used in this study, grouped by treatment groups, is shown in Table 1.[26]

From the patient-level linked data set we created from these billing records, we assess a range of primary and secondary outcomes related to treatment. For example, we observe the number of primary health care interactions in distinct periods; undertaking of diagnostic work, such as monitoring of cholesterol levels, glucose/glycosulated hemoglobin, and creatinine; number of outpatient (ambulatory) services utilized; number and nature of follow-ups by doctor and nurse; counseling sessions with the family nurse; and so on.

To assess health outcomes, we created indicators that follow the Organization for Economic Co-operation and Development (OECD)'s quality of care outcomes indicators for primary care (OECD, 2021). These indicators include avoidable hospital admissions for asthma, chronic obstructive pulmonary disorder, diabetes, congestive heart failure, and hypertension, defined as the number of hospital admissions with any of the above as primary diagnosis; emergency department visits (for any condition); inpatient readmission within 30 and 90 days after any previous inpatient admission; share of prescriptions purchased out of all the

[25]There is little that is not billable, with EHIF's data even including e-mails and calls to patients by doctors and nurses.

[26]Further details on the billing data are provided in the appendix. Note that we do not have access to electronic medical records with relevant clinical measures such as HbA1C, blood pressure, or BMI.

prescribed medications by provider; and mortality outcomes.

In addition, EHIF's Mini Information System Portal is used to list patients who have been diagnosed with chronic illnesses and are therefore at risk of deteriorating health (see Section C for further details on this process). We matched this dataset to the claims data to generate identifiers for higher-risk patients. We also asked all doctors in the study to provide an additional risk score for each of the patients identified as having a chronic disease in terms of their severity of illness. Within their list of chronically-ill patients, all doctors were required to rate their patients' risk of becoming either 'mild to moderately ill' or 'severely ill'. This rating became the basis for our stratified randomization of patients.

4.2 Statistical approach

Our core analysis uses the below specification:

$$Y_{ik,t} = \beta_0 + \beta_1 ECM_i + \beta_2 Strata_k + \beta_3 \gamma + \beta_4 \bar{Y}_{i,2021} + \epsilon_{ik,t}$$

where $Y_{ik,t}$ is the outcome of patient i at time t, with risk group and ECM doctor indicated by the strata k to which the individual belongs. ECM_i is an indicator that the patient was randomly assigned to the ECM treatment group, and β_1 is therefore the treatment effect parameter of interest. γ is a vector of controls – including where appropriate, patient age and gender. In ANCOVA specifications, $\bar{Y}_{i,2021}$ additionally represents a control for the annualized mean of the dependent variable for patient i in the pre-treatment period of 2018-2021 inclusive, up to the initiation of the ECM program. $\epsilon_{ik,t}$ is the error term. Since the size of the population a doctor serves varies across doctors, the probability of treatment is unequal across patients across doctors. As such, we weight treated observations by the inverse of the proportion of treated individuals in each stratification block (Gerber and Green, 2012).[27]

[27] In the appendix, we exploit the richness of the EHIF data to investigate a number of potential identification threats. With a substantial number of doctors excluded from treatment, and whose patient outcomes are summarized in Table F.1, we can make comparisons between ECM control patients and a set of patients who would have been eligible for ECM randomization had their providers been included. By using ANCOVA specifications, we assume that conditional on pre-existing differences between 'pure control' and 'ECM control' patients highlighted in section 3.3, the changes in patient outcomes in the pure control group are a fair counterfactual for those of the ECM control patients.

5 Results

5.1 Balance and representativeness in ECM randomization

Table 1 reports patient-level balance tests between treatment and control groups using annualized counts of patient outcomes from 2018-2021 (up to the start of the ECM program).[28] The final column of Table 1 reports differences between treatment and control patients in treatment clinics, conditional on randomization strata. In general, the ECM control and treatment groups are well balanced at baseline across a range of characteristics, including their current health status, as measured by tracer diagnoses; by their utilization of the health system, including at the primary level; and, by the prescriptions they received for management of their conditions.[29] There is a slight imbalance on age, though with age and gender as key determinants of chronic health outcomes, they are natural controls in our core specifications and we report models with and without these controls. ECM treatment patients are also very slightly (4%) more likely to have had an in-person doctor visit in the last year, and are slightly less likely to use primary care away from their assigned clinic. This, along with the gains in efficiency available from the panel structure of the data, motivate our use of an ANCOVA specification in our core analysis, with controls for baseline (lagged) levels of outcome variables at the patient level.

[28] Appendix Table F.1 reports balance between the ECM control and pure control group to assess representativeness of our patient sample within the wider population.

[29] An expanded set of balance checks across a wider range of pre–ECM characteristics is reported in the appendix given the substantial records we have access to, but these variables are secondary to our main analysis.

Table 1: Pre-treatment balance across ECM control and treatment patients (2018-2021)

Variable	**Means**		**Differences**
	Control	Treatment	Balance
	(1)	(2)	(2)-(1)
Panel A: Demographics			
Age	68.7	67.3	-0.643* (0.343)
Male	0.436	0.462	0.016 (0.016)
Mild risk	0.629	0.629	0.000 (0.000)
Panel B: Outcomes (annualized counts)			
Primary care (assigned clinic)			
GP in-person chronic care	0.414	0.448	0.018** (0.009)
GP phone	3.72	3.47	-0.114 (0.082)
Nurse in-person	0.983	0.995	-0.013 (0.028)
Nurse phone	1.44	1.61	-0.005 (0.048)
Any consultation	6.57	6.52	-0.125 (0.125)
Primary	2.08	2.02	0.008 (0.051)
Outpatient	0.304	0.293	-0.011 (0.011)
Primary care (not assigned clinic)			
Primary	0.247	0.285	-0.063** (0.029)
Outpatient	3.05	3.14	0.090 (0.083)
Other care			
Inpatient	0.174	0.175	-0.002 (0.009)
Inpatient (via ambulance)	0.047	0.046	-0.000 (0.005)
Inpatient re-admission (30)	0.046	0.052	0.006 (0.006)
Inpatient re-admission (90)	0.071	0.076	0.003 (0.009)
Daycare healthcare	0.084	0.089	0.005 (0.006)
Inpatient nursing/rehabilitation	0.017	0.015	-0.004 (0.003)
Outpatient nursing/rehabilitation	0.146	0.145	0.004 (0.017)
Panel C: Outcomes (share of patients)			
Covid incidence	0.094	0.086	-0.004 (0.009)
Covid vaccine	0.686	0.648	-0.037*** (0.013)
Screening			
Glycohemoglobin	0.727	0.747	-0.002 (0.012)
Creatinine	0.986	0.985	0.003 (0.003)
Cholesterol	0.980	0.978	0.002 (0.005)
Glucose	0.963	0.972	0.006 (0.005)
TSH	0.789	0.796	0.010 (0.012)
Diagnosed conditions			
Heart failure	0.366	0.339	-0.004 (0.013)
Stroke	0.008	0.008	0.002 (0.002)
Myocardial infarction	0.026	0.025	-0.002 (0.005)
Hyperlipidemia	0.526	0.521	-0.006 (0.017)
Overweight/obese	0.177	0.171	0.002 (0.012)
Prescriptions			
Diabetes	0.234	0.244	0.007 (0.014)
Anti-hypertensive	0.048	0.051	0.004 (0.006)
Beta-blockers	0.655	0.666	0.014 (0.016)
Statins	0.585	0.599	0.016 (0.018)
Any key	0.854	0.867	0.018 (0.012)
Any other	0.998	0.999	0.001 (0.001)
FE	-	-	Strata
N	3,275	1,781	-

*** $<$ 1%; ** $<$ 5%; * $<$ 10%.

<u>**Notes**</u>: The table measures pre-treatment balance of demographic variables and outcomes of interest for the ECM intervention at the patient level. The **means columns** (1-3) in Panel A show the mean age of patients in each group at the start of the intervention (28/05/2021) and the share of male and mild-risk patients. Panel B shows mean annualized counts of the outcomes of interest in the pre-treatment period, running from 01/01/2018 to 27/05/2021. Those values are calculated from

healthcare billing data, by summing up all instances of occurrence of a given variable (interaction, diagnosis or procedure) for each patient in the pre-treatment period; annualizing and winsorizing the outliers (at 99.9th percentile) the resulting values; and then calculating the arithmetic averages for relevant groups. Panel C shows the share of patient with at least one occurrence of a given outcome in the same period. Sub-panel headings are used to group outcome categories. Standard deviations are shown in the parentheses.

The **balance** column (3) displays differences between ECM control and treatment patient groups on each variable as estimated in a WLS regression, inclusive of the fixed effects for the stratification level of the randomization procedure, which is patient-level strata, i.e. doctor interacted with patient risk classification level. Standard errors of the coefficients are clustered by doctor and shown in parentheses.

The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctors, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each outcome variable is provided in Table E.1.

5.2 ECM impacts on utilization, diagnosis, and management

Table 2 presents the impacts of ECM on the nature of patient care over the period of the program, from May 2021 to March 2023.[30] Across key indicators of patient care, the table presents both (a) binary 'extensive margin' measures as to whether the service was ever provided within the study period and (b) annualized 'intensive margin' counts of the number of times that service was provided. Our estimation results do the same.[31] We report mean levels for the control (Columns 1 and 2) and design-adjusted comparisons between the ECM treatment and control groups (Columns 3 and 4). The specifications we present are conditional on randomization strata fixed effects, age, gender and the mean of the dependent variable for the 2018 to 2021 period up to the initiation of the ECM program.

[30]When making experimental comparisons, we include randomization strata fixed effects.

[31]Specifically, outcome variables in the 'Means' and 'Count' columns (1,2,4,6) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (3,5) measure the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise.

Table 2: **ECM Impact:** On patient's care (ANCOVA)

Variable	**Means (control)**		**ECM treatment vs. control**	
	Any	*Count*	*Any*	*Count*
	(1)	(2)	(3)	(4)
Primary care (assigned clinic)				
ECM inclusion	0.049	0.027	0.764*** (0.033)	0.453*** (0.024)
ECM care plan	0.048	0.058	0.784*** (0.033)	0.923*** (0.073)
GP in-person chronic care	0.471	0.384	0.110*** (0.026)	0.148*** (0.032)
GP phone	0.912	4.101	0.006 (0.006)	0.117 (0.078)
Nurse in-person	0.767	1.067	0.042** (0.016)	0.176*** (0.057)
Nurse phone	0.728	1.917	0.093*** (0.021)	0.286*** (0.070)
Any consultation	0.968	7.485	0.003 (0.003)	0.717*** (0.136)
Primary	0.867	1.472	0.029*** (0.008)	0.102*** (0.031)
Outpatient	0.537	0.597	0.127*** (0.021)	0.229*** (0.032)
Primary care (not assigned clinic)				
Primary	0.106	0.148	0.000 (0.007)	0.005 (0.010)
Outpatient	0.845	3.436	0.016 (0.013)	0.003 (0.081)
Other care				
Inpatient	0.255	0.221	-0.020* (0.012)	-0.016 (0.013)
Inpatient (via ambulance)	0.107	0.073	-0.009 (0.009)	-0.009 (0.007)
Inpatient re-admission (30)	0.038	0.032	-0.005 (0.006)	-0.009** (0.005)
Inpatient re-admission (90)	0.059	0.054	-0.001 (0.007)	-0.007 (0.007)
Daycare healthcare	0.117	0.097	0.003 (0.011)	0.006 (0.012)
Inpatient nursing/rehabilitation	0.04	0.036	0.004 (0.007)	-0.000 (0.009)
Outpatient nursing/rehabilitation	0.142	0.181	-0.005 (0.011)	-0.015 (0.025)
Covid incidence	0.202	0.131	0.017 (0.014)	0.020* (0.011)
Covid vaccine	0.723	0.826	-0.005 (0.013)	-0.031 (0.022)
Screening				
Glycohemoglobin	0.683	0.765	0.050*** (0.014)	0.113*** (0.026)
Creatinine	0.929	2.567	0.038*** (0.007)	0.112 (0.118)
Cholesterol	0.882	1.098	0.052*** (0.009)	0.152*** (0.032)
Glucose	0.844	2.16	0.035*** (0.011)	0.073 (0.145)
TSH	0.636	0.912	0.050*** (0.013)	0.149*** (0.047)
Diagnosed conditions				
Heart failure	0.302	0.723	0.032*** (0.012)	0.161*** (0.041)
Stroke	0.005	0.005	0.003 (0.002)	0.001 (0.002)
Myocardial infarction	0.018	0.024	-0.001 (0.004)	0.001 (0.006)
Hyperlipidemia	0.428	0.631	0.097*** (0.017)	0.279*** (0.036)
Overweight/obese	0.136	0.176	0.057*** (0.013)	0.150*** (0.027)
Prescriptions				
Diabetes	0.266	1.898	0.018** (0.007)	0.099 (0.072)
Anti-hypertensive	0.036	0.081	-0.004 (0.005)	-0.000 (0.012)
Beta-blockers	0.619	2.534	0.001 (0.012)	0.043 (0.050)
Statins	0.597	2.34	0.028** (0.011)	0.124** (0.056)
Any key	0.844	6.862	0.010 (0.009)	0.261** (0.128)
Any other	0.985	17.828	0.003 (0.003)	0.706*** (0.234)
FE	-	-	Strata	Strata
Controls	-	-	Age, gender, DV_{18-21}	Age, gender, DV_{18-21}
N	3,275	3,275	5,056	5,056

*** < 1%; ** < 5%; * < 10%.

Notes: The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023). Outcome variables in 'Count' columns (2,4) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (1, 3) measure the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise.

All regression models are estimated controlling for patients' values age and sex, as well as the value of a given outcome

variable in pre-treatment period (01/01/2018 - 27/05/2021). The only exception is 'ECM inclusion' and 'ECM care plan', which are estimated as WLS, i.e. without pre-treatment values as controls, as those procedures are introduced as a part of the intervention. The pre-treatment values are recorded in parallel with their post-treatment equivalents as either counts or dummies in the respective columns. All models include fixed effects as specified in the bottom panel, where strata refers to doctor interacted with patient risk classification level. Fully empty rows code variables that after winsorizing resulted in all values being 0. Models in columns 3-4 are also weighted by strata-level inverse probabilities of treatment assignment. Standard errors of the coefficients are clustered by doctor and provided in parentheses.
The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

The first two rows of the table indicate that there was a successful inclusion of over 80% of randomized patients into the program. Treatment patients were 76 percentage points more likely to have a care plan; about 6% of control patients received one. The first panel indicates that ECM enrolled patients used significantly more primary care than non-ECM enrolled patients at their assigned providers. Patients randomized into the control group accessed any form of primary care consultation about 7.5 times annually during the post treatment period, of which six interactions were phone calls and two interactions per year were for primary/outpatient care. ECM-assigned patients averaged about 0.7 (9.5%) more interactions per year; with the increase split roughly evenly across phone calls and in-person interactions. Of these new interactions, two-thirds were with nurses, either in person or by phone; and one-third were with doctors directly.[32] Overall, the coefficients related to primary care at the assigned clinic represent approximately a 10% increase in primary care utilization for recipients of the ECM program, relative to control individuals of the same risk level, age and gender at the same doctor.[33]

The second and third panels of Table 2 investigate changes in the utilization of care services at locations other than the ECM provider. Focusing on the core treatment effects of ECM, there appears to be no impact on the use of primary care outside of the ECM-designated doctor. These results suggest that changes in primary care patterns arose from within the specific relationship between ECM patients and ECM providers. In terms of broader (non-primary) care, ECM reduces the likelihood that patients are hospitalized by 8% (2p.p., p=0.068), an important effect that we will investigate further in the following section. We also see a reduction in re-admission rates to hospital of roughly a quarter of the baseline frequency, but no changes in the utilization of services such as day-care or rehabilitation.[34]

[32] These results indicate that while the scheme had clinically meaningful impacts on the intensity of patient care, the increase in case load for clinical staff was moderate. An immediate concern is that these results merely reflect ECM providers shifting effort to ECM patients from control patients. Columns 6 and 7 of Appendix Table F.1) therefore report an almost-identical ANCOVA regression estimate comparing control individuals at ECM providers to the 'pure control' group of ECM-eligible individuals at control providers. Echoing the contamination outlined in Figure 1, roughly 6% of ECM control patients were enrolled in ECM; typically towards the end of the program. Further discussion of related analysis is provided in the Appendix.

[33] We present alterative modeling strategies for robustness in the Appendix. We estimate several heterogeneity analyses across the risk groups (Tables F.2 and F.3), doctor and ECM care plan quality, as well as pre-treatment health profile (Table F.4), in addition to using treatment-on-the-treated (IV) estimation (Table F.6) and correcting our inferences using multiple hypothesis adjustments and randomization-inference p-values (Table F.7). All estimates are qualitatively the same as in Table 2 (see Section F).

[34] Critically, we also observe no differences across any groups in either Covid incidence or vaccination rates, ruling out a potential channel for differences in hospitalization or all-cause mortality between groups based on differences in intensity of primary care treatment that would lead to differences in those mediators. As a result, we can anticipate that differences in downstream outcomes arise from detection and management of non-communicable diseases here and not incidental preventive care during the pandemic.

The fourth panel, titled 'Screening', indicates additional testing for key conditions undertaken as a result of the ECM program. We observed significant increases in the proportion of ECM patients who were tested for glycohemoglobin, creatinine, cholesterol, glucose, and total blood counts, with testing rates approximately 3 to 5 percentage points higher for each category. The coefficients in Column 4 imply that for some conditions there is also an intensification of screening under ECM. The results are in-line with the approach of 'holistic care' outlined in section 2. A goal of holistic care is that doctors should be motivated to undertake more diagnostic work when clinically indicated, which is precisely the effect we observe.

Effects estimated and reported in the fifth panel, titled 'Diagnosed Conditions', is a direct consequence of the diagnostic work. These results show large and significant increases in the diagnosed prevalence of heart failure, hyperlipidemia, and overweight status among the treatment group. In particular, diagnosis of heart failure increases by 10% (+3p.p.); hyperlipidemia by 25% (+10p.p.); and overweight by 40% (+6p.p) overall. Of these, only heart failure diagnoses showed any decline among the control group, suggesting that these are genuine increases in total detection of medical needs and not reflective of effort reallocation between treatment and control patients.[35] The corresponding positive increases in the count of diagnoses implies that there was a sustained screening regime across the multiple years of the program. This panel also indicates that ECM doctors have focused their most significant diagnostic efforts on conditions that are harder for the patient themselves to detect, such as heart failure and hyperlipidemia. We also do not see increases in diagnosis rates for health events which would likely be diagnosed regardless of provider effort due to their severity and acute presentation (heart attack, stroke). This is once again consistent with the conceptual framework presented in Section 2.

Finally, these diagnoses induced increases in the rate of prescription medication offered to individuals among the ECM treatment group, namely, statins (which treat high cholesterol). We estimated that an additional 3% of patients a year received such a prescription (with 60% of the control group already having one) and an additional 2% of patients received diabetes medication (27% in control). While other prescription increases were not individually statistically significant, altogether, the total number of prescriptions managing key conditions (diabetes medication, antihypertensives, beta blockers, and statins) increased for the average individual enrolled in the ECM program by about one-quarter of a prescription a year. Along with this increase, 0.7 further additional prescriptions were induced on average,

[35] Appendix Table F.10 provides a bounds analysis decomposing potential spillover and selection effects.

for a net increase of about one prescription per person (a 6% increase).

Figure 2 illustrates the time-series dynamics of these effects over the course of the program along one key channel. Following ECM onset, we observe immediate and sustained increases in chronic care consultations (Panel A), with treatment-control differences persisting throughout the study period although attenuating in the second year. Hyperlipidemia diagnoses (Panel B) similarly show a sharp increase across the first year, consistent with improved screening identifying previously undetected cases. Statin prescriptions (Panel C) follow a similar pattern with slightly later divergence, reflecting the downstream consequence of new diagnoses. Finally, hospitalization rates (Panel D) show rates among ECM patients dropping below that of controls even slower and later – again suggesting a temporal pathway for the effects of the program (although these differences nearly disappear by the end of the second year). These time-series patterns are consistent with the relational contracting mechanism: the ongoing nature of the treatment-control differences suggests that ECM induces sustained changes in care patterns rather than one-time interventions. Together, these results indicate that the shift in the underlying contract of care induced by ECM, from reactive to holistic healthcare, has real effects on how doctors treat ECM patients.[36] After achieving a relatively modest sustained increase in effort, there is a substantial increase in diagnostics, identified conditions, and prescriptions.

5.3 ECM impacts on hospitalization and mortality

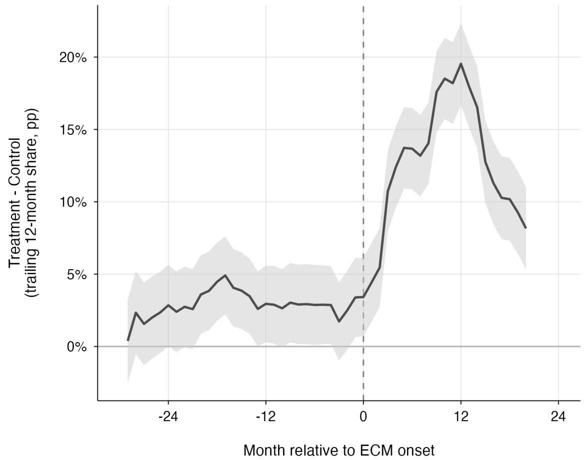
We now turn to downstream impacts of ECM on health outcomes. Specifically, we focus on hospitalization and mortality as the most significant health events in our data.[37] Since these are low frequency events, both are presented as weighted least squares (WLS) estimates on a binary outcome at the end of the treatment period, and as Cox proportional-hazards models. Table 3 presents results across three panels: Panel A pools all patients; Panel B presents results for mild-risk patients; and Panel C presents results for severe-risk patients. Within each panel, we report both WLS and Cox specifications. Since we stratified randomization by risk category, all coefficients we present can be interpreted as causal in nature for these

[36]Appendix Tables F.2 and F.3 present the analysis of Table 2 separately for the two risk groups. Both groups receive similar changes in their care utilization in response to ECM as described in this section. However, whereas severe-risk patients had a wide range of additional diagnoses and prescriptions (namely, new detection of already-existing heart failure and diabetes), by contrast, the mild-risk patients almost exclusively were diagnosed with hyperlipidemia and obesity and prescribed corresponding statins.

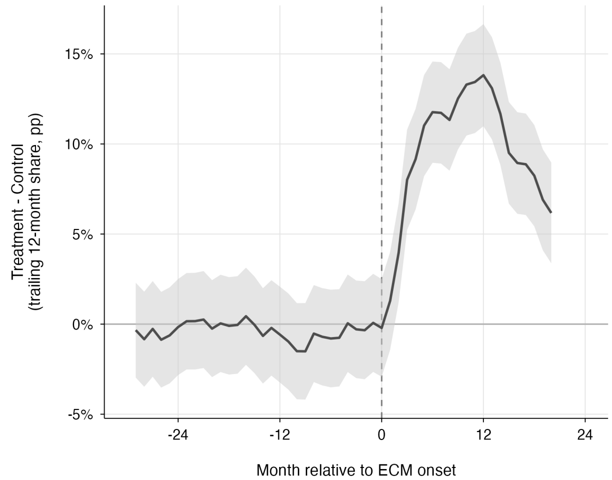
[37]Note that due to data protection regulations, we do not have access to patient clinical information, e.g., HbA1C, blood pressure, BMI, or cause of death.

Figure 2: Time series of treatment effects with 12-month trailing incidence

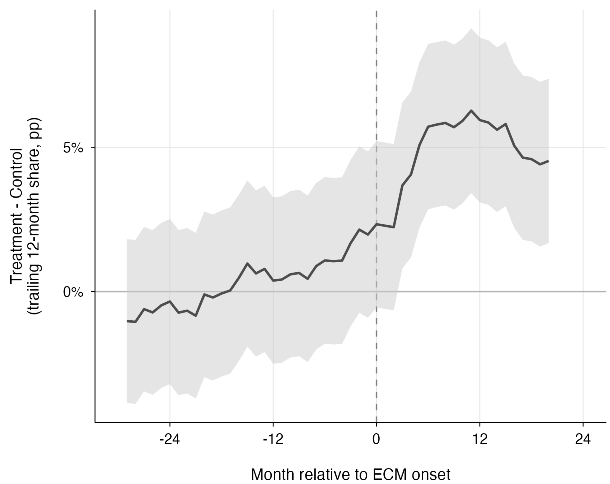
(a) **Consultations**: Doctor in-person chronic



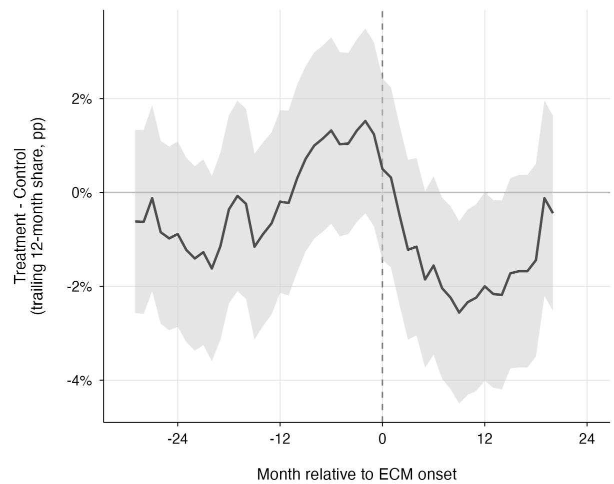
(b) **Diagnoses**: Hyperlipidemia



(c) **Prescriptions**: Statins



(d) **Hospitalization**



Notes: The figures show the difference (Treatment - Control) in the share of patients with each outcome on a trailing 12-month basis, with 95% confidence intervals. For each month, we compute the share of patients who had the outcome at any point in the prior 12 months. Positive values indicate that the outcome was more common in the treatment group than in the control group. The dashed vertical line marks ECM onset (May 2021).

sub-strata.

Table 3: ECM Impact: On hospitalizations and mortality

Variable	Hospitalization			Mortality		
	Design	Controls	IV	Design	Controls	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Pooled sample						
WLS						
ECM patient	-0.021*	-0.020*	-0.025*	-0.009	-0.008	-0.011
	(0.011)	(0.011)	(0.015)	(0.006)	(0.006)	(0.008)
Age (years)	-	0.003***	0.003***	-	0.002***	0.002***
		(0.001)	(0.001)		(0.000)	(0.000)
Sex (male)	-	0.059***	0.060***	-	0.027***	0.027***
		(0.016)	(0.016)		(0.008)	(0.008)
Cox Proportional-Hazards						
ECM patient	-0.092*	-0.086	-0.109	-0.291	-0.221	-0.282
	(0.041)	(0.041)	(0.052)	(0.112)	(0.112)	(0.138)
Age (years)	-	0.015***	0.015***	-	0.074***	0.074***
		(0.002)	(0.002)		(0.006)	(0.006)
Sex (male)	-	0.311***	0.312***	-	0.962***	0.965***
		(0.044)	(0.044)		(0.112)	(0.112)
Control Outcome Mean	0.255	0.255	0.255	0.037	0.037	0.037
N	5,056	5,056	5,056	5,056	5,056	5,056
Panel B: Mild-risk patients						
WLS						
ECM patient	-0.014	-0.015	-0.018	-0.013**	-0.013**	-0.017**
	(0.016)	(0.016)	(0.020)	(0.006)	(0.005)	(0.007)
Age (years)	-	0.004***	0.004***	-	0.002***	0.002***
		(0.001)	(0.001)		(0.000)	(0.000)
Sex (male)	-	0.059***	0.059***	-	0.015**	0.015*
		(0.018)	(0.018)		(0.008)	(0.008)
Cox Proportional-Hazards						
ECM patient	-0.077	-0.081	-0.102	-0.569**	-0.605**	-0.762**
	(0.056)	(0.056)	(0.070)	(0.169)	(0.171)	(0.215)
Age (years)	-	0.021***	0.021***	-	0.089***	0.089***
		(0.003)	(0.003)		(0.010)	(0.010)
Sex (male)	-	0.334***	0.335***	-	0.746**	0.750**
		(0.059)	(0.059)		(0.177)	(0.177)
Control Outcome Mean	0.219	0.219	0.219	0.032	0.032	0.032
N	3,086	3,086	3,086	3,086	3,086	3,086
Panel C: Severe-risk patients						
WLS						
ECM patient	-0.032	-0.030	-0.039	-0.003	-0.000	-0.000
	(0.023)	(0.024)	(0.031)	(0.012)	(0.012)	(0.015)
Age (years)	-	0.002	0.002	-	0.002***	0.002***
		(0.001)	(0.001)		(0.001)	(0.001)
Sex (male)	-	0.058**	0.059**	-	0.048***	0.048***
		(0.023)	(0.024)		(0.015)	(0.014)
Cox Proportional-Hazards						
ECM patient	-0.108	-0.102	-0.132	-0.059	0.099	0.129
	(0.060)	(0.060)	(0.078)	(0.152)	(0.156)	(0.203)
Age (years)	-	0.006	0.006	-	0.064***	0.064***
		(0.003)	(0.003)		(0.009)	(0.009)
Sex (male)	-	0.271***	0.274***	-	1.20***	1.20***
		(0.066)	(0.066)		(0.173)	(0.173)
Control Outcome Mean	0.309	0.309	0.309	0.045	0.045	0.045

N	1,970	1,970	1,970	1,970	1,970	1,970
FE	Strata	Strata	Strata	Strata	Strata	Strata

$^{***} < 1\%$; $^{**} < 5\%$; $^{*} < 10\%$.

Notes: Table shows estimates of ECM treatment assignment on hospitalization and mortality, stratified by patient risk classification. Panel A pools all patients; Panels B and C stratify by mild and severe risk classification. Within each panel, WLS models estimate effects on binary outcomes; Cox proportional-hazards models estimate effects on survival time.

Dependent variables: In WLS models, outcomes are binary indicators for any hospitalization (columns 1-3) or death (columns 4-6). In Cox models, survival time is measured in days from ECM onset (28/05/2021) to first hospitalization or death, right-censored at observation end (31/03/2023). Hospitalization survival is additionally right-censored at death for patients who died without hospitalization.

Specifications: Columns (1) and (4) include strata fixed effects only. Columns (2) and (5) add age and sex controls. Columns (3) and (6) instrument ECM enrollment with assignment. Standard errors clustered by provider in parentheses. Cox models report hazard ratios with 95% confidence intervals.

Sample: ECM treatment and control patients at participating providers.

Columns 1-3 describe the impacts of the ECM program on inpatient care (hospitalization) over the treatment period. For ECM-assigned patients, the incidence of any hospitalization declined by 2.1 percentage points relative to a control risk of 25.5%, an approximately 8% decline (with p-value of 0.068; Panel A of Table 3.).[38] These declines are observed for both mild-risk patients, where the incidence of hospitalization decreased by 1.4 percentage points relative to control rate of 21.9%, and for the severe-risk patients where the corresponding decline was 3.2 percentage points against the control rate of 30.9% (although imprecisely estimated and not significant in each strata, see Table 3).

We also illustrate the impacts of ECM over time by plotting corresponding survival curves in Figure 3 (top row). Even though the strata-specific results are not significant for hospitalization, there are apparent differences towards the end of study period between mild-risk and severe-risk patients as the time at risk increases. For mild-risk patients, the program gradually builds towards a reduced likelihood of hospitalization, with larger differences appearing after roughly a year and a half of treatment. For severe-risk patients, episodes of lower hospitalization rates do not appear to be effectively sustained throughout the period.

Columns 4-6 describe the impacts of the ECM program on mortality over the post-treatment period. For ECM-assigned patients, the average risk of mortality declined by a statistically insignificant 0.8 percentage points over the period, relative to a control risk of 3.7%. However, among mild-risk patients, mortality declined over the treatment period by a statistically significant 1.3 percentage points, against a control risk of 3.2% (p-value of 0.006). Severe-risk patients in the treatment group saw a decline of 0.3 percentage points, relative to the control group's mortality risk of 4.5% (p-value of 0.992).

The Cox proportional-hazards models in Panel B present even clearer patterns in changes in mortality among ECM patients, which are substantial and driven fully by mild-risk patients. The survival model for mild-risk patients indicates a hazard ratio of approximately 0.55, corresponding to over 20% reduction in annual mortality; approximately 40% over the two year period. By contrast, the Cox model for severe-risk patients in Panel C shows no decline in hazard rates. Appendix Table F.8 presents these results in an interaction framework, formally testing the differential effect of ECM across risk groups.[39] Figure 3 (bottom row)

[38] We note that these estimates are not statistically significant when adjusted for multiple hypothesis testing, (Table F.7))

[39] Incorporating the mediation analysis from Table F.5, we estimate that the hyperlipidemia-statin channel is mechanically the largest biomedical channel for the reduction in preventable mortality, which however might be insufficient to meaningfully affect the mortality profile of the severe-risk patients, who already suffer from serious health issues.

illustrates these estimates as survival curves over the ECM period. We observe a growing gap between the effect size on the mild-risk patients versus the randomized control group. By contrast, we observe no impact of the ECM program on outcomes for the severe risk group, which closely tracks the control group across the entire period.[40]

While these mortality effects may seem large and immediate, similar effects have been found in interventions which significantly improve care for vulnerable populations. For example Card, Dobkin and Maestas (2009) found that Medicare reduced mortality by 20% among ER admittees over age 65 in California. In an experimental setting, Goldin, Lurie and McCubbin (2020) observed a 26% mortality reduction over two years from an intervention which induced uninsured Americans to access health insurance, with effects concentrated among middle aged and older adults. Miller, Johnson and Wherry (2021) similarly identify large and rapid reductions in mortality as a consequence of Medicaid expansion in the US, with annual mortality reductions between 7 and 12 percent over a four year period. We note that our participants are older and (as a function of ECM's eligibility criteria) already have multiple chronic health conditions.[41]

Taking this evidence together, the ECM program convincingly shifted doctor activities across their entire practice towards more holistic care and a more frequent recognition of some chronic health issues (but not acute conditions), and, for mild-risk ECM-enrolled patients, the additional effects of the relational change led to persistent and growing outcome differentials over the subsequent two years. These changes in care patterns had substantial impacts on the downstream mortality of such patients, but were unable to affect on mortality for patients with more advanced conditions. As expressed in our conceptual framework, the elasticity of response of health to the interventions induced by ECM for patients with a higher h_{ki} is greater. We interpret the difference between risk-classes as, in effect, patients with higher risk having been already locked into a low-health trajectory before the intervention.

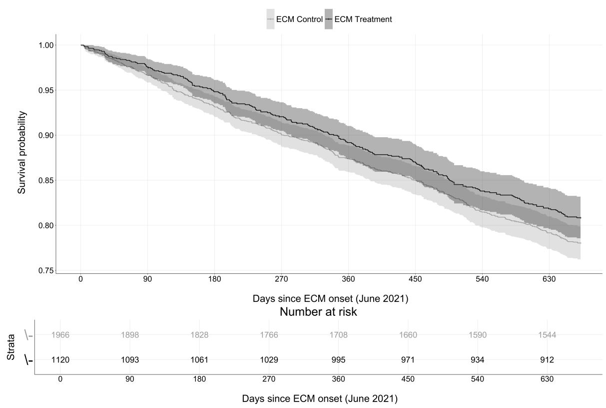
[40]Though our period of study does overlap with the period of the Covid pandemic, mortality differences are extremely unlikely to be attributable to differential care for Covid-19. First, ECM patients were in fact *less* likely to receive a Covid vaccination at baseline (Table 1) Second, they are *more* likely to be recorded as having had Covid at endline (Table 2). And third, the increasing survival differential indicates that our treatment effects arise from longer-term exposure to the program which occurred post-pandemic.

[41]A back-of-the-envelope calculation illustrates the coherence of our results with this literature. The magnitude of impact from increases in statin use likely arises from multiple channels. First, we see a 2.8pp increase in statin use on the extensive margin. Second, the total increase in statin usage of 5 percent implies an intensive margin effect of a similar magnitude. Third, these effects are applied twice in the mortality window. Additionally, there may be improvements in targeting, adherence, and so on due to the additional information providers received about the health of their patients, specifically targeting those with high expected impacts of early intervention. Together, these channels are assessed to explain 7.4% of our mortality results in the mediation analysis in F.5.

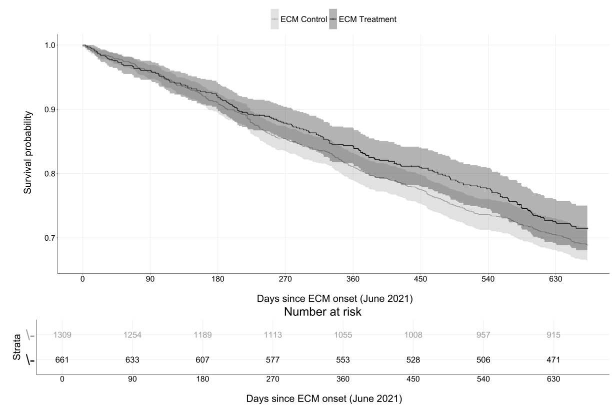
Moving patients, even those with pre-existing chronic conditions as in our study, towards a more holistic care plan, appears to be more effective when the intervention is early.

Figure 3: Survival curves: Hospitalization and mortality by risk group

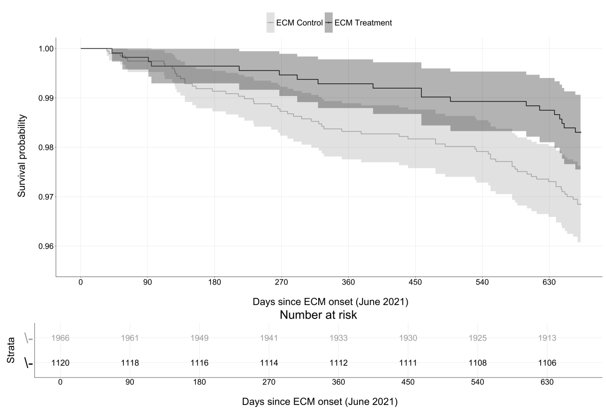
(a) Hospitalization: Mild-risk



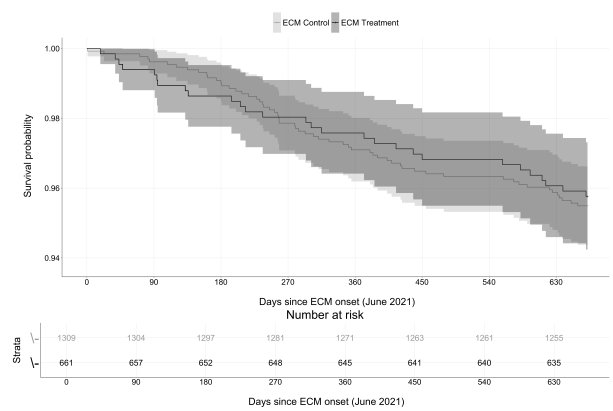
(b) Hospitalization: Severe-risk



(c) Mortality: Mild-risk



(d) Mortality: Severe-risk



Notes: Kaplan-Meier survival curves from ECM onset (May 2021). Top row: probability of remaining hospitalization-free. Bottom row: probability of survival (no mortality). Results shown separately for mild-risk (left) and severe-risk (right) patients. Shaded areas indicate 95% confidence intervals.

The appendices present an extensive set of additional analyses and robustness checks for these core results. Table F.1 compares ECM control patients to "pure control" patients at non-participating clinics, providing suggestive evidence of positive spillovers: ECM control patients show higher screening rates, consistent with doctors applying ECM practices more broadly. Tables F.2 and F.3 replicate our main ANCOVA results separately for mild-risk and severe-risk patients, confirming that effects persist within each subgroup. Table F.4 tests for heterogeneous treatment effects by clinic quality and patient characteristics, finding no systematic differences by provider attributes.

In Section F.4, we undertake mediation analysis to assess the extent to which the variation in mortality can be ascribed to features of ECM, such as more frequent consultations at the primary level and greater uptake of key prescriptions. We find that roughly half of the variation in our treatment effect on mortality for mild-risk patients is explained jointly by three core features of ECM: consultations, monitoring and prescriptions. These results are in line with recent literature emphasizing the importance of doctor engagement and the role of prescriptions in improving patient survival rates (Simeonova, Skipper and Thingholm, 2024; Chandra, Flack and Obermeyer, 2024; Posso, Saravia and Tamayo, 2024).

Table F.6 reports treatment-on-the-treated estimates using randomization as an instrument for actual ECM uptake, with effect sizes approximately 27% larger than ITT estimates, consistent with the uptake rate. Table F.7 adjusts for multiple hypothesis testing using Benjamini-Hochberg and Romano-Wolf procedures; the vast majority of main results survive these more stringent tests (although the hospitalization and statins effects in the population are not statistically significant under the Romano-Wolf adjustments). Figure F.2 similarly presents randomization inference for the survival analyses, confirming that the mortality reduction among mild-risk patients (randomization inference p-value = 0.021) is unlikely to be spurious. Table F.8 presents interaction models formally testing whether mortality effects differ by risk group; the interaction term confirms significantly larger effects for mild-risk patients. Table F.9 presents leave-one-clinic-out sensitivity analysis; treatment effect estimates remain stable when excluding any individual clinic.

Finally, Table F.10 bounds potential spillover and selection effects. We decompose these potential biases using two comparisons with our original ITT ANCOVA model. First, we compare ECM control patients versus patients at clinics that were assigned to ECM but *refused* to participate (Selection), which isolates clinic selection effects since both groups are at ECM-assigned clinics. Our worst-case assumption is that all improvement among ECM controls relative to refusers indicates selection bias – participating clinics may be systematically improving faster; we report a lower bound of the ITT minus the selection magnitude. Second, we compare ECM control patients versus pure control patients at non-ECM clinics (Spillover), which captures both selection and within-clinic spillover effects. Differential improvement among ECM controls relative to pure controls, beyond what selection explains, suggests positive spillovers to control patients and argues against effort reallocation from controls to treatment patients. The patterns suggest modest selection effects and potential positive spillovers, implying our within-clinic ITT estimates are conservative lower bounds on the true treatment effect. These comparisons should be interpreted with caution given baseline imbalances documented in Table F.1, but they provide useful context suggesting that neither selection nor spillover bias substantially alters our conclusions without strong assumptions on their magnitudes and components.

6 Discussion

The implicit contract structure in most healthcare provision has been based around responsiveness of providers to acute patient concerns. Such a 'reactive' healthcare approach does not systematize a broader plan for patient welfare. Though most primary care doctors in well-performing health systems conduct appropriate screenings, provide vaccinations, and advise 'healthy eating and exercise' broadly, there may be substantial gains in health outcomes from reframing the implicit contract between doctor and patient to one that targets the overall health of the patient and makes an individualized care plan towards that end. By broadening the doctor-patient lens to systematically go beyond individual, currently salient ailments to identifying and treating issues that may be latent or emerging, a broader plan of care may enable proactive treatment options for improving health outcomes. A frequent sentiment in healthcare is along the lines of 'an ounce of prevention is worth a pound of cure'. The question is how to economically systematize and effectively target that approach within a modern healthcare system (Newhouse, 2021). Decades of health financing and provider payment reforms aimed at incentivizing population health rather than health care have yielded mixed success.

Primary care, especially in family medicine-based systems such as Estonia, seeks to go beyond reactive curative care by creating enduring doctor-patient relationships, and by institutionalizing check-ups and screenings to identify latent health risks. Yet even in such systems, most primary care is de facto focused on specific complaints of acute ill-health by patients. This model does not maximize patient health, particularly for patients with unidentified latent and developing chronic conditions. Individuals will not identify these conditions at the point at which treatment optimally begins. Inadequate and delayed treatment imposes obvious burdens upon patients and the health system in general. Furthermore, given the externalities associated with individual ill-health, there may be a social cost of this sub-optimal level of treatment. Inducing doctors to undertake more holistic care including early diagnostics, especially for populations that are vulnerable to complications arising from chronic health conditions, may increase the likelihood of detection and treatment.

This paper evaluates the large-scale implementation of a holistic care program in Estonia

– Enhanced Care Management (ECM) – using a within-doctor patient-level randomization with risk stratification of eligible patients by the doctors. Eligible patients were identified using a common standard of chronic disease risk using records from the national health insurance fund, which covers 95% of people in the country. For ECM-enrolled individuals, the program shifts the intended relationship between the doctor and patient by the joint development of an explicit contract of care between the doctor and patient. Since there are no punishments for reneging on contract stipulations – as these would be impractical and inconsistent with the nature of the doctor-patient relationship – the intervention aimed to shift the implicit care "contract" between the two parties towards a holistic plan for long-term patient welfare.

The availability of comprehensive data for medical claims, diagnoses, and prescriptions – including hospitalization and mortality – for the universe of covered citizens in Estonia allows us to obtain well-powered estimates of ECM program effects on provider behavior and patient outcomes across treatment and control patients at the same clinic. We are further able to investigate spillovers by comparing untreated patients at treatment clinics with eligible patients at control clinics; and to disaggregate effects by the provider-assessed patient health status within treatment clinics. These allow us to bound potential downward biases for within-doctor comparisons (driven by doctor-wide treatment effects relative to non-ECM doctors) as well as potential upward biases (driven by reallocation of effort from control to treatment patients by the same doctors). We identify very minor possible upward biases due to effort reallocation; by contrast, we identify substantial potential spillovers to non-enrolled patients at ECM doctors, suggesting that our within-doctor comparisons are a lower bound of total treatment effects.

We find that the introduction of a patient contract for holistic care meaningfully increases screening, diagnosis, and prescriptions for key chronic tracer conditions by an average of about 10% among treated individuals, at relatively low additional cost to clinics in terms of doctor or nurse time. Rather, the contract seems to shift the nature of care provided. We further observe suggestive downstream effects on hospitalization in the overall sample (8% decline, $p=0.068$); and we identify large and significant reductions in mortality risk among mild-risk patients (as large as 20% annual reduction in mortality). These shifts are in-line with a simple conceptual framework in which relational incentives for holistic care induce doctors to identify health problems earlier than patients and begin treatment closer to an optimal level (Porter et al., 2013). This is effective where the elasticity of response of health status to intervention is higher; typically conceived of being at higher levels of baseline health.

While similar interventions have been implemented in settings with large populations facing multiple chronic conditions, high quality evidence about the effects of these programs is still relatively rare (Stokes et al., 2015; Powers et al., 2020; Smith et al., 2021). This study is relatively unique in being able to connect shifts in care plan agreements to changes in service provision to impacts on patient welfare. It does so at a national scale, presenting estimates with strong external validity to the wider health system.[42] These results suggest that in some contexts, a relatively limited intervention, focused on shifting the nature of the care relationship through explicit care planning, can have substantial impacts on healthcare and public service delivery.

Several features of the Estonian context merit consideration when assessing the transferability of these findings. First, Estonia's single-payer universal coverage system facilitated both implementation and measurement: EHIF's comprehensive billing records enabled precise outcome tracking, and universal coverage meant that access barriers did not confound treatment effects. Second, Estonia's family medicine model, with patients registered to specific providers and relatively stable doctor-patient relationships, may have enhanced the effectiveness of care plan agreements that rely on ongoing engagement. Estonia's blended primary care payment model, with a strong capitation component, also likely facilitated greater focus on holistic and preventive care. Third, Estonia has approximately 800 family doctors serving 1.3 million people, yielding patient panels of roughly 1,600 patients per doctor, which is smaller than in many countries and may facilitate more personalized care. Policymakers considering similar interventions elsewhere should assess whether their primary care systems have sufficient provider capacity and (informational) continuity of care to support enhanced care planning, especially given that our heterogeneity results suggest a "Goldilocks problem" that impacts depend heavily on identifying people at early stages of chronic disease – neither too early nor too late – for such an intervention to be (cost-)effective. In fragmented health systems with high patient turnover or severe provider shortages, adaptations may be necessary. Appendix B provides detailed documentation of the ECM intervention components that would need to be adapted for other settings.

This study is an early contribution to research on how care relationships between providers and beneficiaries can be shifted through explicit care planning in public service delivery,

[42] Another strength is the trial's reliance on health system billing records. Using this administrative data source has reduced the cost of the trial and means that the methods and outcomes can be used in other studies and the treated cohorts can be studied longitudinally using the same administrative data source.

and how that relationship can be formulated for better service delivery outcomes. We show that there exists a substantial share of the population who can realize economically meaningful care and health improvements from such an approach in line with theory; yet we also show that there are informational and practical challenges which contribute barriers to targeting and implementation of relational contracts without health system support and guidance. There is a need to understand the response of beneficiaries to stronger relational care "contracts", in this case care plans and holistic care relationships. Given the significance of providers in mediating the welfare outcomes of many beneficiaries of public services, there would seem to be a rich agenda ahead in assessing how relational care "contracting" might impact health systems and broader provider-beneficiary interactions in an individual's human capital investments.

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Appendix: For Online Publication

A Conceptual framework

Let a patient's health status h across k domains be h_{ki}, in which the optimal treatment approach is where treatment is activated when $h_k < h_k^*$. h_{ki} is stochastic and follows a distribution $f(h_k)$, with $prob[h_k < h_k^*] = \alpha$. The patient reports their health status has dropped to $\hat{h}_k$ when $h_k < \hat{h}_k < h_k^*$, at a health status strictly less than when treatment optimally begins. This occurs with probability, $prob[h_{ki} < \hat{h}_k] = \beta$.

Let us assume that the doctor is motivated by the linear sum of her patient's health. Without information on the health of a patient in a particular domain, the doctor assigns its expectation to an individual, $h_{ki} = E[h_k]$, where in most domains, $E[h_k] > h_k^*$. For simplicity we assume that at baseline the doctor does not pay for diagnostics nor recommend treatment for any of her patients based on this fact.

Suppose that the care plan provides the doctor with a technology to collect data on a series of characteristics, x_i, for each patient. For some set of characteristics, x', $E[h_k|x'] < h_k^*$. In this case, the doctor refers the patient with characteristics x' to treatment. Where $\hat{h}_k < E[h_k|x'] < h_k^*$, treatment begins before the patient themselves would have requested it. This can be seen as a direct informational benefit of the care plan intervention.

The doctor can also pay c to identify h_{ki} precisely through undertaking a diagnostic test.[43] If the diagnostic indicates that $\hat{h}_k < h_k < h_k^*$ then treatment can begin and the doctor (and patient) receives a positive benefit from treating the patient before the patient would have requested initiation. If the diagnostic indicates that $h_k > h_k^*$, there is no supplement in patient health and the doctor has invested c without return.

In a similar logic to the above, where the care plan provides a novel means of learning x_i, the doctor gains motivation to undertake a diagnostic test when the conditional expectation of health status falls within a strict subset of the distribution that includes $\hat{h}_k < E[h_k|x'] < h_k^*$.

The relational aspect of the interaction arises from the fact that once diagnosed, the patient must decide whether to adhere to treatment, or not. Adherence costs the patient γ_{ki}, which is idiosyncratic to the patient, follows a distribution $g(\gamma_k)$, and is only observed after the

[43] We can conceive c as being made up of a financial component, c_f, and a personal component, c_p, that is the effort cost of diagnosis including the cognitive, emotional and administrative resources the doctor must invest to engage with the diagnostic process. For example, there is evidence that doctors are sensitive to cost shocks for diagnostic processes (Clemens and Gottlieb, 2014), as well as being sensitive to aspects of their inter-personal relations with patients (Schoenthaler et al., 2012).

diagnostic investment has been made and treatment begun. The patient adheres to the treatment if they perceive the benefits greater than the cost. If the patient adheres to treatment, which occurs with probability $g(\gamma_{ki} < \gamma_k^*)$, the actors get a payoff normalized to 1. If the patient does not adhere to treatment, they get a payoff of 0.[44]

As such, the doctor maximizes,

$$U_D = -c\sum_i T_{ki} + (\alpha' - \beta')A_i \sum_i T_{ki} + \beta' A_i$$

where $T_{ki} \in \{0, 1\}$ is investment in a diagnostic test for domain k of the health of i, $A_i \in \{0, 1\}$ is the adherence of patient i to treatment, $prob[h_k < h_k^*|x'] = \alpha'$, and $prob[h_{ki} < \hat{h}_k|x'] = \beta'$.

And the patient maximizes,

$$U_i = (\alpha' - \beta')T_{ki}(-\gamma_{ki}A_i + A_i) + \beta'(-\gamma_{ki}A_i + A_i)$$

In this scenario, the patient wants the doctor to undertake the diagnostic since it costs them nothing and then provides them with an option value of treatment, but wants to then decide whether to adhere to treatment or not based on their individual experience of the treatment. The doctor wants to invest in diagnostics only when $\hat{h}_k < h_k < h_k^*$ and the patient will adhere to treatment.

In a one-shot interaction, the doctor undertakes diagnostics for domain k when $c < [(\alpha' - \beta')g(\gamma_{ki} < \gamma_k^*)]$. Note that where $\alpha - \beta$ (equivalently $h_k^* - \hat{h_k}$) is large, the doctor is more likely to invest in a diagnostic. It is in this case that the information value of a diagnostic test is most valuable since patient signals are a poor predictor of the distance of true health to h_k^*.

The care plan introduces both a direct information and a repeated game element in which the doctor and patient can monitor and (relationally) punish each other for a lack of adherence to the care plan. Suppose that the patient discounts next period utility by δ and we use trigger strategies to illustrate the point. As such, the patient must now weight the cost of adherence today against the option value of diagnostics and potential health gains from treatment tomorrow.

The patient now values today's adherence at $1/(1 - \delta) > 1$ of the one-shot utility from

[44]While the conditional distributions of the parameters could be distinct to the unconditional, we leave the interaction out of the discussion for simplicity.

adherence, inducing the patient to adhere to treatment with a higher probability, and the doctor to undertake greater diagnostic work, since the probability of a positive payoff is greater. The doctor now undertakes diagnostics when $c < [(\alpha' - \beta')(1/1 - \delta)g(\gamma_{ki} < \gamma_k)]$.

This discussion indicates the various features of the care plan's impact: the first is to make more precise identification of patients who may benefit from diagnostics; the second can be seen as an indirect informational feature, in which the doctor is induced to undertake greater diagnostic work due to the patient's adherence behavior; and the third is that there is a greater incentive for the patient to adhere to treatment once it is prescribed.

B Description of ECM Treatment

This appendix provides a comprehensive description of the Enhanced Care Management (ECM) intervention evaluated in this study, drawing on the World Bank DIME project documentation (World Bank, 2022).

B.1 Core Philosophy and Objectives

The ECM program was designed as a holistic care management approach for chronically ill patients in Estonia. The intervention aimed to shift the healthcare system from reactive, episodic treatment toward proactive, continuous care coordination. According to the project documentation, the program was built on the premise that effective chronic disease management requires more than clinical treatment –it requires active patient engagement, coordinated care teams, and personalized health goals (World Bank, 2022).

The program's primary objectives were to improve health outcomes for chronically ill patients through proactive care management, increase patient engagement and self-management capabilities, reduce preventable hospitalizations and emergency care utilization, enhance care coordination across providers and settings, and test the feasibility of scaling holistic care approaches within Estonia's single-payer system administered by the Estonian Health Insurance Fund (EHIF).

B.2 Four Key Elements of ECM

The ECM intervention comprised four integrated components, as specified in the implementation protocol (World Bank, 2022).

The first element was risk stratification. Patients were identified and stratified based on their chronic disease burden and healthcare utilization patterns. EHIF used health records indicators to classify patients into at-risk categories. Later, treated physicians holistically separated eligible patients into mild/moderate risk, comprising patients with controlled chronic conditions requiring routine monitoring; and severe risk, comprising patients with multiple comorbidities, poor disease control, or high utilization history.

The second element was the development of care management plans. Central to the intervention were individualized care plans developed collaboratively between patients and their care teams. These written agreements specified the patient's current health status and diagnoses, specific and measurable health goals, action steps for both patient and provider, a timeline for follow-up and reassessment, and the patient's signature indicating their commitment to the plan.

The third element was proactive linking. Rather than waiting for patients to seek care when symptoms arose, ECM required providers to proactively reach out to enrolled patients. This proactive approach included scheduled check-ins, appointment reminders, and follow-up contacts to ensure care plan adherence.

The fourth element was a team approach to care delivery. ECM emphasized multidisciplinary care coordination involving primary care physicians (family doctors), nurses with expanded care management roles, specialists as needed for specific conditions, and administrative support for scheduling and tracking.

B.3 ECM Service Codes and Reimbursement

To track ECM activities and provide appropriate reimbursement, EHIF established specific billing codes for ECM services (World Bank, 2022). These codes allowed systematic monitoring of intervention fidelity and formed the basis for measuring treatment take-up in our analysis. The service codes covered initial patient assessment and risk stratification, care plan development sessions, follow-up consultations conducted both in-person and by telephone, care coordination activities, and patient education and self-management support. Reimbursement rates were set to incentivize comprehensive care management while remaining fiscally sustainable within EHIF's budget constraints.

B.4 Care Plan Design and Content

Care plans served as the contractual foundation of the ECM intervention (World Bank, 2022). Each plan was designed to be patient-centered, with goals and actions tailored to individual circumstances, preferences, and capabilities. Plans were required to be specific and measurable, with clear targets such as HbA1c levels, blood pressure ranges, or weight goals rather than vague aspirations. Importantly, plans were developed collaboratively through shared decision-making rather than physician dictation, and were formalized as written documents signed by both patient and provider. Care plans typically addressed medication adherence and management, lifestyle modifications including diet, exercise, and smoking cessation, monitoring schedules for lab tests, vital signs, and symptoms, warning signs requiring immediate attention, and communication protocols between visits.

B.5 Provider Training and Support

Implementation of ECM required substantial investment in provider capacity building (World Bank, 2022). Participating clinics received initial training on the ECM philosophy and its evidence base, care plan development techniques, motivational interviewing and patient engagement strategies, use of ECM billing codes and documentation requirements, and quality improvement methods.

Throughout the intervention period, clinics had access to ongoing support including technical assistance from the EHIF implementation team, peer learning networks with other ECM clinics, performance feedback reports, and troubleshooting support for administrative issues.

Notably, ECM did not include new medications or treatments beyond standard care, additional specialist referrals or diagnostic tests, financial incentives provided directly to patients, home health services or community health workers, electronic health record system changes, or changes to insurance coverage or cost-sharing. The intervention was deliberately designed as a change to how care was delivered –altering how existing resources were organized and deployed –rather than a change requiring new infrastructure or services.

B.6 Care Plan Examples

The following pages present three examples of care plans developed as part of the ECM program. These documents, shown in their original Estonian with English translations, illustrate the structure and content of the contracts that the ECM program induced doctor-patient teams to co-develop. They demonstrate the specificity and collaborative nature of ECM care planning in practice.

[redacted] [redacted]

24h Perearsti nõuandetelefon 1220

PATSIENT

LÄHEDANE

Treatment plan

Raviplaan

Next consultation

JÄRGMINE KONSULTATSIOON: 22.02.2024

TERVISENÄITAJAD

Health indicators

TERVISENÄITAJA	INDIVIDUAALNE EESMÄRK	VÄÄRTUS
Vererõhk parem käsi	120(100-140) / 80(70-90)	166/91 (03.08.2023)
Kehakaal		96 (03.08.2023)
Kehamassiindeks (KMI)	18.5-25	37 (03.08.2023)
Vererõhk parem käsi	120(100-140) / 80(70-90)	115/72 (22.11.2023)
Kehakaal		93 (22.11.2023)
Kehamassiindeks (KMI)	18.5-25	35.9 (22.11.2023)

Health indicators
Health indicator — Individual goal — Value

Blood pressure right arm
Body weight
Body mass Index (BMI)
Blood pressure right arm
Body weight
Body Mass Index (BMI)

HAIGUSED

HAIGUS	KOOD
Hüpertooniatõbi e essentsiaalne e primaarne arteriaalne hüpertensioon e kõrgvererõhktõbi	I10
Rasvumus	E66

Diseases
Disease

Hypertension, essential, primary arterial, hypertensive disease
Obesity

RAVIMID

RAVIM	TOIMEAINE	ANNUSTAMINE	HAIGUS	MÄRKUS
	Perindoprilum+Indapamidum, 2,5mg+0,625mg	1 tablett 1 korda päevas	I10	

Medications
Medicine — Active substance — Dosage — Disease — Note

1 tablet 1 time a day

NÕUANNE JA TEGEVUSKAVA

Helistage 112, kui Te ei saa hingata, tekib tugev äkkvalu või ei saa liigutada kätt, jalga, nägu (ei saa vilistada). Muu erakorralise terviserikke korral pöörduge lähima haigla erakorralise meditsiini osakonda (EMO). Esimesel võimalusel teavitage tekkinud olukorrast perearsti

Advice and action plan
Call 112 when you can’t breathe, you experience severe sudden pain or you can’t move your head, leg, or face (you can’t whistle), in case of other emergency health problems go to the emergency department of the nearest hospital (ER). As soon as possible inform your family doctor about the situation.

Söön regulaarselt ja väikeseid koguseid, õhtul piiran suurte toidukoguste söömist.
Jätkan igapäevaselt liikumist, et kehakaal langeks. Ujun 3x nädalas.
Proovin liikuda päevas 6000 sammu. Ravimeid võtan regulaarselt.
Mõõdan ja jälgin kodus vererõhku.
Vähendan toidus, soola, suhkru ja kõvade rasvade sisaldust.
Proovin langetada kuus 1-2 kg kehakaalu. 1 kg juba langenud
Kaal langenud 3 kuuga 3 kg, RR raviga normaliseerunud, RR kodus 115/75 mmhg piires, ujub 1 x nädalat. õhtul toidukogust piiranud. Jätkab kaalu langetamist. Kontroll 3 kuu möödudes.

Kui täheldan enesetundes muutusi (rindkerevalu, peavalu vm), teavitan koheselt oma perearsti/pereõde.

Erakorralise haiglasse sattumise korral teavitan sellest ka oma perearsti/pereõde.

OLULISED KONTAKTID

Perearstikeskus [redacted]
perearstid
Perearst [redacted]
Abiarst [redacted]
Pereõde [redacted]
Pereõde [redacted]
Tel. [redacted]
E-R 8.00 – 16.00
24h avatud Perearstide nõuandeliin 1220

Kiirabi 112

I eat regularly and in small amounts, in the evening I limit eating large amounts of food.
I continue to exercise daily to lose weight. I swim 3 times a week.
I measure and monitor my blood pressure at home.
I try to walk 6000 steps a day. I take medicine regularly
I reduce the content of salt, sugar and hard fats in food. I try to lose 1-2 kg of weight per month. 1 kg already dropped
Weight lost 3 kg in 3 months, normalized with RR treatment, RR at home within 115/75 mmhg, swims once a week. limited the amount of food in the evening. Continues to lose weight. Check after 3 months.
If I notice changes in how I feel (chest pain, headache, etc.), I immediately inform my family doctor/family members.
In the event of an emergency hospitalization, I will also inform my family doctor/family nurse
IMPORTANT CONTACTS
Family doctor's centre Family docto[redacted]
family doctors
Family doctor [redacted]
Assistant docto[redacted]
Family nurse [redacted]
Tel[redacted]
Mon-Fri 8:00-16:00
24-hour family doctor advice line 1220

Helistage 112, kui Te ei saa hingata, tekib tugev äkkvalu või ei saa liigutada kätt, jalga, nägu (ei saa vilistada). Muu erakorralise terviserikke korral pöörduge lähima haigla erakorralise meditsiini osakonda (EMO). Esimesel võimalusel teavitage tekkinud olukorrast perearsti

Call 112 when you can’t breathe, you experience severe sudden pain or you can’t move your head, leg, or face (you can’t whistle), in case of other emergency health problems go to the emergency department of the nearest hospital (ER). As soon as possible inform your family doctor about the situation.

Treatment plan

Raviplaan

[redacted]

Viimane perearsti või pereõe visiit08.11.2023

Next consultation

JÄRGMINE KONSULTATSIOON:

TERVISENÄITAJAD

Health indicators
Health indicator

Blood pressure
Body weight
Body Mass Index (BMI)

Individual goal | **Value**

TERVISENÄITAJA	INDIVIDUAALNE EESMÄRK	VÄÄRTUS
Vererõhk	120(100-140) / 80(70-90)	140/100 (21.09.2022)
Kehakaal		110.000 (21.09.2022)
Kehamassiindeks (KMI)	18.5-25	32.1 (21.09.2022)

HAIGUSED

Diseases
Disease

Non-insulin dependent diabetes mellitus
Disorders of lipoprotein metabolism and other lipidaemia
Panic disorder
Hypertension essential arterial hypertension
Gastroesophageal reflux disease without esophagitis

HAIGUS	KOOD
Insuliinisõltumatu suhkurtõbi	E11
Lipoproteiiniainevahetuse häired ja muud lipideemiad	E78
Paanikahäire	F41.0
Hüpertooniatõbi e essentsiaalne arteriaalne hüpertensioon	I10
Ösofagiidita gastro-ösofageaalne tagasivooluhaigus	K21.9
Prostatahüperplaasia e eesnäärmesuurenemus	N40

RAVIMID

Medications
Medicine

Active substance | **Dosage** | **Disease** | **Note**

RAVIM	TOIMEAINE	ANNUSTAMINE	HAIGUS	MÄRKUS
	Vortioxetinum 5mg 56TK, õhukese polümeerikattega tablett	1 tablett 1 x päevas	F32.1	meeleolule

1 tablet 1 time a day | mood

Helistage 112, kui Te ei saa hingata, tekib tugev äkkvalu või ei saa liigutada kätt, jalga, nägu (ei saa vilistada). Muu erakorralise terviserikke korral pöörduge lähima haigla erakorralise meditsiini osakonda (EMO). Esimesel võimalusel teavitage tekkinud olukorrast perearsti [redacted]

Call 112 when you can't breathe, there is a sudden severe pain or you can't move your head, leg, face (can't whistle), in case of other emergency health problems go to the emergency department of the nearest hospital (ER). As soon as possible inform your family doctor about the situation.

	Esomeprazolum 40mg 56TK, gastroresistentne kõvakapsel	1 kapsel 1 x päevas raviminfo järgi	K21.9	maokaitse
	Metforminum 500mg 120TK, õhukese polümeerikattega tablett	1 tablett 2 x päevas	E11	alustab diabeediravi
	Moxonidinum 0.4mg 60TK, õhukese polümeerikattega tablett	1 tablett 1 x päevas	I10	vererõhule
	Atorvastatinum 20mg 60TK, õhukese polümeerikattega tablett	1 tablett 1 x päevas õhtul	E78	kolesterooli alandav
	Metforminum+Empagliflozinum 1000mg+12.5mg 120TK, õhukese polümeerikattega tablett	1 tablett 2 x päevas	E11	diabeediravi tõhustamine, uus kombineeritud preparaat lisatud

Gastric protection
Begins diabetes treatment
To blood pressure
Cholesterol lowering
Diabetes treatment enhancement, new combined preparation added

1 capsule 1 x day, see drug information; 1 tablet 2 x day; 1 tablet 1 x day
1 tablet 1 x day evening' 1 tablet 2 x day

NÕUANNE JA TEGEVUSKAVA

Eesmärk I alustab diabeediravi, lähieesmärk normaliseerida veresuhkru näitajad,võiks ravi foonil olla vahemikus 6-6,3 mmol/l
II hoida sidet psühhiaatriga, tarvitada meeleolu rohtu ja tagasilanguse korral kindlasti taaspöörduda psühhiaatrile. Pats toetab pere ja teavitatud ka võimalusest psühholoogi seansse saada perearsti teraapiafondi kaudu. Uuus kontakt 6 nädala pärast.
III eesmärk alustada uuesti või jätkata statiinraviga.
19.12.2022 II visiit - pats 6kuud suitsuvaba, on motiveeritud jätkama elustiili muutust. Vereanal ravi foonil üldkolesterool, LDL, glükoos languses, kolester isegi eesmärkväärtuses. Teadlik ravimitest ja jätkab ravimite tarvitamist. Antidepr ravi foonil meeleolu parem, tagasilangust ei ole hetkel olnud. Eesmärk hoida hetketulemust. Uus visiit 03.2023 kokku lepitud
*27.03.2023 Riskipats III visiit, kokkuvõtete tegemine. Meeleolu pos dünaamikaga. 03.2023 viimane psühhiaatri visiit, suunatud edasi vaimse tervise õe jälgimisele. Suitsetamine ei, alkohol ei. HbA1c 7,4 %
Glükoos 13,3 mmol/l. Glükoosiväärtused 3 kuu jooksul hüppeliselt tõusnud. D vit väärtus madal, pole D vit juurde tarvitanud. Uus eesmärkväärtus on tõhustada diabeediravi. Kolesterooliväärtused eesmärkväärtuses ravi foonil. Diabeediravi tõhustatud, lisatud kombineeritud ravipreparaat. Kontroll 2kuu pärast

Advice and action plan

Goal I is to start diabetes treatment, the main goal is to normalize blood sugar levels in the background of treatment. Should be in the range of 6-6.3 mmol/l. I keep in touch with the psychiatrist, use mood medicine and in case of relapse, definitely return to the psychiatrist. Patient supports the family and has also been informed of the possibility of receiving psychologist sessions through the family doctor's therapy fund. New contact in 6 weeks.
Objective III restart or continue statin therapy
19.12.2022 II visit - patient 6 months smoke-free, is motivated to continue the lifestyle change. Against the background of intravenous treatment, total cholesterol, LDL, glucose are decreasing, cholesterol is even at the target value. Aware of medication and continues to take medication. The mood is better on the background of Antidepr treatment, there has been no relapse at the moment. The goal is to keep the current result. New visit 03.2023 arranged
27.03.2023 Risky patient III visit, making summaries. Mood pos. with dynamics. 03.2023 last psychiatrist's visit, forwarded to follow-up by a mental health nurse. No smoking, no alcohol. HbA1c 7.4% Glucose 13.3 mmol/l. Glucose values have skyrocketed within 3 months. D vit value low, did not take more D vit. The new target value is to enhance diabetes treatment Cholesterol values in the target value against the background of treatment. Diabetes treatment enhanced, added combined treatment preparation. Check after 2 months.

Treatment plan

Raviplaan

[redacted]

Viimane perearsti või pereõe visiit: 08.11.2023

Next consultation

JÄRGMINE KONSULTATSIOON: 24.11.2023

TERVISENÄITAJAD

Health indicators

TERVISENÄITAJA	Health indicator	INDIVIDUAALNE EESMÄRK (Individual goal)	VÄÄRTUS (Value)
Vererõhk	Blood pressure	120(100-140) / 80(70-90)	180/120 (31.08.2023)
Vööümbermõõt	Waist circumference	<102	110.00 (15.10.2021)
Kehakaal	Body weight		113.500 (30.08.2023)
Kehamassiindeks (KMI)	Body Mass Index (BMI)	18.5-25	35.4 (30.08.2023)

HAIGUSED

Diseases

HAIGUS (Disease)	KOOD
Hüpertooniatõbi e essentsiaalne arteriaalne hüpertensioon (Hypertension essential arterial hypertension)	I10

RAVIMID

Medications

RAVIM (Medicine)	TOIMEAINE (Active substance)	ANNUSTAMINE (Dosage)	HAIGUS (Disease)	MÄRKUS (Note)
	Perindoprilum+Amlodipinum 10mg+5mg 30TK, tablett	1 tablett 1 x päevas (1 capsule 1 x day)	I10	Vererõhule 1x H (For blood pressure 1 x H)
	Olmesartanum medoxomilum 20mg 28TK, õhukese polümeerikattega tablett	1 tablett 1 x päevas (1 capsule 1 x day)	I10	Uus vererõhu preparaat, 1 tbl H (New blood pressure preparation 1 tbl H)

NÕUANNE JA TEGEVUSKAVA

Riskipats I visiit: RR 180/120 mmHg, kaal 113,5 kg, KMI 35,4. Pikemas perspektiivis sooviks ise kaaluda 99 kg. Lähieesmärk 2-3 kg kuus kaalu langetada. Abikaasa toetus

Advice and action plan

Risky patient I visit: RR 180/120 mmHg, weight 113.5 kg, BMI 35.4. In the long term, I would like to weigh 99 kg. The immediate goal is to lose weight by 2-3 kg per month. Spousal support…

olemas, pidasid plaani alustada septembris Fitlapi toitumisprogrammi järgi. See oleks pats eriti mugav variant kui teine pereliige ka toitumist jälgib ja toidu valmistab. Alkoholi osas pigem eelistab kokteili kange alkoholiga. Alkoholiühikut ei oska välja tuua. II eesmärk: tervisekampaania "Septembris ei joo" on suurepärane võimalus kaasa minekuks ja pidada 4 nädalat alkoholipaastu.
Eesmärk III: Hoida RR väärtused kontrolli all. Alustab ravi uue RR preparaadiga, jälgida RR väärtuseid, võimalusel RR päevik. Uus visiit 4 nädala pärast.
29.09 vahevisiit, RR ravim kõrvaltoimega+ raviefekt väike. Vahetame preparaadi. RR 150/113 mmHg, saatekiri kardioloogile, uuringud

…available, planned to start following the Fitlap nutrition program in September. This would be a particularly convenient option if another family member also monitors the diet and prepares the food. Regarding alcohol prefers a cocktail with strong alcohol. Can't figure out the alcohol unit. Goal II: the health campaign "Don't drink in September" is a great opportunity to go along and observe an alcohol fast for 4 weeks. Goal III: Keep RR values under control. Starts treatment with a new RR preparation, track RR values, if possible RR diary. Another visit in 4 weeks. 29.09 intermediate visit, RR drug with side effect + treatment effect small. Let's change the preparation. RR 150/113 mmHg, referral to a cardiologist, examinations

C Chronic patients' registry

In this subsection we present the step-by-step approach taken by EHIF to determine whether a patient is ‘chronically ill’ and therefore eligible for the ECM programme.

1. **Aim**

Aim of the current development request is to generate chronic condition patient's registry based on EHIF (Estonian Health Insurance Fund) data. New registry and tool will help FP (family physician) better identify, treat and follow-up patients with chronic conditions.

2. **Changeable business process. Source data**

Generate web based registry that consists of patients´ **data presented by EHIF.**
Displayed on dashboard as following (marked in bold in Estonian):

- **Isikukood** (patient national id)
- **Patsiendi nimi** (patients name)
- **Vanus** arvutatakse isikukoodist (päringu tegemise hetkel) (Age, calculated from national ID code on each query)
- **Patsiendi kontaktid** (aadress, telefon) pärineb kindlustatute registrist (Personal info: address, phone etc.) from the Registry of the Insured
- **Jälgimisel** – väärtused jah/ei (Type of Patient - Known or unknown),
- **Metaboolse triaadi kombinatsioon** - ("Combination of Triad)-
  Displayed in 3 separately columns, by dgn of following diseases (accordinf to ICD-10 classificator):
  1. E10-E14 (diabeet),
  2. I10-I15 (hüpertensioon),
  3. E78 (hüperlipideemia)
- **Ravi järgimine (triaadiga seotud)** (Adherence to treatment)
  - If a patient did not buy any of prescribed medicaments from class A10A or A10X or A10B for diagnosis E10-14 during 90 days, display notification sign in report.
  - If a patient did not buy any of prescribed medicaments from class C02-C03, C06-C09 diagnosis I10-I15 during 90 days, display notification sign in report, exclude C01, C04 ja C05.
  - If a patient did not buy any of prescribed medicaments from class C10AA, C10BA, C10BX diagnosis E78 during 90 days, display notification sign in report.

  *Interval of 90 days is due to the fact that the majority of them belonging to the group of medicines are available in large (90 tbl) packs.

- **Sihtrühma kuulumine (surnud, vahetanud nimistut)**

Identify whether patient belongs to list or not, died during pilot. Data is received/collected from the register. Display one of the exclusion reasons – doctor cannot change it.

- **Arhetüüp** (Distribution of Patients Across Different Archetypes):
- **Kaasuvad haigused** (Total Number of Comorbidities) – kuvatakse NR, võimalik näha ka täpsemalt haiguseid patsiendi kohta
- **Viimane haiglaravi ehk statsionaarne** ("Last hospital discharge between 01.01.2015-today)"
- **Viimane perearsti visiit** (ajavahemikul 01.01.2015-today) = "Last FP visit at pilot start")
- **Sotsiaalne staatus (**Social & behavioural conditions), Identify whether patient is insured with insurance type 11, 27, 26, 34 12, 42,44,45,49,50. **Displayed on dashboard as**

X	✓

Näidata koodi (võimalusel)

And **data inserted by FP**:

Patsiendi välistamise põhjus, valida sobiv põhjus loendist: (Välista need patsiendid, kellel on vähem kasu piloodis osalemisest) ("Patient to be excluded, Reason for exclusion (from drop-down list)", süsteem talletab muudatuse kp – muuta saab korduvalt, piiranguid ja kontrolle ei ole

- **Psüühika probleemide tõttu ettearvamatu/ohtlik** (Safety considerations)
- **Ravi taktikaliselt liiga keeruline** (Severity)
- **Sotsiaalselt/käitumuslikult liiga suurte erivajadustega** (Patients in complete denial/unable to understand their condition(s)
- **Ei soovi osaleda/tuleb iseseisvalt toime** (Patients well-versed and knowledgeable about their needs with a high ability for self-care may not benefit from additional resources)

    - **Mujal ravil** (Existing relationships with other providers such as specialist physicians (e.g. oncologist), private care managers, or institutional care providers (group homes, assisted living)
- **Osalemise kutse edastamine** ("Patient Invited (Date)"
- **Patsiendi nõustumine** ("Patient Accepted (Date)"
- **Raviplaan** (Hyperlink – eraldi avatav vaade kus osaliselt sisestatavad väljad) (Care plan) consisted of following 16 fields, sama vorm prinditavana pdf-s:
  ***Patsiendi nimi** –use same data that found previously
  ***Isikukood** –use same data that found previously
  ***Patsiendi tel nr** - use same data that found previously
  ***Patsiendi sugulase tel nr** – inserted by FP
  ***Ravimid** (Nimekiri kõigist ravimitest, mida patsient hetkel võtab) – data from "EHK Retseptikeskus". Ainult ATC koodid, viimane väljaostmise kuupäev, ajavahemikul 01.01.2015-31.12.2016
  ***Patsiendi tervise vajadused** (Kokkuvõte kõikidest aktiivsetest meditsiinilistest probleemidest ja põhiküsimustest, mida patsient soovib lahendada; patsiendi tervisevajadused, sealhulgas sotsiaalsed probleemid ja kaasuvad haigused) (free text field –inserted by FP (max 200 signs)
  ***Patsiendi eesmärgid** (Sõnastage iga eesmärk konkreetse, mõõdetava ja täitmise tähtajaga) (free text field inserted by FP, max 200 signs)
  ***Perearsti meeskonna koosoleku viimane kuupäev** – dates for case management meetings inserted by FP during the 01.02-31.08.2017
  ***Tegevusplaan** (selge tegevuskava, mida patsient ja ravimeeskond peaks kokkulepitud eesmärkide saavutamiseks järgima) (free text field inserted by FP (max 200 signs)
  ***Oluliste kontaktide nimekiri** (Nende hulka kuuluvad perearstikeskuse telefoni number, tööajaväline telefoninumber, ravimeeskonna õe kontaktinformatsioon) (free text field inserted by FP (max 200 signs)
  ***Ravi ülekandumine (**Sõnastage, mida patsient peaks tegema haiglasse sattumisel (nt helistama ravimeeskonnale, teavitamaks perearsti/õde) (care transitioning free text field inserted by FP (max 200 signs)
- **Haiglaravi kuupäev (piloodi ajal) (Hospital Discharge Dates)**
- **Viimane telefonikõne patsiendile** (kpv) (Phone Call Dates)
- **Järgmise visiidi kuupäev (**"Next appointment", Date)
- **Sotsiaalsete vajaduste tuvastamise kp (**"Social Need Identified (Date)"
- **KOV/Sotsiaaltöötajaga suhtlemise viimane kp (**Social Resource Connection Made (Date)

Main terminology through the whole document

- 24 months preceding the reference period of the algorithm = 01.01.2013-31.12.2014
- The reference period for the algorithm (i.e. timeframe over which diagnoses are considered) is the last 24 months = 01.01.2015-31.12.2016
- The reference date is the date of running the algorithm (e.g. the date when the pilot is supposed to start) = 01.02.2017
- **FP** = Family practitioner (perearst/PA)
- **Claim** = claim for provided treatment (**RTA** haigekassa mõistes) not prescription nor card for medical device)
- **Date of claim =** in current document we use **closing/completion date of claim** (raviarve lõpetamise kp)

Claims for specialist care
Ravitüüp 1; 2; 15; 16; 18; 19; 20
Pakitüüp: 70;71;20;85

Claims for FP:
Pakitüüp: 80
Kõik arved (ka nullarved)

- **Target group** consists of people aged ⩾18 (need, kes 01.01.2013-31.12.2014 lõppenud arvetel olid juba 18a vanad)

Step I (Esimene valim)

1.1. Identify patients with primary OR secondary diagnoses of E10-E14 (ie diabetes/DM), I10-I15 (ie hypertension/HTN), E78 (ie hyperlipidaemia/Lipidm) for the period 01.01.2015-31.12.2016. – form a list of all found patients – mark column HTN/Lipidm/DN with X when corresponding diagnose is found, these patients are **Patsient jälgimisel (KNOWN)**

Triad Displayed on dashboard in 3 columns

Step II (teine valim)

1.2. Identify patients with primary OR secondary diagnoses of E10-E14 (ie diabetes/DM), I10-I15 (ie hypertension/HTN), E78 (ie hyperlipidaemia/Lipidm) for the period 01.01.2013-31.12.2014. – form a list of all found patients – mark column HTN/Lipidm/DN with X when corresponding diagnose is found and same patients are not found in step 1.1
1.3. For these patients (step 1.2) determine the amount of FP visits they had between 01.01.2015-31.12.2016 (meaning: total amount of services with codes: 9001, 9002, 9003, 9004, 9015, 9017 (teenused kokku))

Exclude patients that had over 4 FP visits (patsiendid kuni 4 külastusega jäävad valimisse) during the 01.01.2015-31.12.2016. As explained above, the reason for doing so is that we want to exclude unknown patients that only fall into this category due to coding issues
Remaining patients are: **Patsient ei ole jälgimisel (UNKNOWN)**

StepIII (Kolmas valim):
Exclude from the list patients that have received treatment due to any diagnose during 01.07-31.12.2016 of:
pahaloomuline kasvaja acute cancer C00-C97, D0, D4, D37, D38, D39 and Z51

and from period 2015-2016:
skisofreenia: F20
neerupuudulikkus ja neerudialüüs: N17-N19, Z49, Y84.1, Z99.2
kaasasündinud väärarengud: Q0-Q8
harvaesinevad haigused: F01.1, D21.9, D47.4, D48.9, D56.0, D82.4, E70.3, E75.5, E80.0, E85.0, G47.3, H16.3, H49.8, I78.8, K90.8, M60.9, N04.1, R23.8

Step IV (Neljas valim)
Identify whether patients had any diagnosis in any care setting during 01.01.2015-31.12.2016 belonging to the different chronic conditions with primary, secondary diagnoses displayed on dashboard – Estonian text in bold:

1) **aneemia:** D50-D53, D55, D58, D61, D63, D64, D59.0, D59.1, D59.2, D59.4, D59.5, D59.6, D59.7, D59.8, D59.9, D60.0, D60.8, D60.9
2) **kilpnäärme haigusseisundid:** E01-E05, E07, E06.1, E06.2, E06.3, E06.5, E06.9
3) **rasvumus:** E66
4) **astma** J45-J46
5) **alumiste hingamisteede kroonilised haigused**: J40-J44, J47
6) **krooniline südamepuudulikkus:** I11.0, I13.0, I13.2, I50.0, I50.1, I50.9
7) **südamehaigused**: I44, I45, I47, I49
8) **peaaju transitoorse isheemia atakk (TIA) ja peaaju veresoonte haigused**: G45, I60-69
9) **kodade virvendus ja laperdus**: I48
10) **ainete sõltuvus**: F11-F19, F55, Z71.5, Z81.3, Z81.4
11) **alkoholi kuritarvitamine**: F10, Z71.4, Z81.1
12) **meeleoluhäired**: F30-F39
13) **dementsus**: F00-F03, G30-G31, R54, F05.1
14) **nägemise ja kuulmishäired**: H54.1, H54.2, H54.0, H54.9, H90, H91,
15) **funktsiooni nõrkus ja sellest tulenevad riskid**: R54, W00, W04-W08, W10, W18, W19, R41.81, Z91.8
16) **artroosid**: M15-M19
17) **puriini- ja pürimidiiniainevahetuse häire, podagra**: E79, M10
18) **prostatiit**: N40
19) **alajäsemete veenilaiendid** : I83, I87.2
20) **maksahaigused**: K70, K73-K74, K76, K71.3, K71.4, K71.5, K71.7, K72.1, K72.7, K72.9
21) **ateroskleroos**: I65, I66, I70, I67.2, I73.9
22) **osteoporoos**: M80-M82
23) **koletsüstiit**: K80, K81.1
24) **somatoformsed häired**: F45

25) **hemorroidid**: I84
26) **soole divertiikul- e sopististõbi**: K57
27) **reumatoidartriit**: M05-M06, M79.0
28) **südameklappide haigusseisundid**: I34-I37
29) **neuropaatiad**: G50-G64
30) **vertiigo e peapööritus**: H81-H82, R42
31) **inkontinentsus e kusepidamatus**: R32, N39.3, N39.4
32) **neeru- ja ureeteri- e kusejuhakivi**: N20
33) **psoriaas**: L40
34) **migreen**: G43-G44
35) **parkinsoni tõbi**: G20-G22
36) **mao-söögitoru haigused**: K21, K25.4, K25.5, K25.6, K25.7, K25.8, K25.9, K26.4-K26.9, K27.4-K27.9, K28.4-K28.9, K29.2-K29.9
37) **hüpotensioon**: I95
38) **kõne ja keele spetsiifilised arenguhäired**: F80
39) **söömishäired**: F50, R63.0
40) **epilepsia**: G40
41) **ärevushäire**: F40-F41
42) **südameisheemia**: I20-I25

Displayed on dashboard as **Kaasuvad haigused** (Total Number of Comorbidities), display number and option to display text for all found comorbidities
1-7 – write down informations so this can be displayed in detail to FP
(Lugeda kaasuvad haigused kokku (ridu), ja need kellel on üle 7 jäävad valimist välja).

Step V
For the list of all remaining patients conditions considered for the algorithm during the 01.01.2015-31.12.2016 find relevance of below 4 groups of Archetype (arhetüüp)
Kardiovaskulaarne/CVD:
- G45,
- I20-I25,
- I48.0,
- I11.0, I13.0, I13.2, I50.0, I50.1, I50.9

Hingamisteed/Resp.
- J40-J44, J47,
- J45-J46

Vaimsed häired/Mental
- F10, Z71.4, Z81.1,
- F00-F03, G30-G31, R54, F05.1,
- F11-F19, F55, Z71.5, Z81.3, Z81.4;
- F30-F39

Funktsionaalne häire/Functional
- H54.1, H54.2, H54.0, H54.9, H90, H91,
- R54, W00, W01, W04-W08, W10, W18, W19, R41.81, Z91.8

Exclude patients who:
- **Have no conditions from group CVD AND group Resp**
- **Have over 2 CVD conditions**
- **Have over 1 mental conditions**

Täienda leitud valimit andmetega:
1. Date of their **last acute hospital visit** for the period 01.01.2015-today (Displayed on dashboard as „Viimane haiglaravi“ **dd.mm.yyyy** (date of "Last hospital discharge”)
2. Date of the **last FP visit (**Displayed on dashboard as “Viimane visiit perearsti juurde” **dd.mm.yyyy** (date of "Last PHC visit)"**)** between 01.01.2015-today.

D Experimental design of RCT

At the start of the Enhanced Care Management (ECM) program, the Estonian Health Insurance Fund (EHIF) identified 410 clinics (containing 766 doctors) who were eligible for participation. The study team then excluded 13 clinics which had participated in the pilot study, 3 clinics with a single practicing doctor, 19 clinics with five or more practicing doctors, as well as 3 clinics that were not operational at the time. The last of these constraints arose from the fact that Estonia's larger clinics are operated on a distinctive business model to smaller clinics, with greater specialization in roles and a more distributed management of patient experience.

The research team was provided with a dataset of all the clinics, linked providers, with their annual QBS score.[45] This was the basis for construction the sampling frame for the provider randomization. In order to construct performance blocks for randomization of non-excluded clinics, we used the QBS data and management scores for 2019. QBS is Estonia's performance-based incentive program. Table D.1 provides an overview of QBS compliance guidelines.

We constructed a need-adjusted QBS score re-weighting each indicator based on the experience of the scheme, awarding proportional credit to providers at an indicator level and adjusting the coverage rates for providers based on the patient need (Daniels et al., 2024). For sampling stratification, we use the 'need-adjusted' scores for Domain II. The management score is a sum of points awarded on 15 indicators about the clinic's working and managerial practices. The average score per clinic on management indicators is 10 and the average need-adjusted QBS score per clinic is 306. Because the management score was only available at the level of clinic, we use the average QBS score of the clinic and the total management score of the clinic for the sampling.

At the first stage, clinics were stratified into randomization blocks using coarsened exact matching (CEM), by which clinics were grouped according to their performance on QBS and management scoring, the two primary pre-existing methods of evaluation employed by EHIF for performance metrics. The coarsened exact matching algorithm allowed us to create

[45] To motivate providers to provide quality services as determined by the Estonian Health Insurance Fund, a small performance-based element is included in doctor payments called the Quality Bonus System (QBS). It accounts for a relatively small amount (2-4%) of total provider compensation (World Bank, 2018). The initial goal of the QBS system was to signal to family doctors that in a new family medicine system of primary care, it was their responsibility to focus on improving preventive care and management of chronic disease.

Table D.1: QBS compliance guidelines

Category	Indicator	Description	Measurement
Diabetes - type II	Monitoring	Glycosylated haemoglobin	1 X year
		Creatinine values	
		Cholesterol values	
		Cholesterol fraction values	1 X 3 years
		Counselling for chronic patient	1 X year
DIabetes - type II	Medication	Prescribed for all type II diabetes patients	6 prescriptions in 14 months
Hypertension I (low risk)	Monitoring	Glucose or glycosylated haemoglobin	1 x in 3 years
		Cholesterol	
		Counselling for chronic patient	1 X year
		Appointment by family nurse	
Hypertension II (moderate risk)	Monitoring	Cholesterol determined for patients under 80 years of age	1 X year
		Cholesterol fractions determined for patients under 80 years of age	
		Glucose or glycosylated haemoglobin	
		Creatinine	
		ECG	1 x in 3 years
		Counselling for chronic patient	1 X year
		Appointment by family nurse	
Hypertension III (high risk)	Monitoring	Cholesterol determined for patients under 80 years of age	1 X year
		Cholesterol fractions determined for patients under 80 years of age	
		Glucose or glycosylated haemoglobin	
		Creatinine	
		Counselling for chronic patient	
		Appointment by family nurse	
Hypertension medication 1	Medication	Percentage of active ingredients based prescriptions for hypertension patients (all risk levels)	1 X year
Hypertension medication 2	Medication	Prescriptions for moderate or high-risk hypertension patients	6 prescriptions in 14 months
Myocardial Infarction (MI)	Monitoring	Cholesterol	1 X year
		Glucose or glycosylated haemoglobin	
		Cholesterol fractions	
		Counselling for chronic patient	
Myocardial infarction (MI)	Medication	Prescription of beta-blockers treatment group (incl combination drugs)	6 prescriptions in 14 months
		Prescription of statins treatment group (incl combination drugs)	6 prescriptions in 14 months
Hypothyroidism	Monitoring	TSH (thyroid stimulating hormone) determined	1 X year
Total			

sampling blocks of clinics, among which we could then randomize, such that 1/4 of clinics that were not excluded were selected to be approached for enrollment in the ECM program. Clinics were excluded for three reasons: either they had been part of the initial pilot; they were considered a large clinic with more than four providers; or they had no other clinics in their strata block (see Figure D.2a).

At this stage, 93 clinics were selected for enrollment in ECM and 282 were selected as controls. The ECM-eligible patients at the latter clinics are considered the 'pure control' group, which is used for comparisons with the 'ECM control' group for spillover analysis.

Next, of the 93 clinics selected for enrollment in the ECM program, 21 clinics refused to participate in the program when approached at the facility level. These clinics contained 4,266 eligible individuals. In addition, 8 doctors did not have any ECM-selected patients. Those two groups of patients are included neither in the 'pure control' group, nor in the 'ECM control' group,. Similarly, of the 72 clinics which agreed to participate, 26 of 98 providers at those clinics also refused to participate – producing a similar group of 'excluded' patients who are neither in the 'pure control' nor 'ECM control' groups.

Table **??** shows that there are no notable differences between ECM and non-ECM clinics and providers in the size of each clinic, QBS and management scores. The only difference is found on the number of ECM-eligible patients, which tends to be significantly larger for both not assigned and not participating clinics.

Table D.2: Provider-level balance: provider and patient characteristics

Variable	Assigned ECM Clinics vs Pure Control Clinics			Participating Providers vs Refusing Providers		
	Pure Control (1)	Assigned ECM (2)	Balance (2)-(1)	Refusing (4)	Participating (5)	Balance (5)-(4)
Provider characteristics						
Lists (N)	1.89 (1.12)	2.06 (1.10)	0.174 (0.152)	2.32 (1.19)	1.81 (0.929)	-0.329 (0.210)
QBS score	309 (63.6)	306 (65.9)	2.63 (2.13)	295 (71.7)	316 (58.4)	3.59 (2.21)
Management score	11.0 (6.56)	10.9 (6.81)	0.208 (0.133)	9.42 (7.28)	12.4 (5.99)	-0.287 (0.275)
ECM-eligible patients (N)	118 (62.2)	88.5 (42.8)	-34.1*** (5.44)	101 (49.3)	76.3 (31.1)	-15.4 (10.4)
Patient characteristics (provider means)						
Patient age (mean)	70.0 (4.27)	68.1 (4.63)	-2.08*** (0.472)	69.1 (4.91)	67.1 (4.13)	-0.881 (1.05)
Male patients (%)	41.7 (7.66)	43.7 (8.43)	2.11** (0.838)	41.7 (7.27)	45.6 (9.09)	2.72 (2.00)
Pre-period utilization (provider means)						
GP consultations (annual mean)	0.318 (0.236)	0.377 (0.319)	0.062** (0.026)	0.317 (0.310)	0.437 (0.319)	0.072 (0.060)
Nurse consultations (annual mean)	1.02 (0.750)	0.992 (0.597)	-0.002 (0.061)	0.989 (0.709)	0.996 (0.466)	-0.158 (0.105)
Any consultations (annual mean)	5.99 (2.16)	6.21 (1.95)	0.238 (0.212)	5.93 (2.05)	6.50 (1.82)	0.634 (0.434)
Primary care visits (annual mean)	1.98 (0.598)	2.02 (0.541)	0.058 (0.063)	2.06 (0.542)	1.99 (0.542)	-0.078 (0.107)
Hospitalizations (annual mean)	0.196 (0.056)	0.185 (0.066)	-0.012* (0.007)	0.196 (0.073)	0.175 (0.055)	-0.019 (0.014)
Sample size (N)	400	143	-	71	72	-

*** < 1%; ** < 5%; * < 10%.

Notes: The table measures pre-treatment balance at the provider (list) level. Panel A shows provider-level administrative characteristics. Panel B shows provider-level means of patient demographics. Panel C shows provider-level means of patient healthcare utilization in the pre-treatment period (01/01/2018 to 27/05/2021), annualized. Standard deviations are shown in parentheses in the means columns. The **balance columns** compare balance across different groups of providers on each variable as estimated in an OLS regression, inclusive of assignment (column 3) or participation (column 6) dummy and fixed effects for the clinic-level randomization block. Standard errors are shown in parentheses and clustered at the clinic level. The treatment groups are defined as follows: **Assigned ECM** - clinics randomized to be offered ECM participation; **Pure Control** - clinics not randomized to ECM (control clinics); **Participating** - providers at assigned clinics who agreed to participate in ECM; **Refusing** - providers at assigned clinics who declined to participate in ECM.

In the sample of clinics that chose to participate, EHIF identified all the patients who have (one or multiple) chronic illnesses using pre-existing algorithms and the patient data in their Mini Information System Portal. The details on this process can be seen in Section C. The list of those patients identified as in some way 'chronically ill' from this approach were sent to the corresponding doctor for confirmation that: i) all relevant patients were included in the list; ii) that all included patients could be considered 'chronically ill'; and, iii) that no patients should be excluded for reasons that were not contained in patient records, such as peculiar challenges of working with the patient.

Doctors were asked to assign each eligible patient in the resulting list to a further category of health status risk score, as follows:

- 1-Mild/moderate risk of deteriorating health
- 2-Severe risk of deteriorating health

Given the mix of mild/moderate and severe patients within each provider, we conducted a stratified random sampling of patients into ECM based on the risk classification, such that every patient within each risk classification group has equal probability of selection, and there are at most 25 patients selected into the ECM program from each doctor. The limitation of 25 patients was based on EHIF's budgetary limitations for the program. Five providers had identified fewer than 25 patients who had a risk of deteriorating health. For these providers, all the patients were included in treatment. Figure **D.2b** shows the randomization outcome at the patient level (for participating providers), including risk classifications, while Figure **D.1** shows the mapping of patient randomization and provider dropout at different stages of the patient randomization.

Figure D.1: Randomization chart

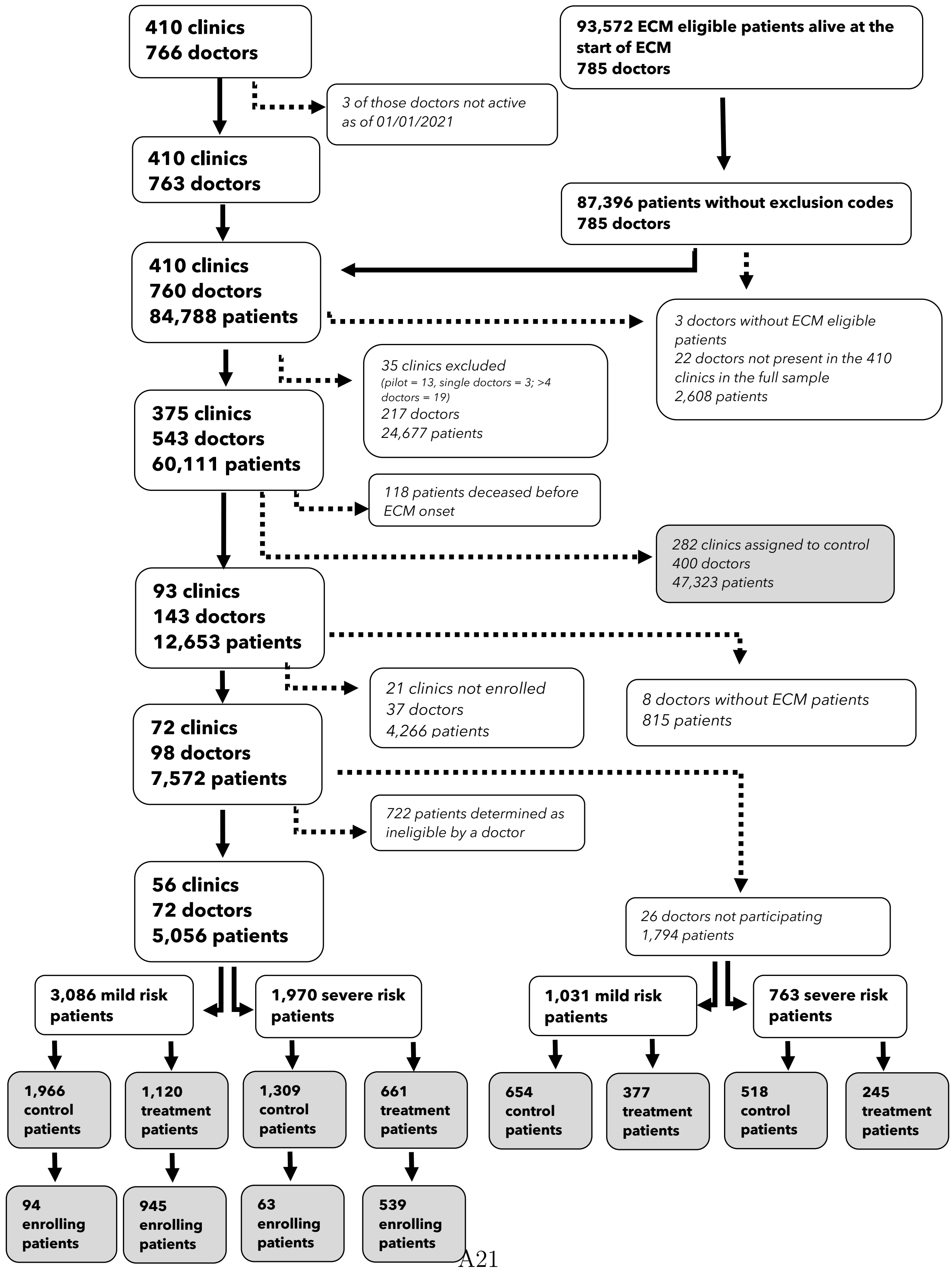
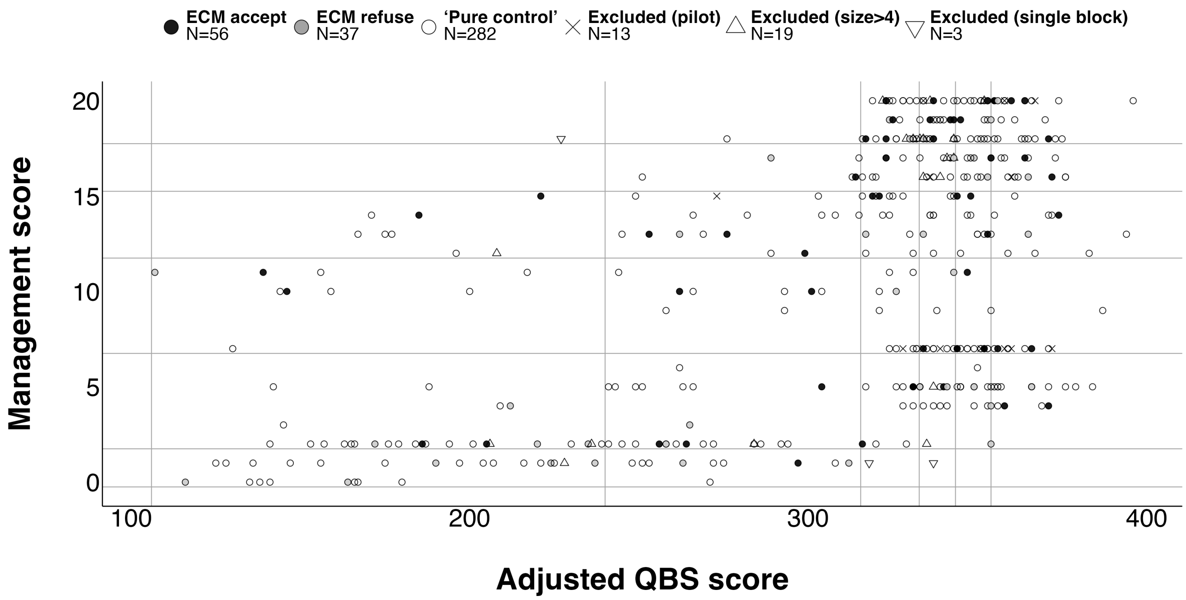


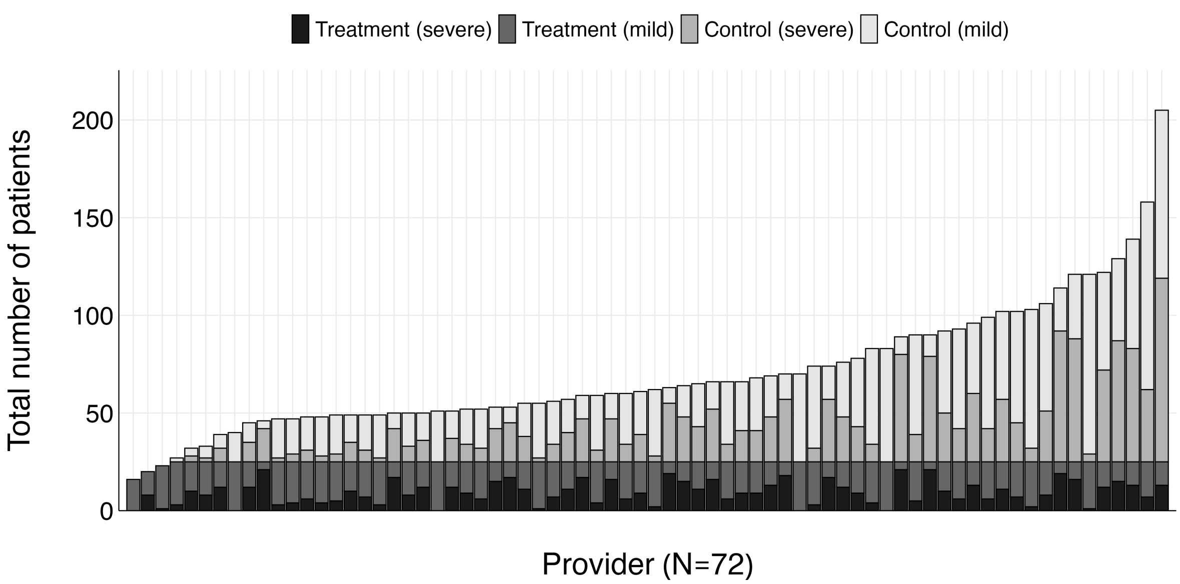
Figure D.2: Clinic randomization blocks and patient strata

(a) Clinic blocks



Notes: The above figure shows the randomization outcome at the clinic level. Each point represents a single clinic. The color and shape of the point correspond to the ECM status of each clinic as per the legend. X-axis records clinic-average QBS score and Y-axis records clinic-average management quality score. Horizontal and vertical lines show threshold boundaries of the randomization strata that were used to randomize the non-excluded clinics into ECM treatment and control.

(b) Patient strata (provider x risk)



Notes: The above figure shows the randomization outcome at the patient level. Each bar represents a single provider participating in the ECM program. The vertical axis represents the total number of patients in the sampling frame from each provider. The area of each bar in lightgrey represents the patients who are not selected in ECM, and the area of the bar in darkgrey represents the patients who are selected in ECM. For both types of patients, the darker shade represent the patients with a severe risk classification. The lighter shade represent patients with a mild-risk classification.

E Further details on data

Much healthcare in Estonia is free at point-of-use for patients covered by EHIF's insurance, or requires a very minimal co-pay. All Estonians covered by EHIF are assigned to a private family doctor.[46] Doctors are primarily paid through a mix of capitation fees (51%), allowances (21%), and fee for service (23%) (Kasekamp, Habicht and Kalda, 2022). Fee-for-service payments are all related to an 'episode of care', such as the provision of a consultation or prescription. As such, every billable activity undertaken within the primary health system is recorded within EHIF's administrative records.

EHIF is also liable for the payment of tertiary costs, such as in- or out-patient episode at a tertiary health institution. As such, EHIF maintains electronic health records describing every billable episode of care in the formal health system for the Estonian population since 2009. There is little that is not billable, with EHIF's data even including e-mails and calls to patients by doctors and nurses.

E.1 EHIF billing data

Since EHIF is a payer, and not a care provider, its records are organized as *billing claims* records, and do not have qualitatively detailed case histories. Bill numbers uniquely identify any episode of care between a single provider and patient (both of whose unique identifiers are associated with the bill number). A billing claim is closed when the provider requests reimbursement for the episode.

Each claim contains contains general information on a given 'episode of care'. It provides a summary of each episode of care identified by the bill number and includes the duration of treatment, type of admission[47], type of care, type of healthcare facility, code of doctor's speciality, and the family doctor for the patient in reference to the care episode.

Each billing claim is further linked to diagnosis and procedure information, stored in separate files. The diagnosis data describe all the diagnoses which were relevant to the given care episode. Each diagnosis is identified using the International Classification of Disease

[46] People are assigned to mother's family doctor at the time of their birth, (re-)register with a chosen family doctor themselves; or are "designated by the Board of Health on the basis of the residential address of the Estonian population register" (Gazette 2001 §8)

[47] There are 12 admission types identified by EHIF, including arrival by oneself, by ambulance, and via referral from a family doctor. See §55 in `https://www.riigiteataja.ee/a` for details.

(ICD). The diagnosis dataset also allows for distinguishing between primary diagnosis and accompanying diagnosis. This data system further allows provider to indicate whether a diagnosis is new.

The data on procedures describe all the medical procedures that were conducted within a given episode of care, including their frequency. Each procedure can be matched against EHIF-determined prices prevalent in a period in which a procedure was undertaken. Any billing claim can contain multiple procedures, as well as diagnoses.

This 3-tier system of data – billing, diagnoses, and procedures – is interlinked based on unique bill numbers. Each part of the data is also sub-divided into eight types of care. These are: day care services, inpatient services, inpatient nursing services, inpatient rehabilitation services, outpatient services, outpatient rehabilitation services, outpatient nursing services, and primary healthcare services.

In summary, the data used is based on electronic records that contain information on the billing claim, related diagnoses, and procedures performed, spread over eight health care services categories over a 14 year period (2009 until 2023). It serves as the basis to construct all the key outcomes of this study (apart from prescriptions data, which are described next). The definition of the outcome variables used in this study is provided in Table E.1, while the summary of the key outcomes, grouped by treatment arms, is shown in Table 1.

E.2 EHIF prescriptions data

In addition, EHIF provides reimbursement for prescriptions. The relevant 'prescriptions' data set is not linked to a specific bill number, but rather records each prescription issued to a given patient, including the doctor issuing it, prescription status, medicines and dosage prescribed, as well as over-the-counter price and the amount covered by EHIF. Prescribed medicines are identified both by their name and by WHO-managed Anatomical Therapeutic Chemical (ATC) Classification codes, which facilitates identifying the course of treatment for each patient.

E.3 EHIF Mini Information System Portal

In addition to the data sources described above, EHIF also maintains an online system called 'Mini Information System Portal' (MISP). It is used by EHIF to store, among others, information on each patient served. For the purposes of this study, EHIF helped us to use MISP to construct a list of chronically-ill patients. The list also included additional information such as the patient's family doctor, the date they were categorized as at risk, and the number of co-morbidities. This information was used to identify the starting, 'ECM eligible' population for this study (see top-right cell in Figure D.1).

Table E.1: Codebook for the outcome variables

Variable	Source	Codes	Description
Demographics			
Age	EHIF billing claims	-	patient's age in June 2021
Male	EHIF billing claims	-	patient's sex
Mild risk	EHIF billing claims	-	patient's health risk class 'mild/moderate' as opposed to 'severe'
Primary care (assigned clinic)			
ECM inclusion	EHIF procedures billing	9092	consultation with a doctor about being included into ECM programme (procedure code ending in '9092') at the assigned clinic
ECM care plan	EHIF procedures billing	9095	consultation with a doctor about developing or renewing a care plan (procedure code ending in '9095') at the assigned clinic
ECM inclusion refuse	EHIF procedures billing	9589	consultation with a doctor about being included into ECM programme (procedure code ending in '9589') at the assigned clinic
Doctor in-person chronic care	EHIF procedures billing	9044	consultation with a doctor in-person (procedure code ending in '9044') at the assigned clinic
Doctor phone	EHIF procedures billing	9018	consultation with a doctor over phone (procedure code ending in '9018') at the assigned clinic
Nurse in-person	EHIF procedures billing	9061	consultation with a nurse in-person (procedure code ending in '9061') at the assigned clinic
Nurse phone	EHIF procedures billing	9064	consultation with a nurse over phone (procedure code ending in '9064') at the assigned clinic
Any consultation	EHIF procedures billing	9044, 9018, 9061, 9064	row pools together all types of consultations with doctors and nurses at the assigned clinic
Primary	EHIF procedures billing	-	patient receiving primary healthcare treatment for any reason or diagnosis, excluding the doctor and nurse consultations, at the assigned clinic
Outpatient	EHIF procedures billing	-	patient receiving outpatient treatment for any reason and diagnosis,excluding the doctor and nurse consultations, at the assigned clinic
Primary care (not assigned clinic)			
Primary	EHIF procedures billing	-	patient receiving primary healthcare treatment for any reason or diagnosis, not at the assigned clinic
Outpatient	EHIF procedures billing	-	patient receiving outpatient treatment for any reason and diagnosis, not at the assigned clinic
Other care			
Inpatient	EHIF procedures billing	-	patient receiving inpatient treatment (hospitalised) for any reason and diagnosis
Inpatient (via referral)	EHIF billing claims	E-T0011	patient hospitalised with admission by doctor referral (admission code: E-T0011)
Inpatient (via ambulance)	EHIF billing claims	E-T0001	patient hospitalised with admission by ambulance (admission code: E-T0001)
Treat. time (total days)	EHIF billing claims	-	total treatment duration (difference between start and end of all treatment bills)
Inpatient time (total days)	EHIF billing claims	-	total treatment duration (difference between start and end of inpatient (hospitalization) treatment bills)
Treat. time (average days)	EHIF billing claims	-	average treatment duration (difference between start and end of all treatment bills)
Inpatient time (average days)	EHIF billing claims	-	average treatment duration (difference between start and end of inpatient (hospitalization) treatment bills)
Inpatient re-admission (30)	EHIF billing claims	-	patient re-hospitalized within 30 days of the start of previous hospitalisation, regardless of the diagnosis
Inpatient re-admission (90)	EHIF billing claims	-	patient re-hospitalized within 90 days of the start of previous hospitalisation, regardless of the diagnosis
Inpatient re-admission (30, severe)	EHIF billing claims	-	patient re-hospitalized for any of the severe conditions within 30 days of the start of previous hospitalisation for any of the severe conditions
Inpatient re-admission (90, severe)	EHIF billing claims	-	patient re-hospitalized for any of the severe conditions within 90 days of the start of previous hospitalisation for any of the severe conditions
Daycare healthcare	EHIF procedures billing	-	patient receiving daycare healthcare treatment for any reason or diagnosis
Inpatient nursing/rehabilitation	EHIF procedures billing	-	patient receiving inpatient nursing or rehabilitation treatment for any reason or diagnosis
Outpatient nursing/rehabilitation	EHIF procedures billing	-	patient receiving outpatient nursing or rehabilitation treatment for any reason or diagnosis
No of diagnoses (total)	EHIF diagnoses billing	-	number of diagnosed conditions (total in the period)
No of diagnoses (average)	EHIF diagnoses billing	-	number of diagnosed conditions (average per healthcare interaction)
No of procedures (total)	EHIF procedures billing	-	number of procedures underwent by a patient (total in the period)
No of procedures (average)	EHIF procedures billing	-	number of procedures underwent by a patient (average per healthcare interaction)

Variable	Source	Codes	Description
Covid incidence	EHIF diagnoses billing (ICD-10)	9092	patient diagnosed with SARS-CoV-2 (Covid-19) (ICD-10 code: U07.1); (procedure code ending in '9092')
Covid test	EHIF procedures billing	3183, 66634,66645,9519	patient underwent any of testing procedures for SARS-CoV-2 (procedure code ending in '3183', '66634','66645','9519')
Covid vaccine	EHIF procedures billing	3197, 3199, 9595, 9590, 9591, 9592, 9593, 9594, 9595, 9596, 9597, 9598, 9599	patient underwent any of vaccination procedures for SARS-CoV-2 (procedure code ending in '3197', '3199', '9595', '9590', '9591', '9592', '9593', '9594', '9595', '9596', '9597', '9598', '9599')
Covid vaccine refuse	EHIF procedures billing	9589	patient refusing vaccine for SARS-CoV-2 (procedure code ending in '9589')
Severe hospitalization			
Intensive care (i)	EHIF procedures billing	2044, 2070	patient time in intensive care of I degree (procedure code ending in '2044' or '2070')
Intensive care (ii)	EHIF procedures billing	2045, 2071	patient time in intensive care of II degree (procedure code ending in '2045' or '2071')
Intensive care (iii)	EHIF procedures billing	2046, 2072	patient time in intensive care of III degree (procedure code ending in '2045' or '2072')
Intensive care (iiia)	EHIF procedures billing	2059, 2073	patient time in intensive care of IIIA degree (procedure code ending in '2059' or '2073')
Pneumonia (h)	EHIF diagnoses billing (ICD-10)	J12.0, J12.1, J12.2, J12.81, J12.82, J12.89, J12.3, J12.9, J18.1, J13, J15.0, J15.1, J14, J15.4, J15.3, J15.20, J15.211, J15.212, J15.29, J15.8, J15.5, J15.6, A48.1, J15.9, J15.7, J16.0, J16.8, J18.0, J18.9, J18.8, J11.08, J11.00, J10.08, J10.01, J10.00	patient diagnosed with pneumonia during hospitalisation (EHIF diagnoses billing (ICD-10) codes: J12.0, J12.1, J12.2, J12.81, J12.82, J12.89, J12.3, J12.9, J18.1, J13, J15.0, J15.1, J14, J15.4, J15.3, J15.20, J15.211, J15.212, J15.29, J15.8, J15.5, J15.6, A48.1, J15.9, J15.7, J16.0, J16.8, J18.0, J18.9, J18.8, J11.08, J11.00, J10.08, J10.01, J10.00)
Screening			
Glycohemoglobin	EHIF procedures billing	66118	patient underwent any of the glycohemoglobin monitoring procedures for diabetes II, as defined by EHIF (procedure code ending in 66118)
Glycohemoglobin (all)	EHIF procedures billing	66118, 6506A, 9118, 9050	patient underwent any of the glycohemoglobin monitoring procedures (procedure code ending in 66118)
Creatinine	EHIF procedures billing	66102	patient underwent any of the creatine monitoring procedures for diabetes II and hypertensive disease, as defined by EHIF (procedure code ending in 66118)
Creatinine (all)	EHIF procedures billing	66102, 9102, 6500D	patient underwent any of the creatine monitoring procedures (procedure code ending in 66118)
Cholesterol	EHIF procedures billing	66104	patient underwent any of the cholesterol or triglycerides monitoring procedures for diabetes II, hypertensive disease and myocardial infarction as defined by EHIF (procedure code ending in 66118)
Cholesterol (all)	EHIF procedures billing	66104, 6503F, 6501F, 6501G, 66105, 9106, 6303G, 9104, 9040, 9042, 6502L	patient underwent any of the cholesterol or triglycerides monitoring procedures (procedure code ending in 66118)
Glucose	EHIF procedures billing	66101	patient underwent any of the glucose monitoring procedures for hypertensive disease and myocardial infarction as defined by EHIF (procedure code ending in 66118)
Glucose (all)	EHIF procedures billing	66101, 9050, 9101, 9131, 9118, 9011, 6500B, 9067Z	patient underwent any of the glucose monitoring procedures (procedure code ending in 66118)
ECG	EHIF procedures billing	6320, 6322, 6323	patient underwent ECG monitoring procedure for hypertensive disease as defined by EHIF (procedure code ending in 6320, 6322, 6323)
TSH	EHIF procedures billing	66706	patient underwent any of the screening, hormone testing, immunoassays for pathogens monitoring procedures for hypothyroidism as defined by EHIF (procedure code ending in 66706)
Any monitoring	EHIF procedures billing	66118, 66102, 66104, 66101, 6320, 6322, 6323, 66706	patient underwent any of the monitoring procedures for chronically ill patients as defined by EHIF (procedure code ending in 66118, 66102, 66104, 66101, 6320, 6322, 6323, 66706)
Diagnosed conditions			

Variable	Source	Codes	Description
Pneumonia	EHIF diagnoses billing (ICD-10)	J12.0, J12.1, J12.2, J12.81, J12.82, J12.89, J12.3, J12.9, J18.1, J13, J15.0, J15.1, J14, J15.4, J15.3, J15.20, J15.211, J15.212, J15.29, J15.8, J15.5, J15.6, A48.1, J15.9, J15.7, J16.0, J16.8, J18.0, J18.9, J18.8, J11.08, J11.00, J10.08, J10.01, J10.00	patient diagnosed with pneumonia during any healthcare interaction (EHIF diagnoses billing (ICD-10) codes: J12.0, J12.1, J12.2, J12.81, J12.82, J12.89, J12.3, J12.9, J18.1, J13, J15.0, J15.1, J14, J15.4, J15.3, J15.20, J15.211, J15.212, J15.29, J15.8, J15.5, J15.6, A48.1, J15.9, J15.7, J16.0, J16.8, J18.0, J18.9, J18.8, J11.08, J11.00, J10.08, J10.01, J10.00)
Heart failure	EHIF diagnoses billing (ICD-10)	I11.0, I13.0, I13.2, I50.9, I50.814, I50.43, I50.42, I50.41, I50.40, I50.33, I50.32, I50.31, I50.30, I50.23, I50.22, I50.21, I50.20, I50.1, I50.810, I50.811, I50.812, I50.813, I50.82, I50.83, I50.84, I50.89	patient diagnosed with heart failure during any healthcare interaction (EHIF diagnoses billing (ICD-10) codes: I11.0, I13.0, I13.2, I50.9, I50.814, I50.43, I50.42, I50.41, I50.40, I50.33, I50.32, I50.31, I50.30, I50.23, I50.22, I50.21, I50.20, I50.1, I50.810, I50.811, I50.812, I50.813, I50.82, I50.83, I50.84, I50.89)
Stroke	EHIF diagnoses billing (ICD-10)	I63.02, I63.12, I63.22, I63.239, I63.240, I63.241, I63.242, I63.243, I63.244, I63.245, I63.246, I63.039, I63.033, I63.032, I63.031, I63.219, I63.119, I63.019, I63.213, I63.212, I63.211, I63.113, I63.112, I63.111, I63.013, I63.012, I63.011, I63.59, I63.19, I63.09, I63.00, I63.10, I63.29, I63.20, I63.311, I63.312, I63.313, I63.319, I63.321, I63.322, I63.323, I63.329, I63.331, I63.332, I63.333, I63.339, I63.341, I63.342, I63.343, I63.349, I63.39, I63.6, I63.30, I63.411, I63.412, I63.413, I63.419, I63.421, I63.422, I63.423, I63.429, I63.431, I63.432, I63.433, I63.439, I63.441, I63.442, I63.443, I63.449, I63.49, I63.40, I63.511, I63.512, I63.513, I63.519, I63.521, I63.522, I63.523, I63.529, I63.531, I63.532, I63.533, I63.539, I63.541, I63.542, I63.543, I63.549, I63.81, I63.89, I63.9, I63.50	patient diagnosed with stroke during any healthcare interaction (EHIF diagnoses billing (ICD-10) codes: I63.02, I63.12, I63.22, I63.239, I63.240, I63.241, I63.242, I63.243, I63.244, I63.245, I63.246, I63.039, I63.033, I63.032, I63.031, I63.219, I63.119, I63.019, I63.213, I63.212, I63.211, I63.113, I63.112, I63.111, I63.013, I63.012, I63.011, I63.59, I63.19, I63.09, I63.00, I63.10, I63.29, I63.20, I63.311, I63.312, I63.313, I63.319, I63.321, I63.322, I63.323, I63.329, I63.331, I63.332, I63.333, I63.339, I63.341, I63.342, I63.343, I63.349, I63.39, I63.6, I63.30, I63.411, I63.412, I63.413, I63.419, I63.421, I63.422, I63.423, I63.429, I63.431, I63.432, I63.433, I63.439, I63.441, I63.442, I63.443, I63.449, I63.49, I63.40, I63.511, I63.512, I63.513, I63.519, I63.521, I63.522, I63.523, I63.529, I63.531, I63.532, I63.533, I63.539, I63.541, I63.542, I63.543, I63.549, I63.81, I63.89, I63.9, I63.50)
Myocardial infarction	EHIF diagnoses billing (ICD-10)	I21.09, I22.0, I21.01, I21.02, I21.19, I22.1, I21.11, I21.29, I22.8, I21.4, I22.2, I21.21, I21.3, I21.A9, I21.A1, I21.9, I22.9	patient diagnosed with myocardial infarction during any healthcare interaction (EHIF diagnoses billing (ICD-10) codes: I21.09, I22.0, I21.01, I21.02, I21.19, I22.1, I21.11, I21.29, I22.8, I21.4, I22.2, I21.21, I21.3, I21.A9, I21.A1, I21.9, I22.9)
No. of severe diag. (total)	EHIF diagnoses billing (ICD-10)	-	number of any healthcare interactions due to any of the severe conditions (total in the period; conditions include acute myocardial infarction, COPD, heart failure, pneumonia, and stroke; EHIF diagnoses billing (ICD-10) codes: as specified in notes for individual conditions)
COPD	EHIF diagnoses billing (ICD-10)	J44.1, J44.0, J41.8, J42, J43.9, J43.8, J43.2, J43.1, J43.0, J44.9	patient diagnosed with a chronic obstructive pulmonary disease (COPD) during any healthcare interaction (ICD-10 code: J44.1, J44.0, J41.8, J42, J43.9, J43.8, J43.2, J43.1, J43.0, J44.9)
Asthma	EHIF diagnoses billing (ICD-10)	J45	patient diagnosed with asthma during hospitalisation (ICD-10 code: J45)
Diabetes	EHIF diagnoses billing (ICD-10)	E11	patient diagnosed with diabetes during hospitalisation (ICD-10 code: E11)
Hypertension	EHIF diagnoses billing (ICD-10)	I10, I11, I12, I13, I15	patient diagnosed with hypertension during hospitalisation (EHIF diagnoses billing (ICD-10) codes: I10, I11, I12, I13, I15)

Variable	Source	Codes	Description
Any avoidable hospitalization	EHIF diagnoses billing (ICD-10)	J45, J44, E11, I50.9, I10, I11, I12, I13, I15	number of hospitalisations for any of the avoidable conditions (total in the period; conditions include acute asthma, diabeted II, COPD, hypertension, heart failure; EHIF diagnoses billing (ICD-10) codes: as specified in notes for individual conditions)
Alcohol abuse	EHIF diagnoses billing (ICD-10)	F10, Z71.4	patient receiving healthcare services of any type due to diagnosis of alcohol abuse (EHIF diagnoses billing (ICD-10) codes: F10 and Z71.4)
Arthritis	EHIF diagnoses billing (ICD-10)	M05, M06, M15, M16, M17, M18, M19	patient receiving healthcare services of any type due to diagnosis of arthritis (EHIF diagnoses billing (ICD-10) codes: M05, M06, M15, M16, M17, M18, M19)
Atrial fibrillation	EHIF diagnoses billing (ICD-10)	I48	patient receiving healthcare services of any type due to diagnosis of atrial fibrillation abuse (ICD-10 code: I48)
Chronic kidney disease	EHIF diagnoses billing (ICD-10)	N18	patient receiving healthcare services of any type due to diagnosis of atrial fibrillation abuse (ICD-10 code: N18)
Cancer	EHIF diagnoses billing (ICD-10)	C18, C34, C50, C61	patient receiving healthcare services of any type due to diagnosis of cancer (EHIF diagnoses billing (ICD-10) codes: C18, C34, C50, C61)
Depression	EHIF diagnoses billing (ICD-10)	F32	patient receiving healthcare services of any type due to diagnosis of depression (ICD-10 code: F32)
Substance use	EHIF diagnoses billing (ICD-10)	F11, F12, F13, F14, F15, F16, F17, F18, F19	patient receiving healthcare services of any type due to diagnosis of substance use (EHIF diagnoses billing (ICD-10) codes: F11, F12, F13, F14, F15, F16, F17, F18, F19)
Hyperlipidemia	EHIF diagnoses billing (ICD-10)	E78	patient receiving healthcare services of any type due to diagnosis of hyperlipidemia (ICD-10 code: E78)
Hypertensive heart	EHIF diagnoses billing (ICD-10)	I11	patient receiving healthcare services of any type due to diagnosis of hypertensive heart (ICD-10 code: I11)
Ischemic heart disease	EHIF diagnoses billing (ICD-10)	I21, I22, I23, I24, I25	patient receiving healthcare services of any type due to diagnosis of ischemic heart disease (ICD-10 code: I21, I22, I23, I24, I25)
Osteoporosis	EHIF diagnoses billing (ICD-10)	M80, M81	patient receiving healthcare services of any type due to diagnosis of osteoporosis (EHIF diagnoses billing (ICD-10) codes: M80, M81)
Underweight	EHIF diagnoses billing (ICD-10)	E66, R63.5	patient receiving healthcare services of any type due to diagnosis related to deficient body mass (EHIF diagnoses billing (ICD-10) codes: E66, R63.5)
Overweight/obese	EHIF diagnoses billing (ICD-10)	R63.4, R63.6, T75.82, X52	patient receiving healthcare services of any type due to diagnosis related to excessive body mass (EHIF diagnoses billing (ICD-10) codes: R63.4, R63.6, T75.82, X52)
Prescriptions			
N(total)	EHIF prescriptions billing	-	total number of prescriptions issued to a patient
N (realized)	EHIF prescriptions billing	-	total share of prescriptions realized by a patient
Cost (total)	EHIF prescriptions billing	-	total price of prescriptions realized by a patient
Cost (EHIF)	EHIF prescriptions billing	-	total price of prescriptions realized by a patient that was paid by EHIF
Cost (EHIF per.)	EHIF prescriptions billing	-	total share of price of prescriptions realized by a patient that was paid by EHIF
Time av. (days)	EHIF prescriptions billing	-	average time, in days, between prescription being issued and being realized by a patient
Diabetes	EHIF prescriptions billing (ATC)	A10	patient issued a prescription (Rx) for diabetes medication (ATCC codes starting with A10)
Diabetes (realized)	EHIF prescriptions billing (ATC)	A10	patient realized a prescription (Rx) for diabetes medication (ATCC codes starting with A10)
Diabetes (assigned)	EHIF prescriptions billing (ATC)	A10	patient issued a prescription (Rx) for diabetes medication (ATCC codes starting with A10) at the assigned clinic
Anti-thrombotic	EHIF prescriptions billing (ATC)	B01	patient issued a prescription (Rx) for anti-thrombotic medication (ATCC codes starting with B01)
Anti-thrombotic (realized)	EHIF prescriptions billing (ATC)	B01	patient realized a prescription (Rx) for anti-thrombotic medication (ATCC codes starting with B01)
Anti-morrhagic	EHIF prescriptions billing (ATC)	B02	patient issued a prescription (Rx) for anti-morrhagic medication (ATCC codes starting with BO2)
Anti-morrhagic (realized)	EHIF prescriptions billing (ATC)	B02	patient realized a prescription (Rx) for anti-morrhagic medication (ATCC codes starting with B02)
Anti-anemic	EHIF prescriptions billing (ATC)	B03	patient issued a prescription (Rx) for anti-anemic medication (ATCC codes starting with B03)
Anti-anemic (realized)	EHIF prescriptions billing (ATC)	B03	patient realized a prescription (Rx) for anti-anemic medication (ATCC codes starting with B03)
Cardiac	EHIF prescriptions billing (ATC)	C01	patient issued a prescription (Rx) for cardiac therapy medication (ATCC codes starting with C01)
Cardiac (realized)	EHIF prescriptions billing (ATC)	C01	patient realized a prescription (Rx) for cardiac therapy medication (ATCC codes starting with C01)
Anti-hypertensive	EHIF prescriptions billing (ATC)	C02	patient issued a prescription (Rx) for anti-hypertensive medication (ATCC codes starting with C02)
Anti-hypertensive (realized)	EHIF prescriptions billing (ATC)	C02	patient realized a prescription (Rx) for anti-hypertensive medication (ATCC codes starting with C02)

Variable	Source	Codes	Description
Anti-hypertensive (assigned)	EHIF prescriptions billing (ATC)	C02	patient realized a prescription (Rx) for anti-hypertensive medication (ATCC codes starting with C02) at assigned clinic
Diuretics	EHIF prescriptions billing (ATC)	C03	patient issued a prescription (Rx) for duretics medication (ATCC codes starting with C03)
Diuretics (realized)	EHIF prescriptions billing (ATC)	C03	patient realized a prescription (Rx) for duretics medication (ATCC codes starting with C03)
Beta-blockers	EHIF prescriptions billing (ATC)	C07	patient issued a prescription (Rx) for beta blocking medication (ATCC codes starting with C07)
Beta-blockers (realized)	EHIF prescriptions billing (ATC)	C07	patient realized a prescription (Rx) for beta blocking medication (ATCC codes starting with C07)
Beta-blockers (assigned)	EHIF prescriptions billing (ATC)	C07	patient issued a prescription (Rx) for beta blocking medication (ATCC codes starting with C07) at the assigned clinic
Ca-bloc.	EHIF prescriptions billing (ATC)	C08	patient issued a prescription (Rx) for calcium channel blocker medication (ATCC codes starting with C08)
Ca-bloc. (realized)	EHIF prescriptions billing (ATC)	C08	patient realized a prescription (Rx) for calcium channel blocker medication (ATCC codes starting with C08)
Statins	EHIF prescriptions billing (ATC)	C10	patient issued a prescription (Rx) for statins medication (ATCC codes starting with C10)
Statins (realized)	EHIF prescriptions billing (ATC)	C10	patient realized a prescription (Rx) for statins medication (ATCC codes starting with C19)
Statins (assigned)	EHIF prescriptions billing (ATC)	C10	patient issued a prescription (Rx) for statins medication (ATCC codes starting with C10) at the assigned clinic
Antibiotic	EHIF prescriptions billing (ATC)	J01	patient issued a prescription (Rx) for bacterial antibiotics medication (ATCC codes starting with J01)
Antibiotic (realized)	EHIF prescriptions billing (ATC)	J01	patient realized a prescription (Rx) for bacterial antibiotics medication (ATCC codes starting with J01)
Vaccines	EHIF prescriptions billing (ATC)	J07	patient issued a prescription (Rx) for a vacine (ATCC codes starting with J07)
Vaccines (realized)	EHIF prescriptions billing (ATC)	J07	patient realized a prescription (Rx) for a vaccine (ATCC codes starting with J07)
Anti-histamine	EHIF prescriptions billing (ATC)	R06	patient issued a prescription (Rx) for anti-histamineamine medication (ATCC codes starting with R06)
Anti-histamine (realized)	EHIF prescriptions billing (ATC)	R06	patient realized a prescription (Rx) for anti-histamineamine medication (ATCC codes starting with R06)
Any key	EHIF prescriptions billing (ATC)	C02, C07, A10, C10	patient issued any of the key prescriptions (Rx) - anti-hypertensives, beta-blockers, diabetes medication, statins - in managing chronically ill patients (ATCC codes starting with C02, C07, A10, C10)
Any key (realized)	EHIF prescriptions billing (ATC)	C02, C07, A10, C10	patient realized any of the key prescriptions (Rx) - anti-hypertensives, beta-blockers, diabetes medication, statins - in managing chronically ill patients (ATCC codes starting with C02, C07, A10, C10)
Any key (assigned)	EHIF prescriptions billing (ATC)	C02, C07, A10, C10	patient issued any of the key prescriptions (Rx) - anti-hypertensives, beta-blockers, diabetes medication, statins - in managing chronically ill patients (ATCC codes starting with C02, C07, A10, C10) at the assigned clinic
Any other	EHIF prescriptions billing (ATC)	-	patient issued a prescription (Rx) for any other medication than anti-hypertensives, beta-blockers, diabetes medication, or statins - in managing chronically ill patients (ATCC codes starting with C02, C07, A10, C10)
Any other (realized)	EHIF prescriptions billing (ATC)	-	patient realized a prescription (Rx) for any other medication than anti-hypertensives, beta-blockers, diabetes medication, or statins - in managing chronically ill patients (ATCC codes starting with C02, C07, A10, C10)

E.4 Survey of doctors

At the start of the ECM program, we undertook an online survey of all family doctors in Estonia (covering both treatment and control groups) using EHIF's existing survey infrastructure. This survey aimed to measure details of how doctors conduct consultations with chronic patients, their operational capacity and levels of satisfaction with their practice. [48] Specifically, the topics covered in the survey were:

- **Doctor's overall clinical approach**:
  - Frequency of contact and coordination with chronic patients provided by the doctor.
  - Preparedness levels of doctor/clinical staff to manage patients with or developing chronic conditions.
  - Details on type of care provided to patients with chronic conditions.
  - Details on nature of coordination between patients and community services; between doctor and hospitals.
- **Practice profile**:
  - Number of full-time personnel working in the practice, hours/shifts worked by the personnel.
  - Average time spent with every patient in a routine visit by the doctor.
  - Any extra duties undertaken by the staff in preceding months.
- **Satisfaction and stress**:
  - Satisfaction levels with being a doctor.
  - Satisfaction levels with specific aspects of doctor's practice.

The response rate was broadly similar across geographic regions. The descriptive statistics reported in the paper are raw averages of the responses received.

[48] All surveying and other contact with doctors was conducted in Estonian, unless otherwise specified.

E.5 Care plan assessments

In order to better understand how ECM was implemented in practice, our intervention involved 4 external consultants, who were tasked with conducting training and coaching of the enrolled doctors, running regular feedback sessions with them, as well as performing an evaluation of a random set of care plans prepared for the ECM patients.

Evaluation of the care plans was a part of one of the visits to the doctor and his/her team. It was aimed to coincide with the completion of most if not all of the care plans. While on site, the evaluator assessed care plans from five patients, randomly selected from the full set of ECM treatment patients assigned to the visited doctor. The randomization process relied on random sorting of numbers 1 through 25 (max. number of ECM treatment patients per doctor) and selecting patients corresponding to the first five numbers. All the care plans selected were printed out, assessed using an online survey form, and then returned to the clinics to destroy or add to the patient records. In total, 72 care plans were evaluated.[49] The survey evaluation comprised 8 questions. Their text is listed below, along with the response options in the square brackets.

- Is this care plan X available? [0 - No; 1 - Yes]
- Overall, are all mandatory fields of the care plan filled with relevant information? [1 - Excellent; 2 - Good; 3 - Satisfactory; 4 - Unsatisfactory; 5 - Absent]
- Does the care plan provide a series of non-medical activities that promote holistic health? [1 - Excellent; 2 - Good; 3 - Satisfactory; 4 - Unsatisfactory; 5 - Absent]
- Does the care plan seem to be specific to the needs of the individual patient? [1 - Excellent; 2 - Good; 3 - Satisfactory; 4 - Unsatisfactory; 5 - Absent]
- Are patient goals measurable and timebound in care plan? [1 - Excellent; 2 - Good; 3 - Satisfactory; 4 - Unsatisfactory; 5 - Absent]
- Is there an action plan to achieve those patient goals in care plan? [0 - Not included; 1 - Yes, action plans are completely tailored to the goals set; 2 - Yes, patient goals are included in the action plans, among other plans to promote health]

[49] Examples of the care plans are shown in Section B.6 of the Appendix.

- Is all the information easy to grasp and understandable from the patient's point of view i.e., not too medical in care plan? [1 - Excellent; 2 - Good; 3 - Satisfactory; 4 - Unsatisfactory; 5 - Absent]
- Any comments for this care plan? [Open-ended]

F Further results

This section presents ECM results using a series of alternative group comparisons and model specifications.

F.1 Comparisons to 'pure control' group

As described in section 3.3, a random subset of 282 eligible clinics were not offered participation in ECM. As such, relative to the original 93 offered participation, this is a valid counterfactual group of clinics and patients. However, 56 of the original 93 clinics offered enrollment took ECM up, such that there is a degree of selection into treatment in the eligible population.

Comparisons to the 'pure control' patients do *not* represent a 'clean' causal comparison in the sense of the within-clinic randomization. As documented in Table 1 and below, there are baseline imbalances between ECM control patients and pure control patients across several characteristics, including age and prior healthcare utilization. These imbalances likely reflect selection by clinics into ECM participation. While our ANCOVA approach conditions on baseline characteristics, residual confounding may remain. We therefore present these comparisons as *suggestive* evidence only, with the within-clinic randomized comparisons in the main text serving as our primary causal estimates.

Appendix Table F.1 presents the pre-treatment balance and ANCOVA results (replicating respectively the approach of Tables 1 and 2) that compare the ECM control to the 'pure control' group patients. The latter refers to all patients classified by EHIF as eligible for ECM, but at 'pure control' clinics (not assigned to ECM intervention).[50]

Columns 1 through 3 of Appendix Table F.1 indicate that relative to the full set of patients at non-treatment clinics, ECM patients were somewhat younger at the start of the intervention and were also somewhat more likely to be male. They displayed higher utilization of some types of primary healthcare, key prescriptions and monitoring tests, but lower utilization of both inpatient care (including ambulatory hospitalization and short-term readmission) and inpatient and outpatient nursing/rehabilitation services. Relative to the pure control group, ECM patients were also less likely to seek healthcare due to heart failure, but more likely to

[50]When making comparisons to pure control patients, we use fixed effects for the blocks we used in the clinic-level randomization.

do so for hyperlipidemia. This may be explained by the fact that those doctors who agreed to be part of ECM could differ from those in the rest of the system, either because they are more motivated doctors, or because their patients were in a position to benefit more significantly from the program.

Comparisons between the ECM control group and ‘pure control’ patients in clinics that were randomized out of treatment allow us to assess potential spillovers, conditional on the ANCOVA approach sufficiently absorbing the imbalances outlined above. Columns 6 and 7 of Appendix Table F.1 imply that there were potentially large *positive* spillovers to non-ECM patients in some outcomes, with ECM control patients having similarly-sized advantages over pure control patients in the follow-up period. Most notably, the estimates in Columns 6 and 7 suggest the program induced a broader intensification of screening at ECM providers, as ECM control individuals were screened for many conditions at significantly higher rates than the similar ‘pure control’ eligible individuals at non-ECM providers. Since the spillover impacts are positive, the within-doctor estimates we present in the main paper are lower bounds on the true effects of the program on treated individuals.

Table F.1: Pre-treatment balance and ANCOVA results across ECM control patients and pure control group

Variable	Pre-treatment balance (2018-21)			ANCOVA (2021-23)			
	Means			Means (ECM control)		ECM control vs. pure control	
	Pure Control	ECM Control	Representativeness	*Any*	*Count*	*Any*	*Count*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Demographics							
Age	70.8	68.7	-2.10*** (0.419)	-	-	-	-
Male	0.404	0.436	0.034** (0.014)	-	-	-	-
Mild risk	–	0.629	–	-	-	-	-
	(count)	*(count)*					
Primary care (assigned clinic)							
ECM inclusion	-	-	-	0.049	0.027	0.049*** (0.007)	0.027*** (0.004)
ECM care plan	-	-	-	0.048	0.058	0.048*** (0.006)	0.058*** (0.009)
GP in-person chronic care	0.329	0.414	0.067** (0.034)	0.471	0.384	0.067** (0.033)	0.033 (0.031)
GP phone	3.52	3.72	0.057 (0.196)	0.912	4.101	0.007 (0.026)	−0.140 (0.213)
Nurse in-person	1.03	0.983	-0.050 (0.063)	0.767	1.067	0.099** (0.038)	0.165** (0.079)
Nurse phone	0.992	1.44	0.419** (0.169)	0.728	1.917	0.070** (0.031)	−0.134 (0.126)
Any consultation	5.88	6.57	0.493** (0.246)	0.968	7.485	0.012 (0.023)	−0.010 (0.306)
Primary	1.99	2.08	0.145* (0.077)	0.867	1.472	0.046* (0.024)	0.102 (0.072)
Outpatient	0.357	0.304	-0.009 (0.025)	0.537	0.597	−0.014 (0.026)	−0.064 (0.048)
Primary care (not assigned clinic)							
Primary	0.344	0.247	-0.103 (0.065)	0.106	0.148	−0.015 (0.034)	−0.016 (0.067)
Outpatient	2.90	3.05	0.148 (0.095)	0.845	3.436	−0.001 (0.010)	0.091 (0.195)
Other care							
Inpatient	0.193	0.174	-0.015* (0.009)	0.255	0.221	0.003 (0.008)	−0.002 (0.010)
Inpatient (via ambulance)	0.061	0.047	-0.013*** (0.003)	0.107	0.073	−0.012** (0.006)	−0.008* (0.004)
Inpatient re-admission (30)	0.056	0.046	-0.009 (0.006)	0.038	0.032	−0.004 (0.005)	−0.001 (0.004)
Inpatient re-admission (90)	0.086	0.071	-0.013** (0.006)	0.059	0.054	−0.005 (0.005)	−0.003 (0.005)
Daycare healthcare	0.081	0.084	0.003 (0.004)	0.117	0.097	0.011* (0.007)	0.011* (0.006)
Inpatient nursing/rehabilitation	0.037	0.017	-0.018*** (0.003)	0.04	0.036	−0.017*** (0.004)	−0.011** (0.005)
Outpatient nursing/rehabilitation	0.231	0.146	-0.090*** (0.018)	0.142	0.181	−0.014** (0.007)	−0.109*** (0.021)
	(any)	*(any)*					
Covid incidence	0.074	0.094	0.021** (0.010)	0.202	0.131	−0.001 (0.010)	−0.005 (0.007)
Covid vaccine	0.602	0.686	0.075*** (0.026)	0.723	0.826	0.013 (0.016)	−0.003 (0.029)
Screening							
Glycohemoglobin	0.677	0.727	0.048** (0.023)	0.683	0.765	0.044** (0.018)	0.039* (0.021)
Creatinine	0.973	0.986	0.011*** (0.003)	0.929	2.567	0.033*** (0.007)	0.074 (0.100)
Cholesterol	0.951	0.980	0.024*** (0.005)	0.882	1.098	0.045*** (0.009)	0.051* (0.031)
Glucose	0.944	0.963	0.019** (0.009)	0.844	2.16	0.034 (0.022)	0.046 (0.087)
TSH	0.741	0.789	0.050** (0.020)	0.636	0.912	0.033** (0.017)	0.048 (0.038)
Diagnosed conditions							
Heart failure	0.436	0.366	-0.075*** (0.024)	0.302	0.723	−0.021* (0.012)	−0.073** (0.029)
Stroke	0.008	0.008	-0.001 (0.002)	0.005	0.005	−0.001 (0.001)	−0.001 (0.001)
Myocardial infarction	0.022	0.026	0.003 (0.004)	0.018	0.024	0.001 (0.002)	0.001 (0.004)
Hyperlipidemia	0.448	0.526	0.079*** (0.025)	0.428	0.631	0.037*** (0.013)	0.044* (0.027)
Overweight/obese	0.155	0.177	0.019 (0.014)	0.136	0.176	0.008 (0.009)	0.002 (0.013)
Prescriptions							
Diabetes	0.226	0.234	0.003 (0.010)	0.266	1.898	0.006 (0.005)	0.073 (0.050)
Anti-hypertensive	0.056	0.048	-0.008 (0.009)	0.036	0.081	−0.001 (0.004)	−0.005 (0.006)
Beta-blockers	0.644	0.655	0.010 (0.011)	0.619	2.534	0.018*** (0.007)	0.058 (0.038)
Statins	0.523	0.585	0.057*** (0.017)	0.597	2.34	0.022** (0.009)	0.150*** (0.044)
Any key	0.835	0.854	0.017* (0.009)	0.844	6.862	0.026*** (0.007)	0.247** (0.100)
Any other	0.997	0.998	0.001* (0.001)	0.985	17.828	0.004* (0.002)	0.341** (0.157)
FE	-	-	Block	-	-	Block	Block
N	47,323	3,275	-	3,275	3,275	50,598	50,598

Controls	-	-	-	-	-	Age, gender, DV_{18-21}	Age, gender, DV_{18-21}

$^{***} < 1\%$; $^{**} < 5\%$; $^{*} < 10\%$.

Notes: The table measures pre-treatment balance of demographic variables and outcomes of interest (columns 1-3) and patient-level health outcomes in the post-treatment period (columns 4-7) at the patient level. The **means columns** (1-2) first shows the mean age of patients in each group at the start of the intervention (28/05/2021), the share of male and mild-risk patients. The values under the *counts* label show patient outcomes of interest as mean annualized counts in the pre-treatment period, running from 01/01/2018 to 27/05/2021. Those values are calculated from healthcare billing data, by summing up all instances of occurrence of a given variable (interaction, diagnosis or procedure) for each patient in the pre-treatment period; annualizing and winsorizing the outliers (at 99.9th percentile) the resulting values; and then calculating the arithmetic averages for relevant groups. The values under the *any* label show the share of patients with at least one occurrence of a given outcome in the same period.

The **representativeness** column (3) displays differences between pure control and ECM control patient groups on each variable as estimated in a WLS regression, inclusive of the fixed effects for the stratification level of the randomization procedure, which is clinic-level randomization block.

Values in columns (4, 5) report ECM control group health outcomes in the post treatment period (01/01/2018 - 27/05/2021), respectively as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) and as counts, meaning the outcomes take a value of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise.

All regression models comparing the health outcomes of the ECM control to pure control patients (columns 6-7) are estimated controlling for patients' values age and sex, as well as the value of a given outcome variable in pre-treatment period (01/01/2018 - 27/05/2021). The only exception is 'ECM inclusion' and 'ECM care plan', which are estimated as WLS, i.e. without pre-treatment values as controls, as those procedures are introduced as a part of the intervention. The pre-treatment values are recorded in parallel with their post-treatment equivalents as either counts or dummies in the respective columns. Fully empty rows code variables that after winsorizing resulted in all values being 0. Models in columns 5-6 are unweighted due to lack of strata-equivalent weights for the 'Pure control' group.

Sub-headings are used to group outcome categories. Standard errors of the coefficients are clustered by doctor and provided in parentheses. Pure control group is missing values for mild risk variable, as the health risk class was not evaluated for this group of patients.

The treatment groups are defined as follows: **Pure Control** - all patients classified by EHIF as eligible for ECM, but at clinics not assigned to ECM intervention (see 'Pure control' group in the randomization chart in Figure D.1); **ECM Control** - patients selected to be in the ECM control at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each outcome variable is provided in Table E.1.

We do see a slight decrease in care on the intensive margin for ECM control patients that might suggest some effort-shifting within the program. The within-provider relative increases in doctor phone calls to ECM patients, for example, may be entirely the product of control group declines, and about half the increase in nurse phone calls are similarly offset by control group declines. By contrast, *in-person* visits were higher for ECM control patients than pure control patients, suggesting a null overall net difference. In other words, the scale of the differences between ECM controls and outside controls are not large enough for our treatment effects to arise purely from shifting care capacity to ECM-randomized patients away from control patients.

F.2 Heterogeneity by patient risk classification

Tables F.2 and F.3 replicate the ANCOVA models presented in the main text in Table 2, subdividing the sample into mild-risk and severe-risk patients respectively. This parallels the sample splitting applied for survival analysis in Table 3 and therefore allows us to determine whether the overall effects found in the main text are driven by only a sub-group of patients in a given risk class. For both mild-risk and severe-risk patients the full-sample effects uncovered in Table 2 persist, with a reduction in sample size causing only small increases in the associated standard errors. The mild-risk sub-group of patients boosts a better health profile - with fewer consultations, hospitalizations, healthcare interactions due to diagnosis of severe conditions, and key prescriptions issued.

Table F.2 shows that in particular for the mild-risk patients the effects of ECM intervention uncovered in the full sample remain mostly unchanged. The effects on primary healthcare utilization, as well as on screening procedures, persist, both in terms of effect size and significance, strengthening noticeably only for doctor phone consultations. The positive ECM effects on the number of interactions due to severe diagnosed conditions persist, but for heart failure and obesity they are reduced by about 40%. A contrary pattern is seen in the effects on prescriptions, where the effects increase by about 30% for statins, all key prescriptions, and all other prescriptions. Table F.3 also shows few deviations from the full-sample results of Table 2.

Table F.2: **ECM Impact:** On patient's care (ANCOVA, mild-risk)

Variable	**Means (control)**		**ECM treatment vs. control**	
	Any	*Count*	*Any*	*Count*
	(1)	(2)	(3)	(4)
Primary care (assigned clinic)				
ECM inclusion	0.051	0.028	0.771*** (0.032)	0.466*** (0.026)
ECM care plan	0.048	0.06	0.793*** (0.032)	0.942*** (0.075)
Doctor in-person chronic care	0.467	0.381	0.097*** (0.030)	0.144*** (0.039)
Doctor phone	0.91	3.819	0.009 (0.009)	0.211*** (0.081)
Nurse in-person	0.768	1.044	0.070*** (0.019)	0.216*** (0.067)
Nurse phone	0.727	1.799	0.093*** (0.022)	0.351*** (0.095)
Any consultation	0.973	7.065	0.004 (0.003)	0.894*** (0.184)
Primary	0.882	1.487	0.025** (0.011)	0.071* (0.037)
Outpatient	0.556	0.62	0.138*** (0.022)	0.219*** (0.039)
Primary care (not assigned clinic)				
Primary	0.087	0.11	0.010 (0.010)	0.019 (0.016)
Outpatient	0.842	3.155	0.019 (0.014)	0.046 (0.123)
Other care				
Inpatient	0.219	0.186	-0.014 (0.016)	-0.007 (0.016)
Inpatient (via ambulance)	0.09	0.061	-0.013 (0.010)	-0.010 (0.007)
Inpatient re-admission (30)	0.027	0.022	0.006 (0.006)	-0.000 (0.006)
Inpatient re-admission (90)	0.046	0.042	0.005 (0.009)	-0.004 (0.008)
Daycare healthcare	0.102	0.083	0.020 (0.015)	0.028 (0.017)
Inpatient nursing/rehabilitation	0.033	0.03	-0.002 (0.009)	-0.003 (0.011)
Outpatient nursing/rehabilitation	0.146	0.178	-0.017 (0.013)	-0.024 (0.027)
Covid incidence	0.214	0.136	0.023 (0.016)	0.017 (0.013)
Covid vaccine	0.722	0.824	-0.003 (0.013)	-0.031 (0.019)
Screening				
Glycohemoglobin	0.651	0.681	0.053*** (0.020)	0.109*** (0.027)
Creatinine	0.916	2.278	0.048*** (0.010)	0.204 (0.145)
Cholesterol	0.874	1.073	0.067*** (0.012)	0.153*** (0.034)
Glucose	0.83	1.656	0.046*** (0.014)	0.179 (0.135)
TSH	0.628	0.857	0.051** (0.020)	0.130*** (0.048)
Diagnosed conditions				
Heart failure	0.25	0.558	0.004 (0.014)	0.093* (0.053)
Stroke	0.005	0.004	0.003 (0.004)	-0.000 (0.003)
Myocardial infarction	0.017	0.019	0.002 (0.005)	0.005 (0.008)
Hyperlipidemia	0.438	0.64	0.093*** (0.021)	0.292*** (0.048)
Overweight/obese	0.126	0.173	0.042*** (0.014)	0.086*** (0.025)
Prescriptions				
Diabetes	0.206	1.318	0.001 (0.008)	0.105 (0.076)
Anti-hypertensive	0.027	0.052	0.001 (0.009)	0.009 (0.011)
Beta-blockers	0.567	2.242	-0.005 (0.016)	0.040 (0.060)
Statins	0.566	2.13	0.028* (0.016)	0.170** (0.069)
Any key	0.809	5.746	-0.000 (0.015)	0.335** (0.137)
Any other	0.984	15.713	0.001 (0.005)	1.07*** (0.282)
FE	-	-	Strata	Strata
Controls	-	-	Age, sex, DV_{18-21}	Age, sex, DV_{18-21}
N	1,966	1,966	3,086	3,086

*** < 1%; ** < 5%; * < 10%.

<u>Notes</u>: The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023). Only mild-risk patients are included in the analyses. Outcome variables in 'Count' columns (2,4,6) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (1, 3,5) measure the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise.

All regression models are estimated controlling for patients' values age and sex, as well as the value of a given outcome

variable in pre-treatment period (01/01/2018 - 27/05/2021). The only exception is 'ECM inclusion' and 'ECM care plan', which are estimated as WLS, i.e. without pre-treatment values as controls, as those procedures are introduced as a part of the intervention. The pre-treatment values are recorded in parallel with their post-treatment equivalents as either counts or dummies in the respective columns. All models include fixed effects as specified in the bottom panel, where strata refers to doctor interacted with patient risk classification level and block to clinic-level randomization block. Fully empty rows code variables that after winsorizing resulted in all values being 0. Models in columns 3-4 are also weighted by strata-level inverse probabilities of treatment assignment, whereas those in columns 5-6 are unweighted due to lack of equivalent weights for the 'Pure control' group. Standard errors of the coefficients are clustered by doctor and provided in parentheses.
The treatment groups are defined as follows: **Pure Control** - all patients classified by EHIF as eligible for ECM, but at clinics not assigned to ECM intervention (see 'Pure control' group in the randomization chart in Figure D.1); **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

Table F.3: **ECM Impact:** On patient's care (ANCOVA, severe-risk)

Variable	**Means (control)**		**ECM treatment vs. control**	
	Any	*Count*	*Any*	*Count*
	(1)	(2)	(3)	(4)
Primary care (assigned clinic)				
ECM inclusion	0.046	0.026	0.755*** (0.044)	0.432*** (0.026)
ECM care plan	0.048	0.055	0.771*** (0.044)	0.894*** (0.089)
Doctor in-person chronic care	0.476	0.389	0.131*** (0.033)	0.154*** (0.035)
Doctor phone	0.916	4.467	0.002 (0.009)	-0.039 (0.141)
Nurse in-person	0.767	1.097	-0.004 (0.020)	0.117 (0.088)
Nurse phone	0.729	2.079	0.094*** (0.028)	0.169* (0.088)
Any consultation	0.961	8.118	0.002 (0.006)	0.402** (0.177)
Primary	0.845	1.449	0.033** (0.013)	0.146** (0.063)
Outpatient	0.509	0.563	0.107*** (0.031)	0.247*** (0.044)
Primary care (not assigned clinic)				
Primary	0.134	0.205	-0.015 (0.011)	-0.016 (0.019)
Outpatient	0.85	3.858	0.011 (0.017)	-0.076 (0.117)
Other care				
Inpatient	0.309	0.273	-0.031 (0.024)	-0.035 (0.026)
Inpatient (via ambulance)	0.133	0.091	-0.003 (0.016)	-0.006 (0.012)
Inpatient re-admission (30)	0.056	0.045	-0.020** (0.010)	-0.023*** (0.009)
Inpatient re-admission (90)	0.079	0.071	-0.011 (0.013)	-0.016 (0.013)
Daycare healthcare	0.139	0.117	-0.024 (0.017)	-0.031* (0.018)
Inpatient nursing/rehabilitation	0.052	0.046	0.014 (0.013)	0.004 (0.012)
Outpatient nursing/rehabilitation	0.135	0.185	0.011 (0.017)	-0.006 (0.039)
Covid incidence	0.183	0.123	0.008 (0.023)	0.024 (0.019)
Covid vaccine	0.725	0.827	-0.008 (0.023)	-0.036 (0.041)
Screening				
Glycohemoglobin	0.731	0.89	0.042** (0.018)	0.116*** (0.041)
Creatinine	0.949	2.946	0.022** (0.009)	-0.044 (0.171)
Cholesterol	0.895	1.135	0.027* (0.014)	0.145*** (0.046)
Glucose	0.865	2.678	0.016 (0.014)	-0.167 (0.254)
TSH	0.648	0.961	0.046*** (0.016)	0.147** (0.060)
Diagnosed conditions				
Heart failure	0.38	0.97	0.077*** (0.020)	0.270*** (0.069)
Stroke	0.006	0.007	0.002 (0.004)	0.002 (0.005)
Myocardial infarction	0.02	0.031	-0.005 (0.007)	-0.006 (0.011)
Hyperlipidemia	0.413	0.618	0.101*** (0.021)	0.252*** (0.049)
Overweight/obese	0.15	0.181	0.081*** (0.021)	0.247*** (0.054)
Prescriptions				
Diabetes	0.357	2.769	0.042*** (0.011)	0.069 (0.137)
Anti-hypertensive	0.048	0.125	-0.011 (0.010)	-0.015 (0.024)
Beta-blockers	0.697	2.972	0.011 (0.019)	0.047 (0.097)
Statins	0.642	2.655	0.024 (0.015)	0.038 (0.088)
Any key	0.896	8.537	0.026** (0.010)	0.118 (0.240)
Any other	0.986	21.004	0.006 (0.005)	0.102 (0.339)
FE	-	-	Strata	Strata
Controls	-	-	Age, sex, DV_{18-21}	Age, sex, DV_{18-21}
N	1,309	1,309	1,970	1,970

*** < 1%; ** < 5%; * < 10%.

__Notes:__ The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023). Only severe-risk patients are included in the analyses. Outcome variables in 'Count' columns (2,4,6) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (1, 3,5) measure the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise.

All regression models are estimated controlling for patients' values age and sex, as well as the value of a given outcome

variable in pre-treatment period (01/01/2018 - 27/05/2021). The only exception is 'ECM inclusion' and 'ECM care plan', which are estimated as WLS, i.e. without pre-treatment values as controls, as those procedures are introduced as a part of the intervention. The pre-treatment values are recorded in parallel with their post-treatment equivalents as either counts or dummies in the respective columns. All models include fixed effects as specified in the bottom panel, where strata refers to doctor interacted with patient risk classification level and block to clinic-level randomization block. Fully empty rows code variables that after winsorizing resulted in all values being 0. Models in columns 3-4 are also weighted by strata-level inverse probabilities of treatment assignment, whereas those in columns 5-6 are unweighted due to lack of equivalent weights for the 'Pure control' group. Standard errors of the coefficients are clustered by doctor and provided in parentheses.
The treatment groups are defined as follows: **Pure Control** - all patients classified by EHIF as eligible for ECM, but at clinics not assigned to ECM intervention (see 'Pure control' group in the randomization chart in Figure D.1); **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

F.3 Provider heterogeneity

In order to further check if the ECM treatment had differential outcomes for certain subgroups of patients, in Table F.4 we also present the results of several models, where the ECM treatment dummy is interacted with a series of other variables. Those include clinic-level service level (as measured by QBS scores, columns 3-4) and management quality (columns 5-6), which aim to check if ECM was more effective in better-run clinics. ECM treatment is also interacted with the provider-level assessment of the care plans developed (columns 7-8). Those were assessed by consultants as described in section E.5. The variable measuring the plan quality is constructed by extracting the values of the first principal component of the 6 survey questions intended to evaluate different facets of each care plan. Finally, ECM treatment is also interacted with the annualized count of each outcome in the pre-treatment period (columns 9-10).

Overall, we find no evidence of heterogeneous treatment effects across different levels of healthcare and care plan quality. Patients suffering from certain pre-existing conditions did see a differential ECM impact on some of the outcomes measured. Those significant interaction effects between pre-existing health problems and ECM treatment assignment are mostly seen for chronic conditions, including heart problems, high cholesterol, obesity, and insulin-level management. It suggests that ECM might have allowed the patients with known long-term health issues to more frequently consult those with their health providers.

Table F.4: **ECM Impact:** On patient's care (interactions; counts)

Variable	**Means (control)**		**QBS**		**Mng. Q.**		**Plan Q.**		**Pre-18**	
	Any (1)	*Count* (2)	β_{treat} (3)	$\beta_{interact}$ (4)	β_{treat} (5)	$\beta_{interact}$ (6)	β_{treat} (7)	$\beta_{interact}$ (8)	β_{treat} (9)	$\beta_{interact}$ (10)
Primary care (assigned clinic)										
ECM inclusion	0.049	0.027	0.529***	-0.000	0.478***	-0.002	0.457***	-0.008	-	-
			(0.103)	(0.000)	(0.057)	(0.004)	(0.022)	(0.013)		
ECM care plan	0.048	0.058	1.30***	-0.001	0.801***	0.011	0.949***	0.021	-	-
			(0.427)	(0.001)	(0.162)	(0.012)	(0.072)	(0.040)		
Doctor in-person chronic care	0.471	0.384	0.174	-0.000	0.171**	-0.001	0.157***	-0.005	0.151***	-0.005
			(0.236)	(0.001)	(0.076)	(0.005)	(0.032)	(0.018)	(0.040)	(0.054)
Doctor phone	0.912	4.078	0.642	-0.002	0.023	0.005	0.082	-0.029	0.144	-0.007
			(0.915)	(0.002)	(0.196)	(0.016)	(0.101)	(0.046)	(0.126)	(0.041)
Nurse in-person	0.767	1.066	0.725**	-0.001*	0.373***	-0.018**	0.184***	-0.027	0.194**	-0.019
			(0.325)	(0.001)	(0.137)	(0.009)	(0.055)	(0.028)	(0.079)	(0.082)
Nurse phone	0.728	1.911	1.05***	-0.002*	0.356***	-0.007	0.285***	-0.062*	0.163*	0.082*
			(0.402)	(0.001)	(0.138)	(0.013)	(0.072)	(0.033)	(0.090)	(0.050)
Any consultation	0.968	7.485	2.60**	-0.005	0.936***	-0.024	0.660***	-0.123	0.269	0.069*
			(1.32)	(0.003)	(0.328)	(0.025)	(0.162)	(0.076)	(0.287)	(0.040)
Primary	0.867	1.472	0.175	-0.000	0.164*	-0.005	0.113***	-0.006	0.155***	-0.026
			(0.306)	(0.001)	(0.095)	(0.006)	(0.038)	(0.020)	(0.058)	(0.030)
Outpatient	0.537	0.597	-0.151	0.001**	0.120**	0.009*	0.219***	-0.001	0.278***	-0.163
			(0.150)	(0.000)	(0.057)	(0.005)	(0.033)	(0.017)	(0.044)	(0.126)
Primary care (not assigned clinic)										
Primary	0.106	0.148	-0.098	0.000	-0.012	0.001	0.003	0.003	0.003	0.006
			(0.098)	(0.000)	(0.019)	(0.001)	(0.010)	(0.006)	(0.010)	(0.022)
Outpatient	0.845	3.436	0.086	-0.000	0.121	-0.004	0.091	-0.023	-0.124	0.041
			(0.717)	(0.002)	(0.205)	(0.015)	(0.098)	(0.050)	(0.150)	(0.040)
Other care										
Inpatient	0.255	0.221	-0.043	0.000	0.007	-0.002	-0.012	-0.002	-0.050***	0.194**
			(0.072)	(0.000)	(0.029)	(0.002)	(0.012)	(0.006)	(0.018)	(0.094)
Inpatient (via ambulance)	0.107	0.073	-0.040	0.000	-0.012	0.000	-0.006	0.003	-0.008	-0.016
			(0.067)	(0.000)	(0.013)	(0.001)	(0.007)	(0.003)	(0.007)	(0.094)
Inpatient re-admission (30)	0.038	0.032	-0.004	-0.000	-0.011	0.000	-0.007	0.004*	-0.009*	-0.023
			(0.026)	(0.000)	(0.010)	(0.001)	(0.005)	(0.002)	(0.005)	(0.083)
Inpatient re-admission (90)	0.059	0.054	-0.043	0.000	-0.003	-0.000	-0.005	0.003	-0.016*	0.286
			(0.034)	(0.000)	(0.014)	(0.001)	(0.007)	(0.003)	(0.008)	(0.223)
Daycare healthcare	0.117	0.097	0.042	-0.000	-0.008	0.001	0.007	-0.012**	-0.001	0.076
			(0.092)	(0.000)	(0.032)	(0.002)	(0.012)	(0.005)	(0.018)	(0.206)
Inpatient nursing/rehabilitation	0.04	0.036	0.061*	-0.000*	0.012	-0.001	-0.002	-0.005	0.007	-0.475**
			(0.034)	(0.000)	(0.020)	(0.001)	(0.008)	(0.005)	(0.008)	(0.209)
Outpatient nursing/rehabilitation	0.142	0.181	0.142	-0.000	0.078	-0.008*	-0.008	0.007	-0.039	0.159
			(0.154)	(0.000)	(0.050)	(0.004)	(0.031)	(0.013)	(0.026)	(0.171)
Covid incidence	0.202	0.131	-0.020	0.000	0.015	0.000	0.020*	-0.010*	0.018	0.044
			(0.076)	(0.000)	(0.027)	(0.002)	(0.011)	(0.006)	(0.012)	(0.146)
Covid vaccine	0.723	0.825	0.114	-0.000	-0.046	0.001	-0.039*	-0.006	-0.083**	0.090**
			(0.161)	(0.000)	(0.045)	(0.004)	(0.023)	(0.010)	(0.041)	(0.046)
Screening										
Glycohemoglobin	0.683	0.765	0.118	-0.000	0.160**	-0.004	0.120***	0.006	0.116***	-0.004
			(0.192)	(0.001)	(0.068)	(0.005)	(0.030)	(0.016)	(0.030)	(0.045)
Creatinine	0.929	2.545	0.077	0.000	0.268	-0.015	0.106	-0.060	0.195	-0.043
			(0.900)	(0.002)	(0.262)	(0.018)	(0.114)	(0.057)	(0.198)	(0.108)

Cholesterol	0.882	1.098	0.436*	-0.001	0.173***	-0.002	0.158***	-0.009	0.297***	-0.130**
			(0.225)	(0.001)	(0.065)	(0.005)	(0.033)	(0.016)	(0.065)	(0.061)
Glucose	0.844	2.065	-0.559	0.002	0.398	-0.033*	0.043	-0.075	0.083	-0.022
			(0.524)	(0.002)	(0.261)	(0.019)	(0.135)	(0.067)	(0.306)	(0.199)
TSH	0.636	0.898	0.391	-0.001	0.285***	-0.013**	0.142***	-0.024	0.068	0.085*
			(0.294)	(0.001)	(0.096)	(0.007)	(0.044)	(0.022)	(0.051)	(0.045)
Diagnosed conditions										
Heart failure	0.302	0.723	0.107	0.000	0.096	0.004	0.153***	0.005	0.050	0.176***
			(0.379)	(0.001)	(0.095)	(0.007)	(0.051)	(0.027)	(0.035)	(0.062)
Stroke	0.005	0.005	-0.016	0.000	-0.005	0.001	0.003	0.000	0.000	0.165
			(0.010)	(0.000)	(0.006)	(0.000)	(0.003)	(0.001)	(0.002)	(0.421)
Myocardial infarction	0.018	0.024	0.044	-0.000	-0.015	0.001	-0.002	0.001	0.002	-0.062
			(0.031)	(0.000)	(0.016)	(0.001)	(0.007)	(0.003)	(0.005)	(0.122)
Hyperlipidemia	0.428	0.631	0.266	0.000	0.248***	0.003	0.282***	-0.019	0.208***	0.118**
			(0.363)	(0.001)	(0.093)	(0.007)	(0.043)	(0.024)	(0.041)	(0.047)
Overweight/obese	0.136	0.176	0.316	-0.000	0.100**	0.004	0.145***	0.012	0.097***	0.342***
			(0.245)	(0.001)	(0.045)	(0.004)	(0.027)	(0.013)	(0.023)	(0.121)
Prescriptions										
Diabetes	0.266	1.898	-0.167	0.001	0.285	-0.013	0.176	-0.025	0.107**	-0.005
			(0.953)	(0.003)	(0.318)	(0.025)	(0.162)	(0.082)	(0.049)	(0.037)
Anti-hypertensive	0.036	0.081	-0.038	0.000	-0.045	0.004	-0.005	0.031***	-0.006	0.065
			(0.131)	(0.000)	(0.042)	(0.003)	(0.016)	(0.010)	(0.007)	(0.115)
Beta-blockers	0.619	2.534	0.100	-0.000	-0.040	0.008	0.091	0.036	0.046	-0.001
			(0.317)	(0.001)	(0.142)	(0.012)	(0.077)	(0.039)	(0.064)	(0.020)
Statins	0.597	2.34	0.460	-0.001	0.253	-0.009	0.175**	0.015	0.197***	-0.033
			(0.560)	(0.001)	(0.158)	(0.012)	(0.075)	(0.040)	(0.063)	(0.021)
Any key	0.844	6.862	0.306	0.000	0.466	-0.011	0.438*	0.058	0.427***	-0.024
			(1.35)	(0.004)	(0.485)	(0.038)	(0.233)	(0.123)	(0.141)	(0.024)
Any other	0.985	17.828	1.92	-0.003	1.40**	-0.047	0.856**	-0.290	0.839*	-0.008
			(2.31)	(0.006)	(0.687)	(0.053)	(0.349)	(0.178)	(0.503)	(0.027)
FE	-		Bloc x Risk		Bloc x Risk		Bloc x Risk		Strata	
Controls	-		Age, sex		Age, sex		Age, sex		Age, sex	
N	3,275		5,056		5,056		4,843		5,056	

*** < 1%; ** < 5%; * < 10%.

Notes: The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023) for patients assigned to either control or treatment condition. Outcome variables in the 'Count' columns (2) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (1) measure the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and 0 otherwise All regression models in columns 3-10 use measure the outcome variable specified in each row as counts. All models include a dummy for ECM treatment groups. In each model that dummy is interacted with the variable specified in the column heading. Treatment group and interaction coefficient are listed under β_{treat} and $\beta_{interact}$ respectively. The interaction variables are: **QBS** - variable measuring doctor-level Quality Bonus Scheme score; **Mng. Q.** - doctor-level management quality scores; **Plan Q.** - doctor-level evaluations of ECM care plan quality, prepared by external consultants and based on the first principal component of 6 care plan evaluation survey questions (see details in Section E.5);**Pre-18** - pre-treatment value of a given condition/diagnosis/procedures between 2018 and the onset of ECM in June 2021 (also measured as counts). All models contain controls for patients' age and sex and are weighted by strata-level inverse probabilities of treatment assignment. The models further include fixed effects as specified in the bottom panel, where strata refers to doctor interacted with patient risk classification level and block to clinic-level randomization block.
The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

F.4 Mediation analysis

One of the key effects of ECM was the decreased risk of death during the treatment period among mild-risk patients. This effect is likely to be a compound of many different factors, of which our data allows us to measure only a restricted subset. In order to gauge the degree to which observable actions undertaken within ECM help to explain the mortality differences, this sub-section turns to mediation analysis as outlined in Rijnhart et al. (2021).

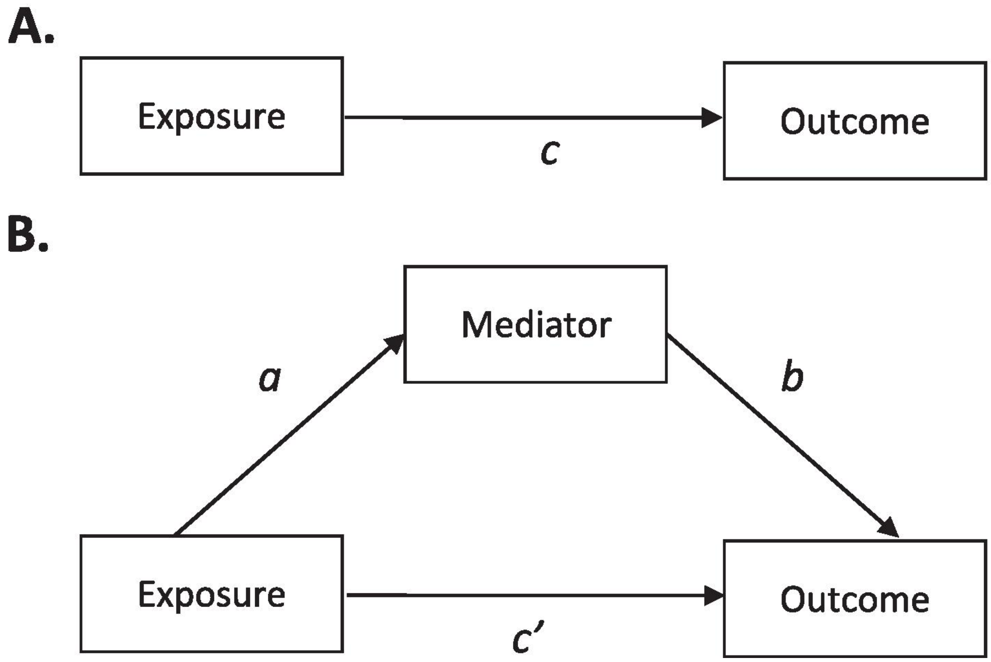
Mediation analysis recognizes that the effects of an explanatory factor X (ECM treatment in this case) on the outcome of interest Y (mortality) might not be direct, but mediated through a third variable. For ECM the direct effect is most likely minuscule, as the creation of the care plan alone has no effects on a patient's health and therefore their probability of dying. The uncovered effects on mortality are most likely the results of a series of changes in a patient's life, including dietary adjustments, increases levels of physical activity, more careful monitoring of one's health etc. Those changes unfortunately cannot be measured using the billing micro-data. Rather, our data allows us to assess the impact of ECM-induced behaviors on the decreased risk of dying. For instance, statin prescriptions might be one of such mediating factors. Figure F.1, based on (Rijnhart et al., 2021), presents a graphical decomposition of mediation process into total exposure effect (panel A) and exposure-mediator effect (panel B). The extent to which the direct effect of exposure is working only through the mediator can be calculated by subtracting c' coefficient from c. Alternatively, the quotient $\frac{c-c'}{c}$ can be obtained, to get the ratio of the direct effect that is working via mediator alone.

In the causal inference setting, like an RCT analysed here, mediation analysis strives to determine the difference between two counterfactual outcomes $Y_i(x, M_i(x))$, where Y_i is individual's i outcome of interest, x indicates the treatment condition of an individual (0 for control and 1 for treatment), and $M_o(x)$ the value of mediator variable for individual i under treatment condition x (Rijnhart et al., 2021). This leads to the following notation for total unit treatment effect τ_i, as discussed by (Tingley et al., 2014), who also introduce R package that is used below to implement the analyses:

$$\tau_i = Y_i(1, M_i(1)) - Y_i(0, M_i(0))$$

Alternatively, this can be written down as a sum of "causal mediation effects" $\delta_i(x)$ and "direct effects" $\zeta_i(x)$:

Figure F.1: Mediation analysis flowchart (based on Rijnhart et al. 2021)



$\tau_i = \delta_i(x) + \zeta_i(x)$

The causal mediation effects are obtained by calculating the difference in the outcome that would be obtained if the treatment status was kept constant at x, but mediator value was adjusted to the values expected under treatment and control conditions. In other, words, this is the change in the outcome that would be expected if mediator changed its values as if under different treatment condition, but everything else stayed the same:

$\delta_i(x) = Y_i(x, M_i(1)) - Y_i(x, M_i(0))$

The direct effect is in turn obtained by keeping the mediator at the same level, depending on the treatment condition, but allowing the treatment status itself to vary:

$\zeta_i(x) = Y_i(1, M_i(x)) - Y_i(0, M_i(x))$

Table F.5: **Mediation analysis:** ECM effect on mortality

Mediating variable	Causal mediation effects $\delta_i(x)$	Direct effects $\zeta_i(x)$	Ratio mediated $\frac{\delta_i(x)}{\delta_i(x)+\zeta_i(x)}$
	(1)	(2)	(3)
Primary care (assigned clinic)			
Doctor in-person chronic care	-0.005*** (-0.001)	-0.009 (-0.006)	0.367** (0.106)
Doctor phone	-0.001 (-0.001)	-0.013** (-0.005)	0.040 (0.006)
Nurse in-person	-0.003*** (-0.001)	-0.010* (-0.005)	0.240** (0.072)
Nurse phone	-0.002*** (-0.001)	-0.012** (-0.006)	0.126** (0.044)
Any consultation	-0.004*** (-0.001)	-0.010* (-0.006)	0.265** (0.076)
Primary	-0.001** (-0.001)	-0.012** (-0.005)	0.102** (0.047)
Outpatient	-0.002*** (-0.001)	-0.012** (-0.005)	0.133** (0.052)
Primary care (not assigned clinic)			
Primary	0.000 (0.000)	-0.014** (-0.006)	0.001 (0.020)
Outpatient	0.000 (0.000)	-0.013** (-0.005)	0.011 (0.014)
Other care			
Inpatient	-0.001 (-0.001)	-0.013** (-0.005)	0.061 (0.065)
Inpatient (via ambulance)	-0.002 (-0.002)	-0.011** (-0.005)	0.167 (0.008)
Inpatient re-admission (30)	0.000 (-0.001)	-0.013** (-0.005)	0.026 (0.049)
Inpatient re-admission (90)	-0.001 (-0.001)	-0.013** (-0.005)	0.046 (0.045)
Daycare healthcare	0.000 (0.000)	-0.014** (-0.005)	0.007 (0.039)
Inpatient nursing/rehabilitation	0.000 (-0.001)	-0.013** (-0.005)	0.020 (0.039)
Outpatient nursing/rehabilitation	0.000 (0.000)	-0.014** (-0.005)	0.001 (0.026)
Covid incidence	0.001* (0.000)	-0.014** (-0.005)	0.045 (0.094)
Covid vaccine	0.000 (0.000)	-0.014** (-0.005)	0.031 (0.075)
Screening			
Glycohemoglobin	0.000 (0.000)	-0.014** (-0.005)	0.008 (0.067)
Creatinine	0.002* (0.001)	-0.015*** (-0.005)	0.119* (0.236)
Cholesterol	0.000 (0.000)	-0.014** (-0.005)	0.029 (0.106)
Glucose	0.001 (0.000)	-0.015** (-0.005)	0.091 (0.257)
TSH	0.000 (0.000)	-0.014** (-0.005)	0.004 (0.047)
Diagnosed conditions			
Heart failure	0.000 (0.000)	-0.013** (-0.005)	0.003 (0.011)
Stroke	0.000 (0.000)	-0.014** (-0.005)	0.000 (0.014)
Myocardial infarction	0.000 (0.000)	-0.014** (-0.005)	0.001 (0.020)
Hyperlipidemia	-0.002*** (-0.001)	-0.011* (-0.006)	0.173** (0.066)
Overweight/obese	0.000 (0.000)	-0.013** (-0.005)	0.005 (0.033)
Prescriptions			
Diabetes	0.000 (0.000)	-0.013** (-0.005)	0.006 (0.009)
Anti-hypertensive	0.000 (0.000)	-0.014** (-0.005)	0.000 (0.017)
Beta-blockers	0.000 (0.000)	-0.013** (-0.005)	0.016 (0.019)
Statins	-0.001** (-0.001)	-0.013** (-0.006)	0.074** (0.036)
Any key	-0.001** (-0.001)	-0.013** (-0.005)	0.066** (0.031)
Any other	-0.001*** (-0.001)	-0.012** (-0.005)	0.078** (0.031)

*** $<$ 1%; ** $<$ 5%; * $<$ 10%.

Notes: The table shows the results of mediation analysis for mild-risk patients, implemented using the approach of (Tingley et al., 2014). The definitions of the causal and direct effects are discussed in detail in the text above, as well as, in much greater detail, in the cited paper.

The mediation analysis is implemented by estimating two OLS models. The first model evaluates the effect ECM treatment assignment on the value of mediating variable of interest. Second, the outcome of interest, in this case dummy variable for whether a patient died during the observation period (1) or not (0), is modelled using both the ECM treatment assignment and the mediating variables. Both models also include the standard set of controls - patient age, sex, as well as strata-level fixed effects.

Standard errors are obtained by re-running the analysis using quasi-Bayesian Monte Carlo method based on normal approximation (Tingley et al., 2014), with 1,000 simulations. Only patients assigned to ECM control and treatment groups are included in the analyses.

The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

Applying this approach to assess the scope of ECM activities impacting mortality for mild-risk patients, as done in Table F.5, it can be seen that no single variable mediates the majority of the uncovered mortality effects. More frequent interactions with the primary healthcare system appear to be driving between 10% and 36.7% of the direct effect (column 3). Another effect of this size is only seen for hyperlipidemia diagnoses and creatinine monitoring. Around 6-8% of the direct effects are also mediated by more frequent prescriptions, in particular statins. We also undertake a combined assessment of the key features of ECM: more regular interactions with the primary healthcare system and regular uptake of appropriate prescriptions, and find that together these account for roughly half of the experimental variation we see in mortality rates.

F.5 Treatment-on-the-treated estimates

In order to estimate the effect of ECM uptake, rather than only ECM assignment, instrumental variables (2SLS) version of all the models in Table 2 were also estimated and are presented in Table F.6. The statistical significance of the effects remains almost perfectly consistent with the ones discussed in the main text. The absolute effect size is increased by approximately 27%, consistent with the treatment uptake rate.

Table F.6: **ECM Impact:** On patient's care (IV/TOT)

Variable	**Means (control)**		**ECM treatment vs. control**	
	Any	*Count*	*Any*	*Count*
	(1)	(2)	(3)	(4)
Primary care (assigned clinic)				
Doctor in-person chronic care	0.471	0.384	0.139*** (0.033)	0.189*** (0.040)
Doctor phone	0.912	4.078	0.010 (0.008)	0.150 (0.098)
Nurse in-person	0.767	1.066	0.056*** (0.020)	0.223*** (0.071)
Nurse phone	0.728	1.911	0.121*** (0.027)	0.364*** (0.085)
Any consultation	0.968	7.485	0.004 (0.004)	0.914*** (0.163)
Primary	0.867	1.472	0.037*** (0.010)	0.130*** (0.041)
Outpatient	0.537	0.597	0.161*** (0.026)	0.292*** (0.039)
Primary care (not assigned clinic)				
Primary	0.106	0.148	-0.000 (0.010)	0.006 (0.013)
Outpatient	0.845	3.436	0.012 (0.017)	0.003 (0.103)
Other care				
Inpatient	0.255	0.221	-0.025 (0.015)	-0.021 (0.017)
Inpatient (via ambulance)	0.107	0.073	-0.012 (0.012)	-0.011 (0.008)
Inpatient re-admission (30)	0.038	0.032	-0.006 (0.007)	-0.012* (0.006)
Inpatient re-admission (90)	0.059	0.054	-0.001 (0.009)	-0.009 (0.009)
Daycare healthcare	0.117	0.097	0.004 (0.014)	0.008 (0.016)
Inpatient nursing/rehabilitation	0.04	0.036	0.006 (0.009)	-0.000 (0.011)
Outpatient nursing/rehabilitation	0.142	0.181	-0.008 (0.014)	-0.020 (0.031)
Covid incidence	0.202	0.131	0.022 (0.018)	0.025* (0.014)
Covid vaccine	0.723	0.825	-0.013 (0.017)	-0.042 (0.028)
Screening				
Glycohemoglobin	0.683	0.765	0.063*** (0.017)	0.144*** (0.032)
Creatinine	0.929	2.545	0.051*** (0.009)	0.142 (0.148)
Cholesterol	0.882	1.098	0.065*** (0.011)	0.194*** (0.041)
Glucose	0.844	2.065	0.047*** (0.014)	0.063 (0.161)
TSH	0.636	0.898	0.069*** (0.015)	0.177*** (0.056)
Diagnosed conditions				
Heart failure	0.302	0.723	0.045*** (0.015)	0.205*** (0.052)
Stroke	0.005	0.005	0.003 (0.003)	0.001 (0.003)
Myocardial infarction	0.018	0.024	0.001 (0.005)	0.001 (0.008)
Hyperlipidemia	0.428	0.631	0.115*** (0.022)	0.356*** (0.044)
Overweight/obese	0.136	0.176	0.075*** (0.018)	0.191*** (0.034)
Prescriptions				
Diabetes	0.266	1.898	0.026* (0.014)	0.126 (0.090)
Anti-hypertensive	0.036	0.081	-0.002 (0.007)	-0.001 (0.015)
Beta-blockers	0.619	2.534	0.016 (0.013)	0.055 (0.064)
Statins	0.597	2.34	0.042*** (0.015)	0.158** (0.069)
Any key	0.844	6.862	0.025* (0.013)	0.333** (0.158)
Any other	0.985	17.828	0.004 (0.004)	0.900*** (0.301)
FE	-	-	Strata	Strata
Controls	-	-	Age, sex	Age, sex
N	3,275	3,275	5,056	5,056

*** < 1%; ** < 5%; * < 10%.

Notes: The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023) for patients assigned to either control or treatment condition. Outcome variables in the 'Count' columns (2,4) are measured as annualized and winsorized (at 99.9th percentile) sums of a given outcome (diagnosis, procedure, or consultation) per patient and period. 'Any' columns (1, 3) measures the same variables converted to 0/1 dummy values, meaning they take values of 1 if a patient had a particular diagnosis, procedure, or consultation at any point during the treatment period, and

0 otherwise.

All regression models in columns 3-4 refer to instrumental regression coefficients, where the treatment assignment is random assignment to ECM Control or ECM Treatment, and the treatment uptake is defined as a patient developing an ECM healthcare plan with their doctor. All regression models are estimated controlling for patients' values age and sex, as well as the value of a given outcome variable in pre-treatment period (01/01/2018 - 27/05/2021) The only exception is 'ECM inclusion' and 'ECM care plan', which are estimated as WLS, i.e. without pre-treatment values as controls, as those procedures are introduced as a part of the intervention. The pre-treatment values are recorded in parallel with their post-treatment equivalents as either counts or dummies in the respective columns. All models include fixed effects as specified in the bottom panel, where strata refers to doctor interacted with patient risk classification level and block to clinic-level randomization block. Fully empty rows code variables that after winsorizing resulted in all values being 0. Models in columns 3-4 are also weighted by strata-level inverse probabilities of treatment assignment. Standard errors of the coefficients are clustered by doctor and provided in parentheses.

The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctor, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each of the variables is provided in Table E.1.

F.6 Multiple hypothesis adjustments

The values of statistical significance of model coefficient from Table 2 were also adjusted for multiple hypothesis testing using Benjamini-Hochberg and Romano-Wolf procedures. This approach is taken to ensure the treatment effects found don't simply stem from the number of tests carried out.

Benjamini-Hochberg procedure adjust each p-value by multiplying it by $\frac{m}{i}$ - the ratio of the number of hypotheses being tested (m) and the rank of a given p-value in an ascending distribution of all p-values tested (i). It therefore increases the testing rigour the higher the number of hypotheses tested, but relaxes it for comparatively higher p-values.

In turn, Romano-Wolf procedure is a more stringent test, controlling for the family-wise error rate (FWER), which accounts for the possibility of outcomes, and therefore also the associated p-values, not being (fully) independent of each other. In this procedure, bootstrapped resampling (with 10,000 iterations here) is used to re-estimate the test statistic of interest and compare them to the original estimate, as documented in (Clarke, 2019).

The results of those tests are shown below in Table F.7. In all but few instances they confirm that the results uncovered are unlikely to be due to chance. Apart from the results originally significant only at 10% level, the only challenges to that interpretation come from p-values for nurse in-person consultations and the prescriptions results as re-estimated using Romano-Wolf procedures (columns 7-8).

F.7 Randomization inference

Finally, the p-values for both the ANCOVA results (Table 2) and survival analyses (Figure 3) are also re-calculated using randomization inference. By re-randomizing treatment assignment 10,000 times, using the original randomization procedure, we can test how likely it was to recover the effects of at least the same magnitude by a random chance. The p-values in columns 9-10 of Table 2 confirm that the effects found in the ANCOVA models are extremely unlikely to be spurious. Similarly, Figure F.2, suggests that the effect on mortality among the mild-risk patients is unlikely to be due to chance, with randomization p-value standing at 0.021. On the other hand, both the effects on mortality and first hospitalization in the severe-risk group, as well as in aggregate, are found to yield randomization p-values above 0.05, corresponding to the non-significant results in main text.

Table F.7: **ECM Impact:** Robustness checks

Variable	$\boldsymbol{\beta}_{\textbf{treatment}}$		**P-values**							
			ANCOVA		**Benjamini-Hochberg**		**Romano-Wolf**		**Randomization inference**	
	Any (1)	*Count* (2)	*Any* (3)	*Count* (4)	*Any* (5)	*Count* (6)	*Any* (7)	*Count* (8)	*Any* (9)	*Count* (10)
Primary care (assigned clinic)										
ECM inclusion	0.764	0.466	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
ECM care plan	0.784	0.935	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Doctor in-person chronic care	0.111	0.151	<0.001***	<0.001***	<0.001***	<0.001***	0.001***	<0.001***	<0.001***	<0.001***
Doctor phone	0.007	0.051	0.27	0.597	0.417	0.713	0.985	0.999	0.299	0.596
Nurse in-person	0.044	0.170	0.008***	0.006***	0.022**	0.016**	0.172	0.101	<0.001***	<0.001***
Nurse phone	0.095	0.285	<0.001***	<0.001***	<0.001***	0.001***	<0.001***	0.004***	<0.001***	<0.001***
Any consultation	0.003	0.645	0.308	<0.001***	0.438	0.001***	0.989	0.004***	0.291	<0.001***
Primary	0.029	0.107	<0.001***	0.013**	0.001***	0.035**	0.01**	0.229	0.002***	0.002***
Outpatient	0.124	0.218	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Primary care (not assigned clinic)										
Primary	-0.002	0.002	0.842	0.827	0.865	0.827	0.998	0.999	0.832	0.844
Outpatient	0.013	0.073	0.358	0.448	0.473	0.587	0.989	0.998	0.259	0.525
Other care										
Inpatient	-0.020	-0.017	0.087*	0.186	0.179	0.313	0.818	0.947	0.139	0.261
Inpatient (via ambulance)	-0.009	-0.009	0.303	0.208	0.438	0.335	0.989	0.96	0.316	0.241
Inpatient re-admission (30)	-0.004	-0.008	0.437	0.075*	0.539	0.155	0.995	0.728	0.455	0.102
Inpatient re-admission (90)	-0.001	-0.007	0.908	0.266	0.908	0.41	0.998	0.979	0.909	0.368
Daycare healthcare	0.004	0.012	0.719	0.46	0.782	0.587	0.998	0.998	0.672	0.32
Inpatient nursing/rehabilitation	0.004	-0.002	0.597	0.793	0.713	0.815	0.998	0.999	0.536	0.753
Outpatient nursing/rehabilitation	-0.005	-0.010	0.65	0.71	0.751	0.776	0.998	0.999	0.653	0.669
Covid incidence	0.017	0.019	0.225	0.094*	0.362	0.183	0.974	0.798	0.178	0.035**
Covid vaccine	-0.019	-0.035	0.208	0.125	0.35	0.23	0.972	0.874	0.157	0.1
Screening										
Glycohemoglobin	0.049	0.113	0.001***	<0.001***	0.003***	0.001***	0.022**	0.006***	<0.001***	<0.001***
Creatinine	0.039	0.103	<0.001***	0.387	<0.001***	0.53	<0.001***	0.993	<0.001***	0.316
Cholesterol	0.052	0.154	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Glucose	0.036	0.055	0.002***	0.713	0.006***	0.776	0.046**	0.999	<0.001***	0.73
TSH	0.052	0.139	<0.001***	0.005***	0.001***	0.014**	0.004***	0.089*	<0.001***	<0.001***
Diagnosed conditions										
Heart failure	0.033	0.147	0.015**	0.004***	0.035**	0.012**	0.266	0.071*	0.017**	0.002***
Stroke	0.004	0.002	0.164	0.354	0.29	0.524	0.943	0.993	0.147	0.392
Myocardial infarction	-0.001	-0.003	0.758	0.672	0.802	0.776	0.998	0.999	0.724	0.635
Hyperlipidemia	0.094	0.287	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***	<0.001***
Overweight/obese	0.057	0.146	<0.001***	<0.001***	0.001***	<0.001***	0.007***	<0.001***	<0.001***	<0.001***
Prescriptions										
Diabetes	0.023	0.142	0.102	0.372	0.198	0.529	0.85	0.993	0.097*	0.295
Anti-hypertensive	-0.002	-0.006	0.706	0.75	0.782	0.793	0.998	0.999	0.685	0.766
Beta-blockers	0.013	0.046	0.43	0.551	0.539	0.679	0.995	0.999	0.417	0.573
Statins	0.038	0.158	0.015**	0.037**	0.035**	0.08*	0.265	0.484	0.011**	0.04**
Any key	0.022	0.341	0.053*	0.131	0.116	0.23	0.65	0.874	0.056*	0.098*
Any other	0.003	0.848	0.323	0.016**	0.442	0.039**	0.989	0.259	0.387	0.029**
Iterations	-	-	-	-	-	-	10,000	10,000	10,000	10,000
FE	Strata									
Controls	Age, sex									
N	5,056									

*** < 1%; ** < 5%; * < 10%.

Notes: The table measures patient-level health outcomes in the post-treatment period (28/05/2021 - 31/03/2023) for patients assigned to either control or treatment condition. The first two columns (1 and 2) copy the values of regression coefficients from ANCOVA models presented in columns 3 and 4 of Table 2 for greater transparency. All model specifications remain unchanged compared to their description in the notes under that table, unless otherwise indicated.

The remaining columns (3-10) indicate the p-values associated with each coefficient, depending on the estimation technique. Columns 3 and 4 replicate the p-values from the ANCOVA models in Table 2, again for easier comparison. Columns 5 and 6 adjust the p-values using Benjamini-Hochberg procedure. Columns 7 and 8 estimate the p-values using randomized inference method, based on 10,000 iterations. Finally, columns 9 and 10 estimate the p-values using Romano-Wolf correction, controlling for the familywise error rate (FWER).

The treatment groups are defined as follows: **ECM Control** - patients selected to be in the ECM control at participating doctors, irrespective of their actual treatment status; **ECM Treatment** - patients selected to receive ECM treatment at participating doctors, irrespective of their actual treatment status. The exact **coding definition** of each variable is provided in Table E.1.

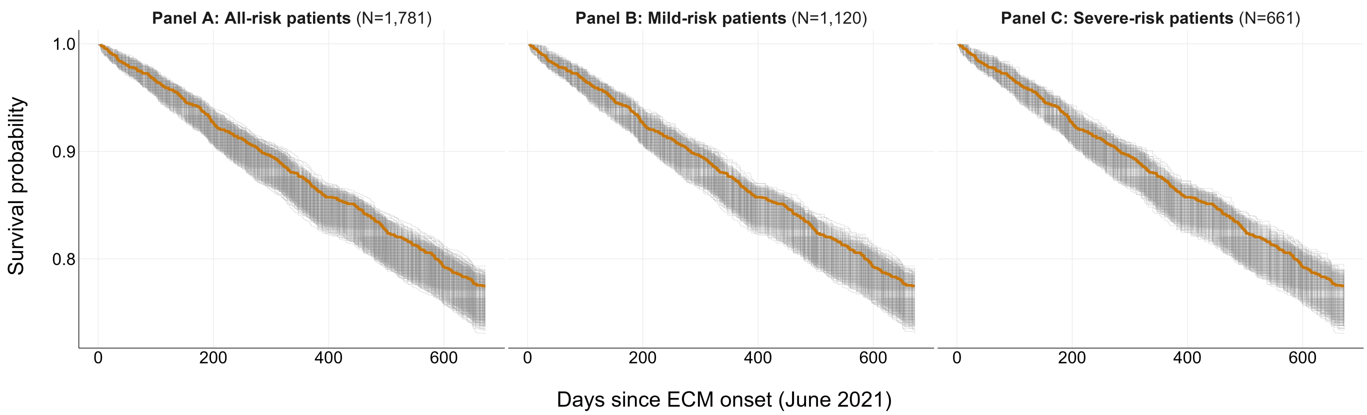
F.8 Hospitalization and mortality interaction models

Table F.8 presents interaction models for hospitalization and mortality outcomes, allowing us to test whether the ECM treatment effect differs significantly between mild-risk and severe-risk patients within a single regression framework. Panel A reports interacted WLS estimates, while Panel B reports interacted Cox proportional-hazards models. The interaction term "ECM patient $\times$ Mild risk" captures the differential effect of ECM for mild-risk patients relative to severe-risk patients (the omitted category).

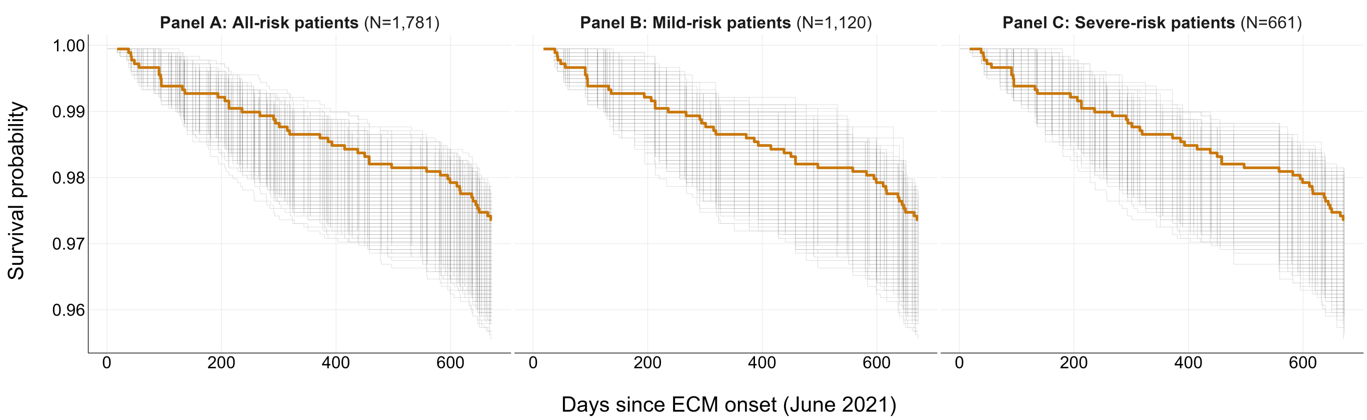
These results complement the stratified analysis in the main text (Table 3) by providing a formal test of heterogeneity across risk groups. The interaction terms confirm the patterns observed in the separate regressions: while there is no significant differential effect on hospitalization, the mortality reduction is concentrated among mild-risk patients. The interaction term "ECM patient $\times$ Mild risk" in the Cox mortality model (Panel B) is large and highly significant (-0.737, $p < 0.01$), indicating that mild-risk patients experience substantially greater survival benefits from ECM than severe-risk patients.

Figure F.2: Survival curves (randomization inference)

(a) Hospitalization



(b) Mortality



Notes: The plot shows survival probability curves, which measure patient's survival probability from ECM onset on 28/05/2021 until the first hospitalization (top panel) and death (bottom panel). All observations are right-censored at the end of the observation period (31/03/2023). For survival until hospitalization they are additionally right-censored at the time of death for patients who died without being hospitalized before 31/03/2023. The survival probabilities are shown for the group of patients assigned to receive ECM treatment - both regardless of their risk class code (Panel A) and divided into mild-risk (Panel B) and severe-risk patients (Panel C), with N specifying the sample size for each group. The black lines show the survival curves under the original ECM treatment assignment, while the grey lines show survival curves under each of 10,000 re-randomized placebo treatment assignments following the original randomization approach.
Randomization inference p-values for subfigure (a) are equal to **0.199** for all-risk patients, **0.382** for mild-risk patients and **0.293** for severe-risk patients. For subfigure (b) they are equal to **0.234** for all-risk patients, **0.021** for mild-risk patients and **0.760** for severe-risk patients.

Table F.8: ECM Impact: Interaction models for hospitalization and mortality

Variable	Hospitalization			Mortality		
	Design	Controls	IV	Design	Controls	IV
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Interacted OLS						
ECM patient	-0.032	-0.028	-0.036	-0.003	-0.001	-0.001
	(0.023)	(0.024)	(0.031)	(0.012)	(0.012)	(0.015)
ECM patient x Mild risk	0.017	0.013	0.018	-0.010	-0.013	-0.016
	(0.032)	(0.032)	(0.041)	(0.012)	(0.012)	(0.016)
Age (years)	-	0.003***	0.003***	-	0.002***	0.002***
		(0.001)	(0.001)		(0.000)	(0.000)
Sex (male)	-	0.059***	0.060***	-	0.027***	0.027***
		(0.016)	(0.016)		(0.008)	(0.008)
Panel B: Interacted Cox Proportional-Hazards						
ECM patient	-0.108	-0.090	-0.114	-0.057	0.123	0.156
	(0.060)	(0.060)	(0.076)	(0.112)	(0.112)	(0.138)
ECM patient x Mild risk	0.031	0.008	0.010	-0.512***	-0.737***	-0.929***
	(0.082)	(0.082)	(0.103)	(0.148)	(0.148)	(0.172)
Age (years)	-	0.015***	0.015***	-	0.076***	0.076***
		(0.002)	(0.002)		(0.006)	(0.006)
Sex (male)	-	0.311***	0.312***	-	0.986***	0.987***
		(0.044)	(0.044)		(0.112)	(0.112)
FE	Strata	Strata	Strata	Strata	Strata	Strata
Control Outcome Mean	0.255	0.255	0.255	0.037	0.037	0.037
N	5,056	5,056	5,056	5,056	5,056	5,056

*** < 1%; ** < 5%; * < 10%.

Notes: This table presents interaction models testing whether ECM effects on hospitalization and mortality differ by patient risk classification. Panel A reports weighted least squares estimates; Panel B reports Cox proportional-hazards models. The interaction term "ECM patient x Mild risk" captures the differential effect for mild-risk patients relative to severe-risk patients (the omitted category). Standard errors clustered at the provider level in parentheses.

F.9 Leave-one-clinic-out sensitivity analysis

To assess whether our mortality results are driven by outliers or idiosyncratic implementers, we conduct a leave-one-clinic-out sensitivity analysis. For each of the participating clinics, we re-estimate the main hospitalization and mortality models excluding that clinic's patients, and examine the distribution of resulting treatment effect estimates.

Table F.9 summarizes these results. For each outcome-estimator combination, we report the full-sample estimate alongside the mean, range, and standard deviation of the leave-one-out estimates. The stability of estimates across these iterations provides reassurance that our findings are not driven by a handful of atypical sites.

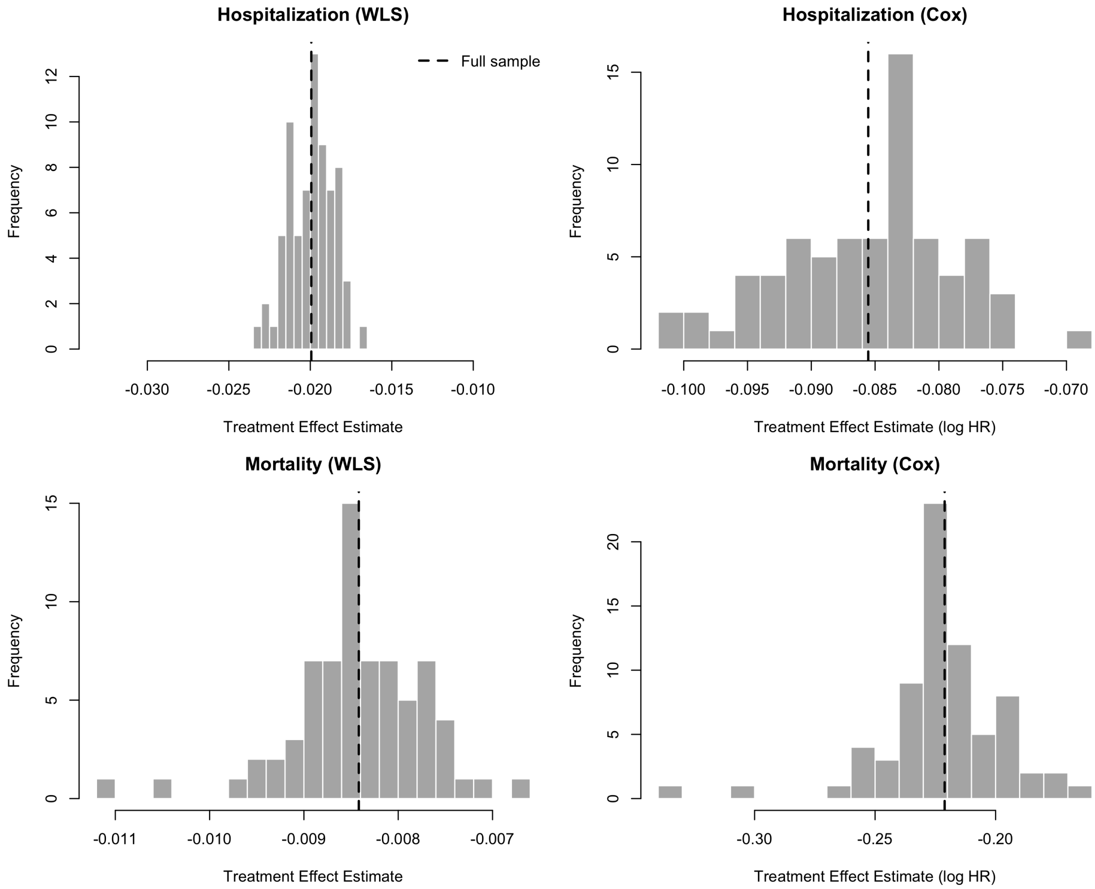
Figure F.3 presents histograms of the leave-one-out coefficients for each outcome, with the full-sample estimate indicated by a dashed vertical line. The tight clustering of estimates around the full-sample value suggests our results are robust to the exclusion of any individual clinic.

Table F.9: Leave-one-clinic-out sensitivity analysis

Outcome	Full Sample	LOO Mean	LOO Range	LOO SD
Hospitalization (WLS)	-0.020	-0.020	[-0.023, -0.017]	0.001
Hospitalization (Cox)	-0.086	-0.086	[-0.101, -0.069]	0.007
Mortality (WLS)	-0.008	-0.008	[-0.011, -0.007]	0.001
Mortality (Cox)	-0.221	-0.221	[-0.334, -0.161]	0.025

Notes: This table summarizes the results of leave-one-clinic-out sensitivity analysis for hospitalization and mortality outcomes. For each outcome and estimator, we report: the full-sample treatment effect estimate, the mean of leave-one-out estimates, the range [min, max], and the standard deviation across leave-one-out iterations. Results demonstrate that estimates are stable to the exclusion of any individual clinic.

Figure F.3: Leave-one-clinic-out sensitivity analysis



Notes: Each histogram shows the distribution of treatment effect estimates when excluding one clinic at a time from the analysis. The dashed red line indicates the full-sample estimate. The tight clustering of leave-one-out estimates around the full-sample value suggests results are not driven by outlier clinics.

F.10 Spillover and selection bounds analysis

A potential concern with our within-clinic experimental design is that control patients at ECM clinics may experience spillover effects – either positive (if doctors apply ECM practices more broadly) or negative (if effort is diverted from control to treatment patients). Additionally, clinic self-selection into ECM participation may introduce selection bias. Either channel could affect the interpretation of our within-clinic ITT estimates as population parameters rather than LATE or TOT effects.

To decompose these potential biases and bound our treatment effects under extreme assumptions informed by the available data, Table F.10 presents four columns of estimates:

1. **ITT ANCOVA (T − C)**: Our main intent-to-treat estimate comparing ECM treatment to ECM control patients within participating clinics, using the ANCOVA specification with strata fixed effects.

2. **Selection ANCOVA (C − Refuse)**: The difference between ECM control patients at participating clinics and patients at clinics that were assigned to ECM but *refused* to participate. Since both groups are at clinics that were randomized to receive ECM, this comparison isolates clinic selection effects – any differential improvement among ECM controls relative to refusers indicates selection bias, as participating clinics may be systematically improving faster. This is separate from any within-clinic spillover effects.

3. **Spillover ANCOVA (C − Pure C)**: The difference between ECM control patients at participating clinics and "pure control" patients at clinics not assigned to ECM. This comparison captures both selection effects and any within-clinic spillover effects on control patients. Differential improvement among ECM controls relative to pure controls, beyond what selection explains, indicates positive spillovers to control patients and argues against effort reallocation from controls to treatment patients.

4. **Bounds**: The range [ITT − Selection ANCOVA estimate, ITT + Spillover ANCOVA estimate] provides bounds on the true treatment effect under different assumptions. The lower bound subtracts the full selection magnitude from the ITT – our worst-case assumption is that all improvement among ECM controls relative to refusers reflects selection bias that also inflates our ITT. The upper bound adds the spillover magnitude to the ITT – if control patients benefit from being at ECM clinics, our within-clinic comparison understates the true treatment effect.

The key insight from this decomposition is that comparing ECM controls to patients at *refusing* clinics (Selection column) under the strong assumption that these differences arise entirely from self-knowledge that determined ECM participation isolates selection effects which mean our ITT is an overestimate of causal impacts, since both groups are at clinics that were assigned to ECM. In contrast, comparing ECM controls to pure controls at non-ECM clinics (Spillover column) incorporates primarily spillover effects, in which the provider's general improvements led to improvements for all patients, and that our ITT is an underestimate of causal impacts. The patterns suggest modest selection effects and potential positive spillovers, implying our within-clinic ITT estimates are conservative lower bounds on the true treatment effect.

We note that interpretation requires caution: while the Selection comparison controls for clinic-level randomization to ECM, the decision to participate remains endogenous. Similarly, the Spillover comparison relies on selection-on-observables assumptions. Nevertheless, the analysis provides useful context suggesting that neither selection nor spillover bias substantially alters our conclusions without strong assumptions on their magnitudes and components.

Table F.10: Spillover and selection bounds analysis

Variable	**ITT ANCOVA** (T − C)	**Selection ANCOVA** (C − Refuse)	**Spillover ANCOVA** (C − Pure C)	**Bounds** [ITT − Selection, ITT + Spillover]
Primary care (assigned clinic)				
ECM inclusion	0.453 (0.023)	0.019 (0.006)	0.027 (0.004)	[0.434, 0.480]
ECM care plan	0.923 (0.072)	0.034 (0.014)	0.058 (0.009)	[0.889, 0.982]
Doctor in-person chronic care	0.148 (0.032)	0.030 (0.051)	0.033 (0.031)	[0.118, 0.182]
Doctor phone	0.117 (0.077)	0.906 (0.310)	-0.140 (0.213)	[-0.789, -0.023]
Nurse in-person	0.176 (0.057)	0.093 (0.086)	0.165 (0.079)	[0.084, 0.341]
Nurse phone	0.286 (0.069)	0.044 (0.175)	-0.134 (0.126)	[0.153, 0.242]
Any consultation	0.717 (0.134)	1.13 (0.454)	-0.009 (0.306)	[-0.414, 0.707]
Primary	0.102 (0.031)	0.226 (0.088)	0.102 (0.072)	[-0.124, 0.204]
Outpatient	0.229 (0.032)	-0.047 (0.063)	-0.064 (0.048)	[0.165, 0.276]
Primary care (not assigned clinic)				
Primary (other)	0.005 (0.010)	-0.150 (0.099)	-0.016 (0.067)	[-0.011, 0.155]
Outpatient (other)	0.003 (0.080)	-0.287 (0.284)	0.091 (0.195)	[0.094, 0.290]
Other care				
Inpatient	-0.016 (0.013)	-0.021 (0.014)	-0.002 (0.010)	[-0.018, 0.005]
Inpatient (via ambulance)	-0.009 (0.007)	-0.008 (0.006)	-0.008 (0.004)	[-0.017, -0.000]
Inpatient re-admission (30)	-0.009 (0.005)	-0.007 (0.005)	-0.001 (0.004)	[-0.011, -0.003]
Inpatient re-admission (90)	-0.007 (0.007)	-0.009 (0.007)	-0.003 (0.005)	[-0.010, 0.001]
Daycare healthcare	0.006 (0.012)	0.000 (0.010)	0.011 (0.006)	[0.006, 0.017]
Inpatient nursing/rehabilitation	-0.000 (0.008)	-0.009 (0.006)	-0.011 (0.005)	[-0.012, 0.009]
Outpatient nursing/rehabilitation	-0.015 (0.024)	-0.044 (0.026)	-0.109 (0.020)	[-0.124, 0.030]
Covid incidence	0.020 (0.011)	0.001 (0.009)	-0.005 (0.007)	[0.015, 0.019]
Covid vaccine	-0.031 (0.022)	-0.043 (0.043)	-0.003 (0.029)	[-0.035, 0.012]
Screening				
Glycohemoglobin	0.113 (0.026)	-0.009 (0.030)	0.039 (0.021)	[0.122, 0.152]
Creatinine	0.112 (0.116)	0.034 (0.128)	0.074 (0.100)	[0.078, 0.186]
Cholesterol	0.152 (0.032)	0.035 (0.040)	0.051 (0.031)	[0.117, 0.203]
Glucose	0.075 (0.143)	0.038 (0.136)	0.045 (0.087)	[0.037, 0.120]
TSH	0.148 (0.046)	-0.048 (0.046)	0.049 (0.038)	[0.196, 0.197]
Diagnosed conditions				
Heart failure	0.161 (0.040)	-0.023 (0.047)	-0.073 (0.029)	[0.088, 0.184]
Stroke	0.001 (0.002)	-0.000 (0.001)	-0.001 (0.001)	[-0.000, 0.001]
Myocardial infarction	0.001 (0.006)	-0.005 (0.005)	0.001 (0.004)	[0.001, 0.006]
Hyperlipidemia	0.279 (0.036)	0.047 (0.038)	0.044 (0.027)	[0.232, 0.323]
Overweight/obese	0.150 (0.027)	-0.037 (0.023)	0.002 (0.013)	[0.152, 0.187]
Prescriptions				
Diabetes	0.099 (0.071)	0.097 (0.066)	0.073 (0.050)	[0.002, 0.171]
Anti-hypertensive	-0.001 (0.011)	0.009 (0.007)	-0.005 (0.006)	[-0.010, -0.006]
Beta-blockers	0.043 (0.049)	0.047 (0.059)	0.058 (0.038)	[-0.004, 0.101]
Statins	0.124 (0.055)	0.183 (0.053)	0.150 (0.044)	[-0.059, 0.274]
Any key	0.261 (0.127)	0.327 (0.133)	0.247 (0.100)	[-0.065, 0.508]
Any other	0.705 (0.231)	0.272 (0.180)	0.341 (0.157)	[0.433, 1.05]
FE	Strata	Block	Block	-
Controls	Age, sex, DV_{18-21}	Age, sex, DV_{18-21}	Age, sex, DV_{18-21}	-
N	5,056	10,437	50,598	-

Notes: This table decomposes potential spillover effects in our within-clinic design. **ITT**: Our main intent-to-treat estimate comparing treatment to control patients within participating clinics (T − C). **Selection**: Difference between ECM control patients at participating clinics and patients at ECM-assigned clinics that refused to participate (C − Refuse); this captures clinic selection effects separate from spillovers, since both groups are at ECM-assigned clinics. **Spillover**: Difference between ECM control patients and pure control patients at clinics not assigned to ECM (C − Pure C); this captures both selection and any within-clinic spillover effects. **Bounds**: Lower bound = ITT − Selection (adjusting for potential selection bias); Upper bound = ITT + Spillover (adjusting for potential positive spillovers to controls). Standard errors in parentheses.

G Pre-analysis plan deviations

This section documents deviations from the pre-analysis plan (PAP) published in the International Journal of Clinical Trials (Daniels et al., 2024).[51]

G.1 Sample and timeline

The PAP described recruitment from 421 clinics (786 providers) identified by EHIF as eligible for the ECM program. After excluding pilot clinics, non-operational clinics, and clinics with five or more providers, 375 clinics remained in the sampling frame. From these, 93 clinics (144 providers) were randomly selected into ECM, with 282 clinics (402 providers) serving as controls. The PAP described an intervention period beginning in 2021. Due to administrative constraints in program rollout and the COVID-19 pandemic's disruption of provider training and patient enrollment, the actual intervention period ran from May 2021 to March 2024, providing a longer follow-up window than originally anticipated.

Following clinic randomization, 47 of the 144 initially selected providers declined to participate, citing time constraints, logistical issues, or health problems. This reduced the participating provider sample to 97 providers who agreed to participate in ECM. The PAP reported an estimated 6,739 eligible patients (2,389 treatment, 4,350 control) across these providers. The final analytic sample comprises 72 providers (from 56 clinics) with 5,056 eligible patients, reflecting additional attrition between initial agreement and program implementation as additional providers dropped out after patient randomization. Provider attrition was not selective on observable clinic characteristics including QBS scores and management indicators.

G.2 Treatment arms

The PAP described a factorial design with four treatment arms varying the intensity of provider support:

[51] The trial was first registered with the American Economic Association RCT Registry (AEARCTR-0003661) in May 2019, prior to provider recruitment. A retrospective secondary registration was filed with ClinicalTrials.gov (NCT05820737) in April 2023. The IJCT publication represents the final, peer-reviewed protocol and should be treated as the authoritative PAP.

1. Basic ECM (care plans only)
2. ECM with provider coaching
3. ECM with provider mentoring
4. ECM with both coaching and mentoring

In the final implementation, the mentoring component was not deployed due to resource constraints and the COVID-19 pandemic's disruption of in-person provider training activities. Provider coaching was implemented as planned. As a result, the effective comparison is between providers receiving ECM with coaching versus control providers, and we collapse treatment arms into a single "ECM treatment" indicator comparing ECM-assigned patients to within-provider control patients. This approach is conservative, as it averages across any residual heterogeneity in treatment intensity. The core intervention of care plan development with patients and proactive outreach was implemented across all participating providers as described in Appendix B.

G.3 Randomization procedures

The PAP specified a two-stage randomization design, which was implemented as planned:

Stage 1: Clinic randomization. Clinics were stratified into performance blocks based on two quality indicators: a need-adjusted Quality Bonus Scheme (QBS) score and a management score reflecting clinic working practices. Within each performance block, one-fourth of clinics were randomly selected into the ECM program using coarsened exact matching. All providers within selected clinics were enrolled in ECM.

Stage 2: Patient randomization. Within each participating ECM provider, patients identified through EHIF's chronic illness registry (MISP) were evaluated and assigned a risk classification (mild/moderate or severe risk of health deterioration). Stratified random sampling selected up to 25 patients per provider into ECM treatment, with selection probability proportional to risk stratum size. Patients not selected served as within-provider controls. For providers with fewer than 25 eligible patients, all patients were assigned to treatment.

G.4 Outcome domains

The PAP specified three primary outcome domains:

1. Healthcare utilization (primary care visits, phone consultations, nurse follow-ups, hospitalizations, outpatient services)
2. Provider management of tracer conditions (compliance with QBS monitoring guidelines for type-II diabetes, hypertension, and myocardial infarction)
3. Primary-healthcare-sensitive acute care (avoidable hospitalizations, emergency department visits, readmissions)

Our analysis addresses all three domains as specified. The PAP designated mortality as a secondary outcome for exploratory analysis; we present mortality results given their policy importance while noting that the study was not powered to detect mortality effects *a priori*.

G.5 Estimation approach

The PAP specified ANCOVA models controlling for baseline values of outcomes, which we implement throughout. The PAP also described instrumental variables estimation using random assignment as an instrument for ECM enrollment; we report both intent-to-treat (ITT) and instrumental-variables local average treatment effect (LATE) estimates as specified.

For survival outcomes, we employ Cox proportional hazards models as specified in the PAP. The PAP did not pre-specify the use of weighted least squares (WLS) for binary survival outcomes, which we include as a robustness check that facilitates direct comparison of effect magnitudes across specifications.

G.6 Pre-registered outcomes

We report results for all pre-registered primary and secondary outcomes. The PAP specified the following outcomes, all of which are addressed in the main text or appendix:

Healthcare utilization. The PAP specified primary healthcare interactions, nurse telephone follow-ups, telephone follow-ups, nurse follow-ups, chronic illness follow-ups, hospitalizations, ambulance use, inpatient nursing and rehabilitation, outpatient interactions, outpatient nursing and rehabilitation, and daycare interactions. We find significant increases in consultations, particularly phone calls and nurse visits, consistent with ECM's emphasis on proactive outreach.

Screening and diagnostic tests. The PAP specified monitoring of glycosylated hemoglobin (HbA1c), creatinine, cholesterol, and cholesterol fractions as key QBS compliance indicators. We find significant increases in these screenings among ECM patients.

Diagnoses of chronic conditions. Consistent with ECM's emphasis on comprehensive assessment, we find significant increases in diagnosed heart failure, hyperlipidemia, and overweight status.

Prescription medications. The PAP specified medication prescriptions for diabetes, hypertension, and post-myocardial infarction patients. We find significant increases in statins and diabetes medications.

Hospitalizations. As a primary outcome in the PHC-sensitive acute care domain, we find suggestive reductions ($p=0.068$) in the pooled sample, with stronger effects among mild-risk patients.

Mortality. As a pre-specified secondary/exploratory outcome, we find significant reductions among mild-risk patients.

Null results. Several outcomes specified in the PAP showed null effects, which we report transparently:

- Emergency department visits: No significant difference between treatment and control groups

- Referrals to specialists: No significant difference
- Care coordination with social services: Minimal implementation, as the mentoring component that was intended to support this coordination was not deployed
- Readmission within 90 days: No significant difference

G.7 Additional analyses not in PAP

We conducted several analyses not specified in the pre-analysis plan, which we clearly identify as exploratory:

- **Heterogeneity by risk classification**: While stratification by risk was pre-specified for randomization, separate analysis of mortality effects by risk group emerged from examining the data. We present these results given their policy importance while acknowledging the exploratory nature of this subgroup analysis.
- **Mediation analysis**: We conducted mediation analysis to understand channels driving mortality effects. This was not pre-specified and should be interpreted as hypothesis-generating.
- **Spillover and selection bounds**: We developed bounds on treatment effects accounting for potential within-clinic spillovers and refusals affecting the causal interpretation of an effect size comparison made only between treatment and control patients at participating providers. This addresses a limitation of the within-provider randomization design that was acknowledged but not fully addressed in the PAP, as the refusals occurred later.
- **Leave-one-clinic-out sensitivity**: We conduct robustness checks excluding individual clinics to assess whether results are driven by outliers.

G.8 Summary

Table G.1 summarizes the key deviations between the PAP and final implementation.

In summary, the main deviations from the PAP reflect implementation challenges (provider attrition, treatment arm consolidation due to pandemic disruption, timeline adjustments)

Table G.1: Summary of PAP deviations

Element	**PAP specification**	**Final implementation**
Providers	144 randomized to ECM; 97 agreed to participate	72 providers in final sample (56 clinics)
Patients	6,739 eligible (2,389 T, 4,350 C)	5,056 in final sample
Treatment arms	4 arms (basic, coaching, mentoring, both)	Collapsed to ECM vs. control; mentoring not deployed
Timeline	Intervention period 2021–2023	May 2021–March 2024
Estimation	ANCOVA, IV, Cox models	As specified, plus WLS robustness checks
Outcomes	3 domains specified	All reported; mortality elevated from secondary

rather than analytical choices. We report all pre-registered outcomes and clearly distinguish pre-specified from exploratory analyses. The core experimental design of two-stage randomization with clinic-level selection and within-provider patient-level randomization stratified by risk category was implemented as planned at the planned sample size, except for later refusals to participate.