Circulation: Cardiovascular Quality and Outcomes

ORIGINAL ARTICLE

Longer-Term Results of a Universal Electronic Consultation Program at the Cardiology Department of a Galician Healthcare Area

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BACKGROUND: Telemedicine models play a key role in organizing the growing demand for care and healthcare accessibility, but there are no described longer-term results in health care. Our objective is to assess the longer-term results (delay time in care, accessibility, and hospital admissions) of an electronic consultation (e-consultation) outpatient care program.

METHODS: Epidemiological and clinical data were obtained from the 41 258 patients referred by primary care to the cardiology department from January 1, 2010, to December 31, 2019. Until 2012, all patients were attended in an in-person consultation (2010–2012). In 2013, we instituted an e-consultation program (2013-2019) for all primary care referrals to cardiologists that preceded patients' in-person consultations when considered. We used an interrupted time series regression approach to investigate the impact of the e-consultation on (1) delay time (days) in care and (2) hospital admissions. We also analyzed (3) total number and referral rate (population-adjusted referred rate) in both periods (in-person consultation and e-consultation), and (4) the accessibility was measured as number of consultations and variation according to distance from municipality and reference hospital.

RESULTS: During the e-consultation, the demand increased (7.2±2.4% versus 10.1±4.8% per 1000 inhabitants, $P<0.001$), and referrals from different areas were equalized. The reduction in delay to consultation during the in-person consultation (−0.96 [95% CI, −0.951 to −0.966], $P<0.001$) was maintained with e-consultations (−0.064 [95% CI, 0.043–0.085], $P<0.001$). After the implementation of e-consultation, we observed that the increasing of hospital admission observed in the in-person consultation (incidence rate ratio, 1.011 [95% CI, 1.003–1.018]), was stabilized (incidence rate ratio, 1.000 [95% CI, 0.985–1.015]; $P=0.874$).

CONCLUSIONS: Implementing e-consultations in the outpatient management model may improve accessibility of care for patients furthest from the referral hospital. After e-consultations were implemented, the upward trend of hospital admissions observed during the in-person consultation period was stabilized with a slight downward trend.

Key Words: cardiology ■ health equity ■ outcomes ■ telemedicine

See Editorial by Phadke

Telemedicine models reduce waiting time and play a key role in organizing the growing demand for care and health care accessibility.[1–4] However, most of them describe short-term care experiences and results; and none analyze the results that the model described may have on outcomes like hospital admissions of those patients who live further away.

Electronic consultation (E-consultation) models have great impact on improving accessibility,[5] but analyses of the effects of outpatient care on healthcare quality are

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WHAT IS KNOWN

- Telemedicine models play a key role in organizing the growing demand for care and healthcare accessibility, but there are no described longer-term results in health care.
- Although there are reported experiences with electronic consultation, the studies only report data on waiting list reductions and accessibility to health care.

WHAT THE STUDY ADDS

- The implementation of an outpatient care program in a cardiology department that includes electronic consultation has been associated with an improved access to cardiology healthcare for all patients and mainly for those furthest from the referral hospital.
- After the implementation of the electronic consultation, the upward trend in hospital admissions for cardiovascular causes during the in-person consultation period stabilized with a slight downward trend.
- Our results indicate that the implementation of a model with these characteristics would improve the efficiency of the outpatient care process in cardiology.

Nonstandard Abbreviations and Acronyms

CD	cardiology department
GP	general practitioner
e-consultation	electronic consultation

limited, especially those that evaluate the clinical complications and prognoses of patients treated in non-face-to-face care programs.[6] Given that our healthcare area shows great population dispersion in rural areas, a high proportion of older adults, and certain communication and transportation difficulties,[7] it is a suitable example to study the effects of using e-consultations as the first step in referrals between general practitioner (GPs) and the Cardiology Department (CD). Moreover, e-consultation has been shown to solve up to a fifth of the demand without need for in-person consultations,[2,8] and this type of healthcare program could facilitate access to specialized care for patients regardless of distance from their referral hospitals.[9]

This study was conducted based on reported analyses of similar systems applied in other countries and our experience with the system.[10] Specifically, we aimed to evaluate impacts on delay time in care, accessibility, and hospital admissions resulting from the use of an outpatient care management program that includes e-consultation using the integrated electronic medical records implemented in a healthcare area with a widely dispersed population.

MATERIAL AND METHODS

In order to minimize the possibility of unintentionally sharing information that can be used to re-identify private information, a subset of the data generated for this study are available at RUNA and can be accessed at http://hdl.handle.net/20.500.11940/15301.

Patients

The Santiago de Compostela Healthcare Area provides healthcare coverage to 446 603 citizens, 352 331 of whom are over 14 years of age.[7] This population is characterized by its high geographical dispersion as only 41.1% live <15 km from their referral hospital, and up to 28.8% are at a distance >35 km. In Figure S1 in the Supplemental Material, we show a map of our healthcare area and distances from municipalities. The healthcare area is endowed with 301 GPs who conduct their healthcare activities in 46 municipalities for all population over the age of 14. The present study included 41 258 patients who were referred by their GP for at least one consultation with the CD between 2009 and 2019.

We proposed a quality of care study. This was an observational and retrospective analysis of the information registered in the Management Control Unit of our Health Area. The information was obtained anonymously and did not pose any risk to the patients, which together with the impossibility of collecting the informed consents given the number of patients and the length of time, the requirements for not requesting them were met. The study was approved by the Institutional Review Board of Santiago de Compostela University Hospital.

Consultation Models

Figure 1 summarizes the patient ambulatory care pathway used in our CD for demands of care from GPs. All requests for cardiology consultations include cause for referral and a recent EKG and laboratory blood exam (hemogram and biochemical determinations).

Since the beginning of 2013, an e-consultation was provided as the first step of ambulatory care for all GP referrals to the CD. The cause of demand for cardiology care and the results of the complementary exams (EKG and blood exam) were included in patient's medical records and analyzed by a cardiologist within 72 hours from primary care referral. We identified the proportion of patients whose care demands were met without a traditional in-person consultation. For these patients, cardiologist's report was still included in patient's medical records, and the GP explained this report to the patient. For the remaining patients for whom further in-person consultation was required, we identified those whose clinical problems were solved with a one-time patient visit and those who needed subsequent care and were scheduled for follow-up visits; in both situations, the GP gives the patient the appointment for CD visit.

Variables

Once the list of patients was obtained, the following variables were recorded: sex, age at date of first e-consultation, date of e-consultation, diagnoses related to cardiovascular risk factors and cardiovascular disease, date of cardiology consultation, number of subsequent consultations, if a face-to-face

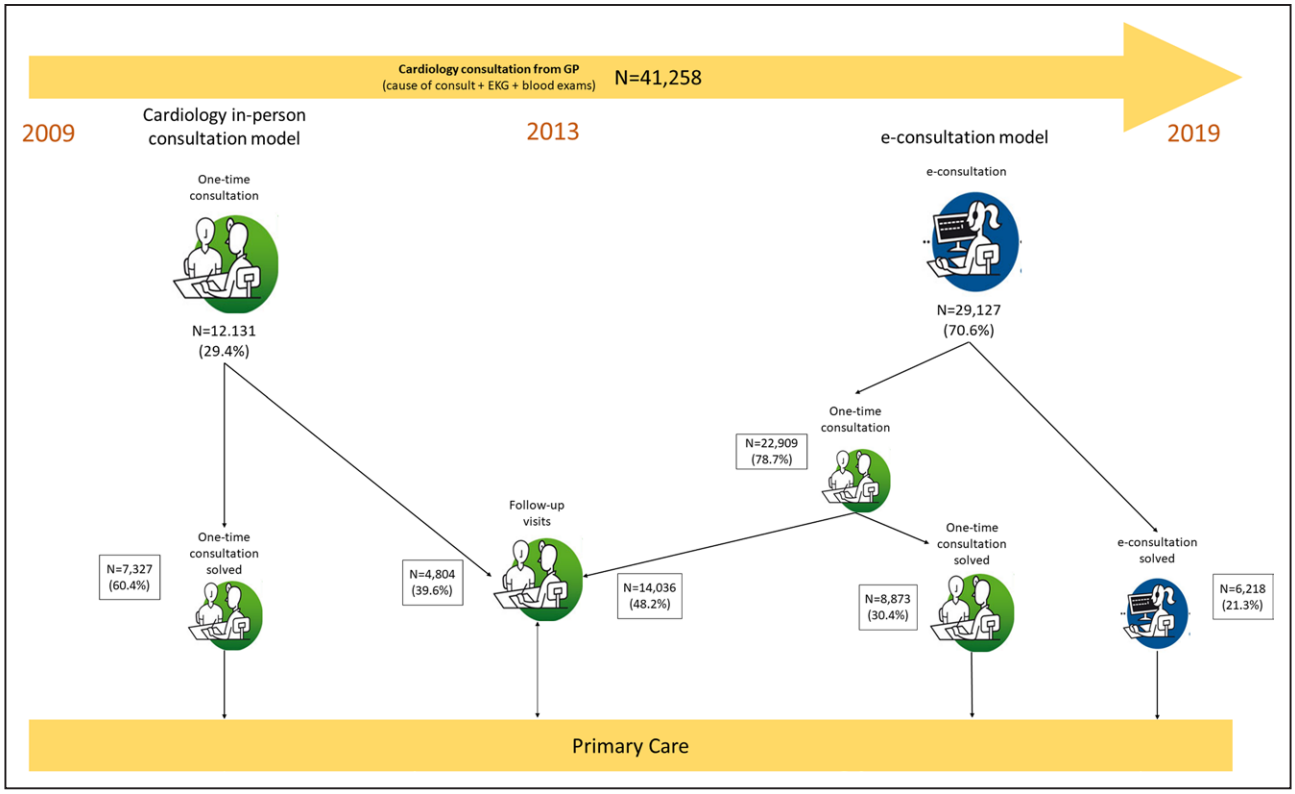

Figure 1. Algorithm for the distribution of patients in the analyzed sample.
e-consultation indicates electronic consultation; and GP, general practitioner.

consultation was conducted after the e-consultation, health care center from which the e-consultation was made, hospital admissions during the first year after the first consultation or e-consultation in the CD, in any department in our healthcare area for cardiovascular causes as main diagnosis, and deaths during the first year after consultation in the CD.

In our healthcare area, the CD provides care for the Santiago de Compostela University Hospital Complex located in the city of Santiago de Compostela and for a regional hospital located in the town of Ribeira.

In addition to the descriptive analysis discussed above, an analysis was conducted on the variations after e-consultations were implemented regarding:waiting time for assistance from CD consultation and hospital admissions in the first year after consultation. Regarding the changes after the implementation of the e-consultation, we analyzed: the total number and referral rate (population-adjusted referred rate) in both periods (in-person consultation and e-consultation), the accessibility was measured as number of consults and variation according to distance from municipality and the referral hospital center.

Statistical analysis

The results of the study are expressed as absolute frequencies (%) for qualitative variables and as mean±SD or median [25th percentile, 75th percentile] in the case of quantitative variables. The χ^2 test was used to assess significant associations between qualitative variables, and Student *t* tests or analysis of variance were used to investigate the association between quantitative and qualitative variables after checking the assumptions of a normal distribution. Statistical significance was set at $P<0.05$.

To investigate the impact of the e-consultation program on (1) delay time in care and (2) hospital admissions, an interrupted time series regression approach was performed.[11] Time elapsed from the beginning of the study in months, type of consultation (0, in-person consultation; 1, e-consultation), and interaction time×type of consultation were entered as predictors. Overdispersion was considered and controlled.

To investigate the spatial trends in the CD, a spatial analysis was conducted using a structured additive regression model.[12] Structured additive regression models Cubic P-splines[13] were used with 20 knots equidistant and a second-order random walk prior. For the correlated spatial effects, we assumed a generalization of the first random walk called the Markov random field.[12] Inference for structured additive regression models was performed using Markov chain Monte Carlo simulation techniques. Statistical analyses were conducted using R version 3.5.1, and open-source BayesX software.

RESULTS

Overview of the Sample

We analyzed 41 258 consultation demands from GPs between 2010 and 2019. Figure 1 summarizes the number of patients in the ambulatory care pathway during this period. Of these patients, 29.4% were from the in-person one-time consultation model, and 70.6% were from the e-consultation model. Among the patients who attended the in-person one-time consultation model, 39.6% were

included in the follow-up cardiology program with subsequent in-person visits. Among those who attended the e-consultation model, 21.3% were solved without an in-person consultation.

Table 1 shows the epidemiological characteristics, personal history, and healthcare data of the patients in the total sample and in both periods (in-person consultation and e-consultation).

Approximately half of the participants were women, with a mean age of 63.2±18.6 years. The most frequent personal history was arterial hypertension (57.3%), chronic ischemic heart disease (24.7%), atrial fibrillation (21.8%), and diabetes (19.7%).

Changes After e-Consultation Implementation

The population-adjusted consultation rates (per 1.000 inhabitants) were higher in the e-consultation period (10.1±4.8) than in the single-act period (7.2±2.4; $P<0.001$). Figure S2 in the Supplemental Material shows the change in consultation rate adjusted by population and municipality in each analysis period.

Delay From GP Referral to Cardiology Consultation

Table 2 summarizes these results. During the cardiology in-person consultation period, we observed a progressive reduction in delay (−0.96 days per month [95% CI, −0.951 to −0.966], $P<0.001$), which was additionally reduced with e-consultation (−0.064 days [95% CI, 0.043–0.085], $P<0.001$) (see Table 1). Figure 2 shows the effect of age on delay in both periods. During the in-person consultation period, patient's age did influence the delay in GP referral, whereas, during the e-consultation period, this age-dependent delay was not observed.

The delay time was not uniformly distributed over the healthcare area (Figure 3). In general, higher delay times were recorded in the area of Ribeira, where the regional hospital is located. As shown in Figure 3, the spatial effects are similar in both periods; however, these differences are lower in the e-consultation period than in the in-person consultation period.

Hospital Admissions at 1-Year After Consultation

Throughout the first year after consultation with the CD, 2707 patients (5.7%) presented a total of 3208 hospital

Table 1. Epidemiological Characteristics, Personal History, and Healthcare Data of Patients in the Sample in Each Program (In-Person Consultation and e-Consultation)

	Total	In-person consultation	e-consultation	*P* value
N	41 258	12 131	29 127	
Women, %	50.0	50.8	49.6	0.030
Age, y*	63.2 (18.6)	61.7 (18.8)	63.8 (18.5)	<0.001
Personal history				
Arterial hypertension, %	57.3	55.0	58.3	<0.001
Diabetes, %	19.7	19.1	19.9	0.059
Ischemic heart disease, %	24.7	12.5	12.8	0.457
Atrial fibrillation, %	21.8	20.2	22.6	<0.001
Heart failure, %	9.2	10.5	9.5	0.002
Cerebral vascular disease, %	4.7	5.8	4.6	<0.001
Peripheral arterial disease, %	3.8	3.8	3.9	0.599
Delay in face-to-face consultation†	10 (5, 22)	35 (18, 77)	7 (5, 13)	
Number of cardiology tests†	1.0 (0, 2)	0 (0, 1)	1 (0, 2)	
Emergencies first year*	0.7 (0.5)	0.8 (0.4)	0.6 (0.5)	<0.001
Hospital admission first year, %	5.4	4.8	5.6	0.001
Death first year, %	2.6	2.3	2.7	0.029
Causes of death				
Cancer, %	22.3	23.5	20.9	<0.001
Ischemic heart disease, %	8.5	8.9	8.1	<0.001
Heart failure, %	8.1	7.5	8.8	<0.001
Ischemic stroke, %	4.6	5.4	3.6	<0.001
Valvular heart disease, %	4.1	4.0	4.2	<0.001
COPD, %	3.3	3.5	2.9	<0.001
Respiratory infection, %	2.8	2.5	3.1	<0.001
Hemorrhagic stroke, %	2.2	2.0	2.4	<0.001

COPD indicates chronic obstructive pulmonary disease; and e-consultation, electronic consultation.
*Data are expressed as means (SD).
†Data are expressed as median [25th percentile, 75th percentile].

Table 2. Summary of Generalized Linear Effects of ITS Model for Delay

Predictor	Coefficient	SE	*P* value	IRR [95% CI]
Intercept	5.057	0.112	<0.001	157.134 [125.922–196.084]
Time, mo	−0.042	0.004	<0.001	0.958 [0.951–0.966]
e-consultation	−2.745	0.201	<0.001	0.064 [0.043–0.095]
Interaction time×e-consultation	0.041	0.004	<0.001	1.042 [1.033–1.051]

e-consultation indicates electronic consultation; IRR, incidence rate ratio; and ITS, interrupted time series.

admissions for cardiovascular causes. The median time from CD consultation to first admission was 100 days (41, 206); 111 (44, 201) days in the cardiology in-person consultation period, and 90 (38, 206) days after e-consultation implementation.

Table 3 shows the clinical-epidemiological characteristics and care activities of patients who presented some cardiovascular admission in the first year, compared with the rest of the sample. Patients with admissions were mostly male ($P<0.001$) and older (70.4±14.6 versus 63.4±18.6 years, $P<0.001$). Patients who were subsequently admitted had a higher prevalence of all chronic cardiovascular diseases analyzed at the time of consultation ($P<0.001$), a shorter delay until in-person consultation in the CD ($P<0.001$), and a higher number of follow-up visits ($P<0.001$) as well as more complementary tests performed ($P<0.001$). Death incidence was 4× higher in patients admitted for cardiovascular reasons (odds ratio, 4.61; $P<0.001$). Ischemic heart disease (24.5%) and heart failure (22.7%) were the 2 most frequent causes for hospital admissions.

The interrupted time series analysis showed that the number of hospital admissions during the cardiology in-person consultation period increased by ≈1.1% per month (incidence rate ratio, 1.011 [95% CI, 1.003–1.018]), and after the implementation of the e-consultation, this upward trend was stabilized with a constant trend (incidence rate ratio, 1.000 [95% CI, 0.985–1.015], $P=0.874$) (Table 4 and Figure 4).

The results of the spatial models are summarized in Figure 5. We can see that spatial differences between hospital admission rates decreased uniformly in most municipalities after the e-consultation implementation.

DISCUSSION

Our findings suggest that the introduction of an e-consultation in the outpatient management model is associated with an increased demand for care and improved accessibility to healthcare services for all patients, especially those furthest from the referral hospital.

To our knowledge, this is the first time that the results of a project to manage demand through the application of e-consultations have been described, analyzing the results on accessibility to healthcare and hospital admissions as a function of the distance of patients to the hospital center. We understand that our experience, in the context of shared integrated electronic

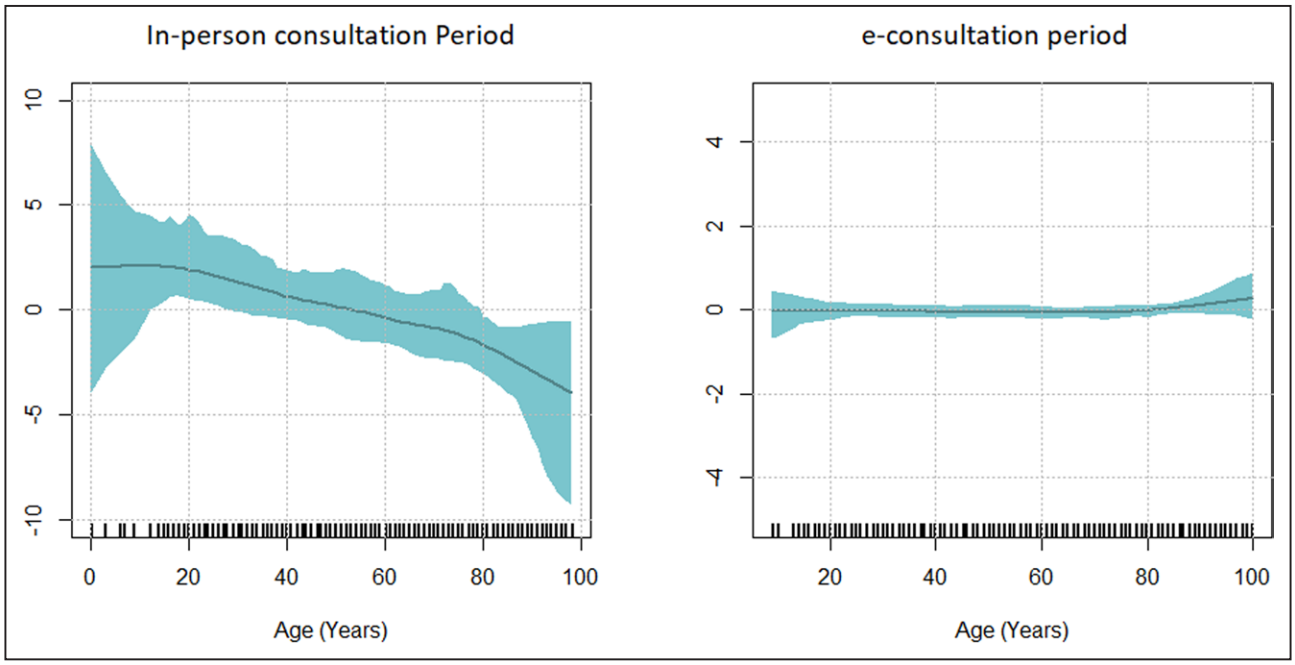

Figure 2. Age distribution of patients referred to the cardiology department in both analysis periods.
e-consultation indicates electronic consultation.

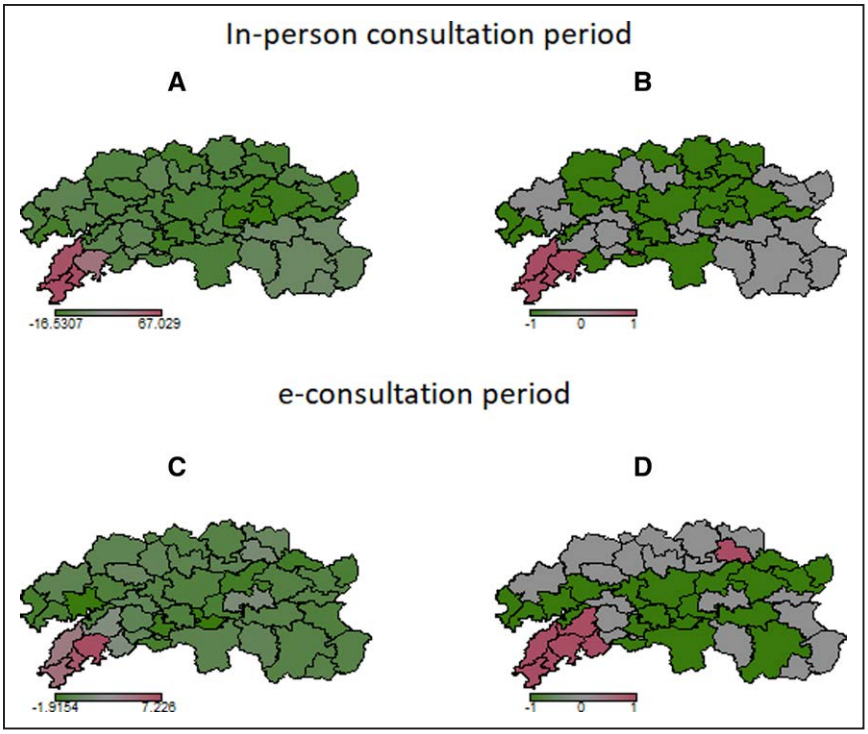

Figure 3. Estimated spatial effects of mean delay and pointwise 95% significance map for the in-person consultation and electronic consultation (e-consultation) periods. Green denotes districts with strictly negative credible intervals; red denotes districts with strictly positive credible intervals

medical records throughout all healthcare levels, can improve the accessibility of patients with more difficulty in accessing healthcare services by reducing delay time in care and a reduction in hospital admissions due to cardiovascular causes. Our findings of an initial reduction in the upward trend of hospital admissions and the subsequent stabilization of admission rates following e-consultation implementation may be related to better and faster provision of patient risk stratification based on the clinical information provided by the GP e-consultation. Those patients who quickly needed specialist care were identified much sooner than under the traditional model, and they may have been able to schedule and go to their first cardiology visit sooner. This may have also improved outcomes, as patients with more critical needs were not only identified sooner, but they may also have actually been treated significantly sooner. Nevertheless, the study design, based on a large retrospective cohort of patients, does not allow for a clear direct-causality effect to be established, as other factors may have also influenced our findings.

A bibliographic review revealed that only the Veterans Health Administration in the US department and the Massachusetts General Hospital have offered a similar e-consultation program[14,15]; however, in the Massachusetts General Hospital program, the GP can decide whether a patient receives an in-person consultation or an e-consultation. Notably, under that model, only 10% of the referrals to CD are e-consultations.[15] In our model, since 2013, all GP referrals have been e-consultations, after which the cardiologists decide which patients receive further in-person consultations.[2]

Healthcare systems based on telemedicine and new technologies may enhance the relationship between levels of care and solve incidents in patient's clinical progress, which would have repercussions in cost savings, improved health objectives, and maintaining an adequate level of satisfaction.[16] Although this reasoning may seem obvious, many studies do not allow to discuss it, as they have important limitations such as the inclusion of small groups of highly selected patients,[17] the use of telemedicine in programs focused on pathologies or specific activities (for example, video-consultations that show exercises of cardiac rehabilitation programs),[18] or have focused on the limitations and barriers to the implementation of e-consultation without finding efficient solutions for them.[19]

In our demand for healthcare analysis at the time of the in-person consultation, between 2009 and 2012, we observed that most patients lived nearest to the hospital, as in records by Geissler,[4] in which 84.7% of patients came from regions close to the hospital. This information leads us to suppose that distance is a barrier for patients living far away as, when this barrier has been overcome with e-consultation, the demand has been balanced. The same idea was reported by the authors of a recent systematic review, who concluded that cardiology e-consults improve access to outpatient cardiac care.[20]

Furthermore, numerous studies have analyzed the effect of distance on cardiovascular prognosis. It was observed that patients who accessed cardiac rehabilitation programs usually lived in areas close to the hospital and were associated with a more favorable prognosis after an acute coronary syndrome.[21] The same prognostic

Table 3. Comparison of the Clinical-Epidemiological Characteristics and the Care Activity for Patients Admitted to the Hospital After e-Consultation and Those With No Hospital Admission

	No hospital admission	Hospital admission	*P* value
N	44 670	2707	
Male, %	49.8	61.5	<0.001
Age, y*	63.4 (18.6)	70.4 (14.6)	<0.001
Distance group			
Home distance, km*	25.0 (19.8)	27.4 (20.3)	<0.001
<15 km, %	32.9	27.5	<0.001
15–35 km, %	34.3	34.3	<0.001
>35 km, %	32.7	38.2	<0.001
Personal history			
Ischemic heart disease, %	11.8	33.4	<0.001
Atrial fibrillation, %	21.8	28.3	<0.001
Cerebrovascular disease, %	5.1	10.3	<0.001
Heart failure	9.8	26.5	<0.001
Peripheral arterial disease, %	3.7	7.8	<0.001
Pulmonary embolism, %	0.6	1.2	<0.001
Overweight and obesity, %	17.5	18.5	0.164
Arterial hypertension, %	56.6	64.1	<0.001
Diabetes, %	19.6	31	<0.001
Healthcare activity			
Consultation delay, d†	10 (5, 22)	8 (5, 18)	
Consultations after the first Cardiology visit†	1 (0, 2)	3 (1, 6)	
Number complementary tests†	1 (0, 2)	1 (0, 3)	
Healthcare model			
In-person consultation model, %	61.9	61.1	0.385
e-Consultation model, %	38.1	38.9	
Death first year, %	2.8	12.9	<0.001

e-consultation indicates electronic consultation.
*Data are expressed as means (SD).
†Data are expressed as median (25th percentile, 75th percentile).

association has been described in other diseases, such as inflammatory bowel disease[22] or even thrombosis consultations.[23]

In our case, in view of the results, we are led to think that the effect is similar because, in our sample, patients who live further away are older and have more cardiovascular comorbidities that determine worse cardiovascular prognosis, as has been described in registries of our environment.[24] However, the implementation of e-consultation, which improved accessibility, was associated with all distance groups, but especially those furthest away, with a decrease in admissions due to cardiovascular causes, as well as mortality or, it at least, interrupted the upward trend present in previous years during the exclusively face-to-face consultations. We think that the improvement in accessibility for patients who live further away and who are older and have more comorbidities had a positive impact on their cardiovascular prognosis.

Stentzel et al[25] described that an improved public transportation system is associated with improved patient accessibility to GPs and selected specialist physicians in a rural region of Germany and concluded that accessibility analyses and providing telematic systems to the patients should be established instruments in planning issues. However, Julien et al[26] recently described that many patients are not able to use new technologies, even in urban settings such as New York. These observations suggest that implementing telematics consultation systems for health professionals (physicians and nurses) would be a good strategy for improving patient accessibility and quality of care. These systems improve accessibility and equity for patients who live further away from the referral hospital centers, avoiding unnecessary travel for patients and those accompanying, and enhancing the relationship between levels of care without affecting quality of care, as we describe in our data analysis.

The implementation of e-consultation needs to analyze not only parameters associated with the accessibility of medical care facilities but also the influence on hard clinical outcomes, such as mortality or hospital admissions.[20] In a previous publication, we showed that our e-consultation model was associated with reduced cardiovascular mortality and emergency department visits.[2]In the present study, we found an important change in the upward trend of hospital admissions observed during the in-person consultation period that was stabilized after the e-consultation model was implemented. As we mentioned before, the reduction in the delay from GP referral to cardiology consultation allows for better and faster patient risk stratification based on the clinical information provided by the GP e-consultation. This contributes to avoiding progressive increase in hospitalization rate during the in-person consultation period.

Although we acknowledge certain limitations in the analysis of our results, the experience described in this

Table 4. Summary of Generalized Linear Effects of ITS Model for Hospital Admissions

Predictor	Coefficient	SE	*P* value	IRR [95% CI]
Intercept	−3.351	0.121	<0.01	0.035 [0.028–0.044)
Time, months	0.011	0.004	0.005	1.011 [1.003–1.018]
e-Consultation	0.455	0.168	0.007	1.577 [1.003–1.018]
Interaction time×e-consultation	−0.011	0.004	0.007	0.989 [0.982–0.997]

e-consultation indicates electronic consultation; IRR, incidence rate ratio; and ITS, interrupted time series.

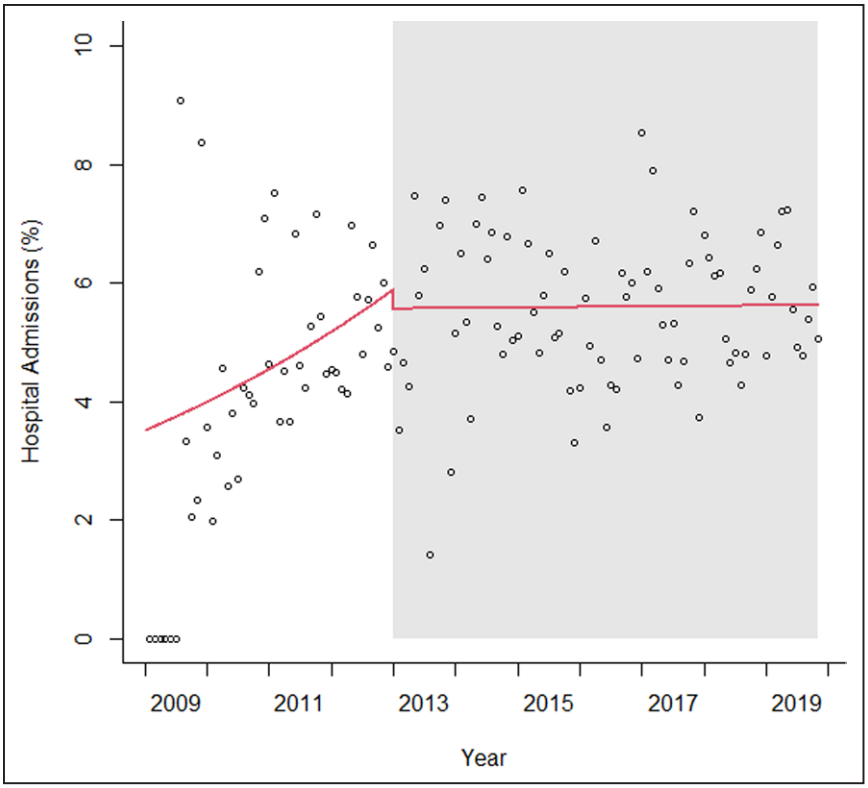

Figure 4. Analysis of the interrupted temporal trend of hospital admissions in the first year after consultation.

large cohort of patients with demographic, clinical, and prognostic information integrated into an electronic medical record system strengthens the relevance of the healthcare management aspects of our findings. The lack of knowledge of the specific reasons for GP referrals or the impossibility of identifying whether if patients had had contact with professionals outside the National Healthcare System may influence our results. The exclusion of patients referred from other hospital departments (due to not having information on their municipality of residence) could induce a selection bias by eliminating patients who could be a priori in a more severe clinical situation and, therefore, limit the external validity of our results.

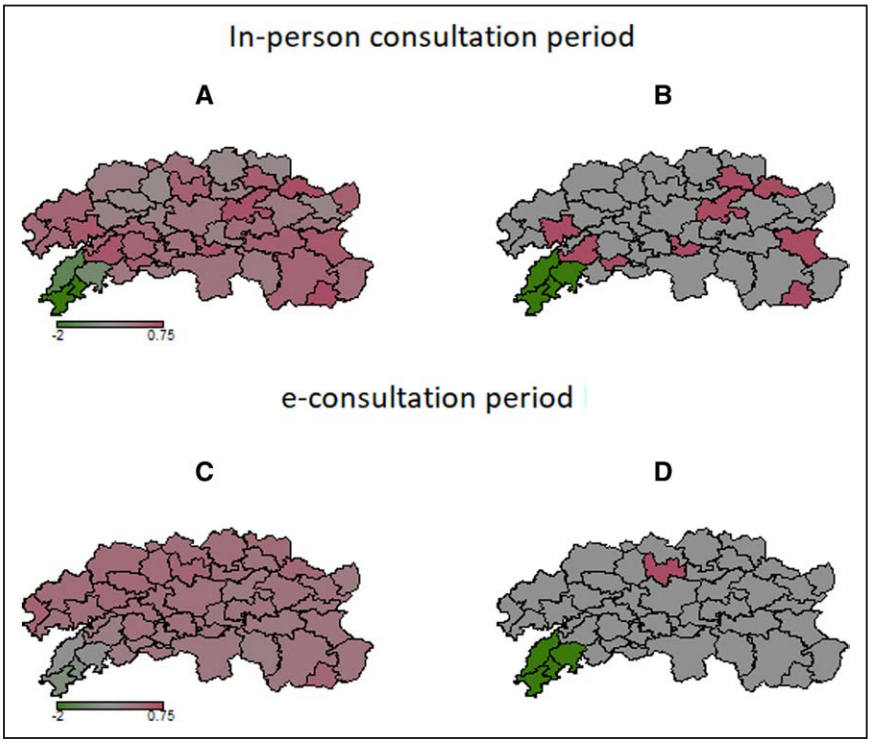

Figure 5. Estimated spatial effects of hospital admission rate and pointwise 95% significance map for the in-person consultation and electronic consultation (e-consultation) periods.
Green denotes districts with strictly negative credible intervals; red denotes districts with strictly positive credible intervals.

Based on our findings, we can conclude that the implementation of an outpatient care program in a CD that includes e-consultation has been associated with an improved access to cardiology healthcare for all patients and mainly for those furthest from the referral hospital. After the implementation of the e-consultation, the upward trend in hospital admissions for cardiovascular causes during the in-person consultation period stabilized with a slight downward trend.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Materials

Figures S1–S2

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