

Implementation of an on-demand app-based heart rate and rhythm monitoring infrastructure for the management of atrial fibrillation through teleconsultation: TeleCheck-AF

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Received 24 April 2020; editorial decision 18 June 2020; accepted after revision 19 June 2020; online publish-ahead-of-print 4 September 2020

Abstract

During the coronavirus 2019 (COVID-19) pandemic, outpatient visits in the atrial fibrillation (AF) clinic of the Maastricht University Medical Centre (MUMC+) were transferred into teleconsultations. The aim was to develop an on-demand app-based heart rate and rhythm monitoring infrastructure to allow appropriate management of AF through teleconsultation. In line with the fundamental aspects of integrated care, including actively involving patients in the care process and providing comprehensive care by a multidisciplinary team, we implemented a mobile health (mHealth) intervention to support teleconsultations with AF patients: TeleCheck-AF. The TeleCheck-AF approach guarantees the continuity of comprehensive AF management and supports integrated care through teleconsultation during COVID-19. It incorporates three important components: (i) a structured teleconsultation ('Tele'), (ii) a CE-marked app-based on-demand heart rate and rhythm monitoring infrastructure ('Check'), and (iii) comprehensive AF management ('AF'). In this article, we describe the components and implementation of the TeleCheck-AF approach in an integrated and specialized AF-clinic through teleconsultation. The TeleCheck-AF approach is currently implemented in numerous European centres during COVID-19.

Keywords

Teleconsultation • mHealth • Telehealth • Atrial fibrillation • Integrated care • Mobile app

Introduction

Atrial fibrillation (AF) is the most prevalent cardiac arrhythmia and associated with morbidity such as heart failure and an increased risk of thromboembolic complications, and mortality.¹ Patients with AF are considered vulnerable and monitoring of vital parameters,

particularly heart rhythm and rate, is important and recommended to guide treatment decisions and prevent AF-related morbidity, such as tachycardiomyopathy.²

During the coronavirus 2019 (COVID-19) pandemic, social distancing was implemented as part of the strategy to prevent extensive spread of the virus and consequently keeping the number of cases at

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What's new?

- On-demand heart rate and rhythm monitoring infrastructures support integrated care through teleconsultation.
- TeleCheck-AF guarantees the continuity of comprehensive atrial fibrillation management through teleconsultation during COVID-19.
- The TeleCheck-AF approach is currently implemented in numerous European centres during COVID-19.

a manageable level for the medical system (flattening the curve). Despite these preventive interventions, as of 3 June 2020, 6 348 900 confirmed cases of severe acute respiratory syndrome virus 2 (SARS-CoV-2) infections causing COVID-19 have been reported globally, including 380 810 deaths.³ Among these, a significant proportion of affected individuals appears to suffer from concomitant cardiovascular conditions.⁴ Medical centres responded by keeping vulnerable multi-morbid patients with chronic conditions out of the hospital and elective cases as well as outpatient appointments were cancelled or performed as teleconsultations, where possible.

Early during the COVID-19 pandemic, the AF outpatient clinic (AF-clinic) of the Maastricht University Medical Centre (MUMC+) was restructured to maintain the management of vulnerable multimorbid AF patients out of the hospital to prevent worsening of the condition as well as to prevent AF-related hospitalizations. Traditional face-to-face outpatient consultations in AF-clinics were transferred into teleconsultations. The downside of this was that teleconsultations were conducted without any information about heart rhythm or rate of the patients, which resulted in discomfort and uncertainty of the physician and patient. While symptoms could be assessed by detailed history taking, the presence of AF, and even more important, the ventricular rate during AF in patients with persistent AF prone to develop tachy-cardiomyopathy was not known. Adoption of medication was mainly based on physician's instinct and subjective patient-reported symptoms rather than on objective measures, and hindered a safe and individualized treatment approach, which is one of the goals of integrated AF-clinics.

In line with the fundamental aspects of integrated care, such as actively involving patients in the care process and providing comprehensive care by a multidisciplinary team, we implemented a mobile health (mHealth) intervention to support teleconsultations with AF patients: TeleCheck-AF. In this article, we describe the components and implementation of the TeleCheck-AF approach in an integrated and specialized AF-clinic through teleconsultation during COVID-19.

The TeleCheck-AF approach

The TeleCheck-AF approach guarantees the continuity of comprehensive AF management and supports integrated care through teleconsultation during COVID-19. It incorporates three important components: (i) a structured teleconsultation ('Tele'), (ii) an app-based on-demand heart rate and rhythm monitoring infrastructure ('Check'), and (iii) comprehensive AF management ('AF') (Figure 1).

Teleconsultation

Teleconsultation allows healthcare professionals to conduct remote patient consultations and communication between physicians.⁵ It can be organized by a telephone conversation as well as by videoconferencing or videotelephony. Cardiologists/electrophysiologists as well as specialized AF nurses can be involved in teleconsultation and all contribute to patient education and ultimately in shared decision-making processes. According to current AF guidelines,² patient characteristics, comorbidities and AF risk factors should be assessed, and as such structured history taking is an important part of the teleconsultation. Although new teleconsultation solutions can produce remote situations that are relatively similar to face-to-face interactions, a standardized assessment of heart rate and rhythm remains challenging. In TeleCheck-AF, we introduce an on-demand app-based heart rate and rhythm monitoring infrastructure for the integration of remote documentation and guidance of AF management through teleconsultation.

On-demand app-based symptom, heart rate, and rhythm check

Remote heart rate and rhythm assessment in TeleCheck-AF is ensured by an on-demand monitoring infrastructure, which is based on a mobile phone app (FibriCheck[®]) using photoplethysmography (PPG) technology through the built-in camera. This app is CE marked, connected to a secured and certified cloud and validated (sensitivity: 96%; specificity: 97%) to detect AF via PPG signals and to provide rate measures during sinus rhythm and AF.^{6,7} Patients are instructed to use this app three times every day and in case of symptoms to provide a semi-continuous longitudinal information about heart rate, rhythm and symptoms. The simultaneous assessment of heart rhythm and symptoms in the app allows assessment of symptom-rhythm correlation. The goal is to provide heart rate and rhythm information to allow a better assessment of the disease state of the patient and to support in treatment decisions during the teleconsultation. On-demand, the app can be activated for a limited predefined time period by a QR-code, which acts as a mHealth-prescription. Once the app is activated by the QR-code, all PPG recordings are instantly submitted to a secured cloud which is accessible by the treating physician and can be used during the teleconsultation. In this TeleCheck-AF approach, we propose activation of the app for 7 days. However, dependent on the clinical question and the physician preference, the use of the app can be adapted and controlled by providing respective QR-codes. The app regularly reminds the patients by pop-up messages to assess heart rate and rhythm which supports adherence and provides suggestions on how to improve recording quality in case of failed measurements. Additionally, the app provides educational information about AF, its complications and treatment.

Atrial fibrillation management

The management of AF consists of four main domains: (i) rate control for symptom management and preservation of left ventricular function, (ii) rhythm control to improve symptoms, (iii) prescribing appropriate oral anticoagulation according to stroke risk to prevent thromboembolic complications, and (iv) management of precipitating

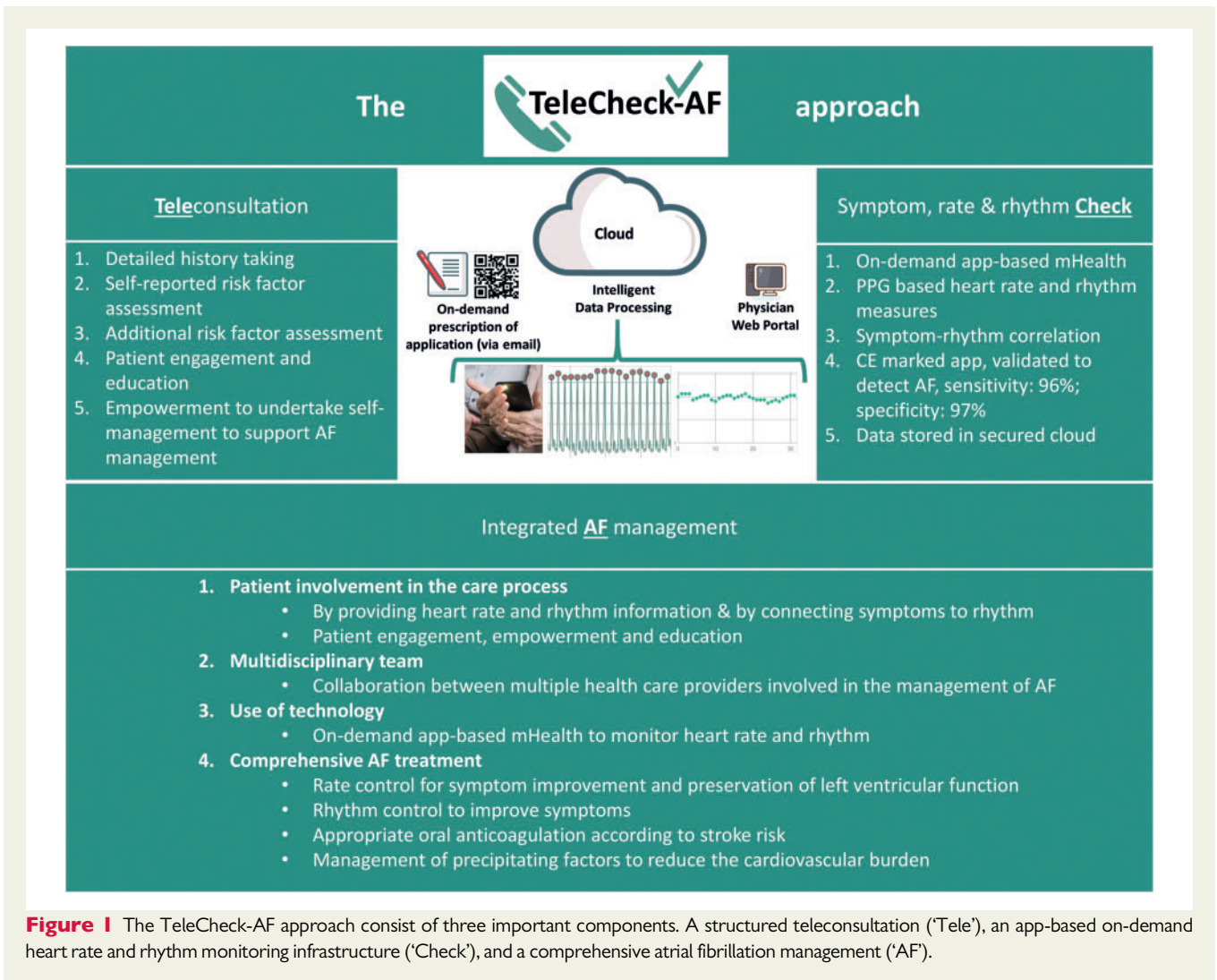


Figure 1 The TeleCheck-AF approach consist of three important components. A structured teleconsultation ('Tele'), an app-based on-demand heart rate and rhythm monitoring infrastructure ('Check'), and a comprehensive atrial fibrillation management ('AF').

factors (i.e. underlying cardiovascular conditions and modifiable risk factors) to reduce the cardiovascular burden.² Given the multifaceted character of AF management and limitations due to fragmentation of care, novel models of care delivery have been identified to improve efficiency and co-ordination of care, whilst improving clinical and patient outcomes. Integrated care is such an approach that is based on the principles of the Chronic Care Model⁸ and aims to provide care which is in line with the patient's needs, preferences and values and is based on the best available evidence. The concept of integrated care for AF management consists of four fundamental and indispensable aspects, including:

Patient involvement in the care process: Following a patient-centred approach, it is important to actively involve patients and their caregivers in the care delivery, which includes involvement in decision-making as well as undertaking self-management activities to support the treatment.⁹ Engagement is an important vehicle to build trust between patient and care provider and for the patient to understand their fundamental role in the care team.

Multidisciplinary team: A multidisciplinary team is often involved to appropriately manage this complex condition. The infrastructure of

such collaborative practice model should be built in an AF-clinic and requires collaboration and communication between multiple specialists that can be involved in the management of AF. Moreover, integration of specialized hospital care and primary health care is crucial to warrant continuous delivery of care and structured follow-up in the appropriate setting, with important roles for nurses and allied health professionals in terms of patient education and co-ordination of care.⁹

Use of technology: The use of smart technology is helpful for health care professionals (e.g. decision support technology, telemonitoring or mHealth) as well as for patients (e.g. disease-specific educational applications, monitoring technology).^{10,11} These applications aim to encourage integrated AF management whether it is by supporting decision-making in the treatment team or empowering patients to monitor their vital parameters and self-manage their condition.

Comprehensive treatment and access to all treatment options: The management of AF should cover all domains of AF treatment as described before, however, the composition and content of these domains will differ per individual patient and the availability of resources.

These fundamental aspects of integrated care are the basic infrastructure of integrated, specialized AF-clinics. In our institution, the AF-clinic was developed a decade ago and has demonstrated clinical value,^{12–14} and international guidelines have adopted this approach, which is recommended as the Gold Standard management approach for AF.² The TeleCheck-AF approach underlines the multifaceted character of AF management. The mHealth intervention puts the patient 'in charge of their own care', by asking them to provide vital data in order to determine the best possible treatment. Engagement with the patient and providing clear instructions is key, which commences before the teleconference. Within the teleconsultation, dedicated AF treatment—based on the data provided by the patient—will be provided as part of a comprehensive AF management approach provided by a multidisciplinary team.

Implementation of TeleCheck-AF in an integrated atrial fibrillation care approach

Who is eligible?

Heart rate and rhythm assessment in the TeleCheck-AF approach is based on PPG measures by an app. As diagnosis of AF still requires a documentation of an AF episode by electrocardiogram,² TeleCheck-AF is mainly appealing for the remote management of patients with previously documented AF. We identified several clinical scenarios in which TeleCheck-AF could support AF management through teleconsultations during the COVID-19 pandemic. First, for the assessment of heart rate and rhythm in patients scheduled for an outpatient clinic visit. Second, to guide rate control in patients who report with symptomatic (haemodynamically stable) recurrent AF episodes to the general practitioner, outpatient clinic, or emergency department. Third, since no Holter recordings are available during COVID-19, the approach can be used to assess rate and rhythm after ablation for AF and fourth, to up-titrate beta-blockers in patients with heart failure. In addition to assessment of heart rate and rhythm, the app also provides information on symptom-rhythm correlation by simultaneously assessing symptoms.

TeleCheck-AF patient instruction

Instruction and education of patients are key factors for successful implementation of the remote on-demand heart rate and rhythm monitoring for the management of AF patients. A case co-ordinator (e.g. a secretary or nurse) has an important role in clearly instructing the patient about why, how and when to use the app.

Why

The case co-ordinator explains that due to COVID-19 pandemic all face-to-face consultations are transferred to teleconsultations and that an electrocardiogram (ECG) cannot be performed to assess heart rate and rhythm. Therefore, an mHealth-prescription to use the FibrCheck[®] app is provided.

How

The case co-ordinator provides instruction which includes an installation manual together with the activation QR-code which is sent to the

patient by e-mail (Figure 2). The case co-ordinator evaluates after 24 h in the cloud if patients were able to activate the app and to perform measurements (Figure 3). In case patients need further support, the case co-ordinator or the helpdesk of FibrCheck[®] can be contacted.

When

The provided patient manual instructs the patient to perform three measurements a day and in case of symptoms for a period of 7 days before the teleconsultation. In addition, patients are asked to assess their body weight and blood pressure, if possible, on a daily basis and provide the measurements during the teleconsultation.

Adherence

The on-demand mHealth approach is critically dependent on the willingness and adherence of the AF patients to perform the measurements. Besides education and engaging patients in their own AF management several features implemented in the app improve the adherence in TeleCheck-AF. On a daily basis, an automatic pop-up message is sent to the patients as reminder to perform heart rate and rhythm measurements. Additionally, the time-period of 'only' 7 days and the straightforward, simple and short measurement procedure (maximum 2 min) makes this approach very acceptable for patients.

Implementation of heart rate and rhythm information into teleconsultation

After 7 days, the QR-code expires, and the data collection stops. In the cloud, an automatic report is generated containing a summary of all measurements including heart rate, rhythm and symptoms. Additionally, all healthcare professionals have access to the raw PPG traces of their patients via the cloud. Before the planned teleconsultation, the physician logs into the cloud and can easily assess heart rate, rhythm and symptoms recorded by the patients during the week before which can be used to guide AF-management during the teleconsultation (Figure 4). If needed, patients are asked to repeat the measurements for one more week to check if medication changes for rate and rhythm control were effective or not. For this, they receive a new QR-code which then can be activated and a follow-up teleconsultation will be planned. Structured and comprehensive risk assessment and management is an important part of TeleCheck-AF during the teleconsultation. Based on self-reported body weight and blood pressure, obesity and hypertension can be managed, and general lifestyle changes recommended (Table 1).

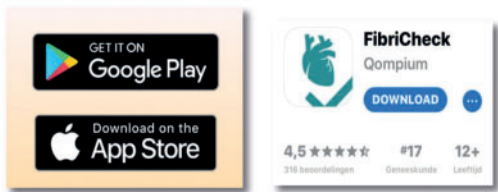
In addition to healthcare professionals, also the app facilitates education by providing information on AF, risk factors, lifestyle, heart failure, and stroke risk (Figure 5). Furthermore, education about the importance of lifestyle and risk factor management as well as treatment adherence is provided by online information material (e.g. www.getsmartaboutafib.net).

Discussion

In recent online statements on the European Society of Cardiology website as well as in consensus papers on the guidance for the management of AF patients during the COVID-19 pandemic from the Heart Rhythm Society, American College of Cardiology, and American Heart Association,¹⁵ the use of telemedicine and mHealth

Step 1.

- Go to the “play store” or the “Apple App Store” on your smartphone.
- Search the app ‘FibriCheck’ and download the application.



Step 2.

After the first-login you’ll need to create an account, fill in your own personal data and the email address you provided to us.



Step 3.

- Do you have a FibriCheck invitation code?” -> Answer this question with “YES”
- Click on “I have a QR code”, point the camera towards the QR code shown here.



Step 4.

- To perform a registration of the heart rhythm, click “start”
- Place your index finger “gently” on the camera of your smartphone (you do not need to cover the flashlight, this can become hot!). The registrations will start automatically and will take 60 seconds. Afterwards the data is automatically sent to your caregiver.



Figure 2 Installation manual including the QR-code for activation. This manual provides a step by step approach to download the app and how to perform a measurement.

solutions for remote patient care are recommended. However, a universal solution to allow wide and fast implementation of mHealth infrastructures is not provided. Herein, we describe our TeleCheck-AF approach incorporating a remote on-demand app-based heart rate and rhythm monitoring infrastructure and a comprehensive AF management approach through teleconsultation.

TeleCheck-AF includes fundamental components of a comprehensive integrated care approach (Figure 1). The patient is actively involved in the treatment trajectory by monitoring heart rate and rhythm information, as well as blood pressure and weight measures.

Education about AF management and the importance of lifestyle and risk factor management is provided by a multidisciplinary team during teleconsultations. Also, there is a focus on empowering patients to self-manage these conditions which includes treatment adherence. Moreover, the app provides push notifications with information about their condition and the importance of adhering to the treatment regimen. This supports self-management and ensures a regular data collection. The app is a true example of mHealth impacting both the patient (i.e. patient involvement by active role to provide data on rate and rhythm and reminding to adhere to the treatment regimen),

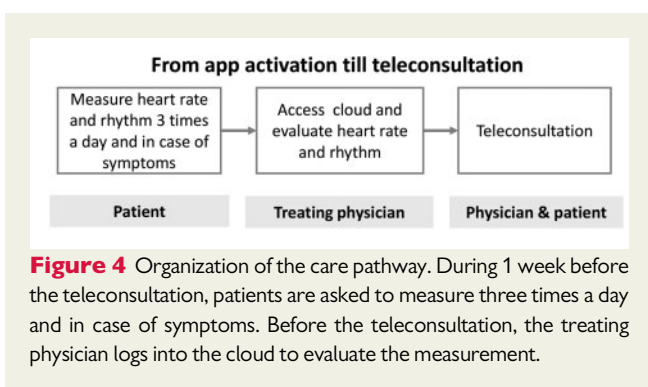
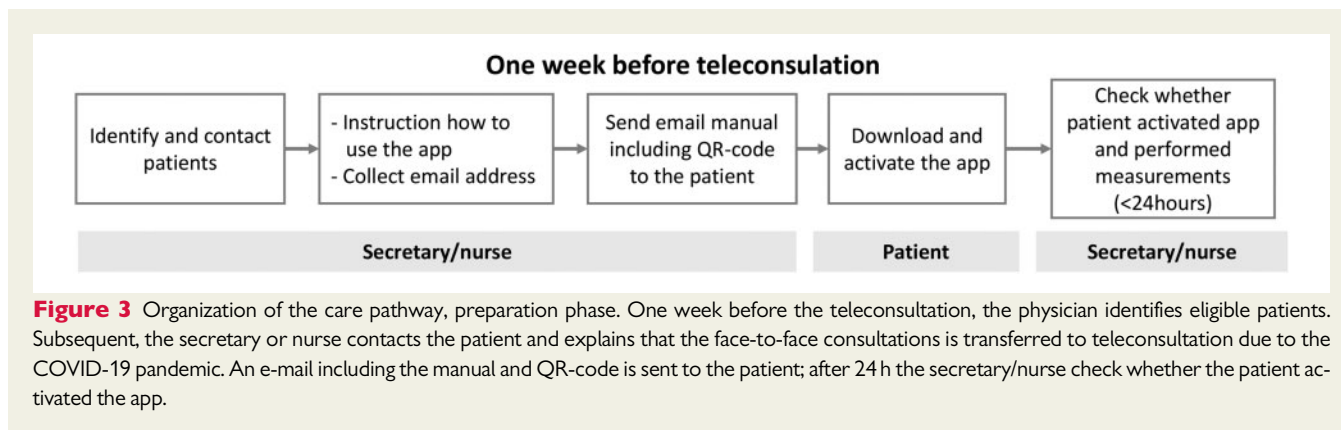


Table 1 Structured teleconsultation

Structured teleconsultation

- (1) Remote assessment of heart rate and rhythm
- (2) Detailed history taking
- (3) Stroke risk assessment (CHA₂DS₂-VASC score)
- (4) Self-reported risk factor assessment
 - Hypertension
 - Obesity
- (5) Additional risk factor assessment
 - Glucose, kidney function, hypercholesterolaemia, and thyroid function if needed in collaboration with general practitioner
 - Education and lifestyle advise
 - AF management: adaptation of rate control, anticoagulation treatment

as well as the health care professional (i.e. validated insights in rate and rhythm). During COVID-19, the accessibility to elective interventions and procedures such as electrical cardioversion as well as elective invasive interventions such as AF ablation is limited.¹⁶ Nevertheless, remote adaptation of rate and rhythm medication

guided by the on-demand monitoring infrastructure together with a comprehensive risk factor management, which has been shown to maintain sinus rhythm and reduce the need of AF ablation,¹⁵ are elemental parts of TeleCheck-AF and helps managing AF patients during the COVID-19 pandemic.

The on-demand mHealth application for a limited predefined time period of 7 days prior the scheduled teleconsultation within the TeleCheck-AF approach is novel and differs from previous settings where mHealth is typically used for a longer rhythm monitoring period or provide decision support, risk assessment and patient education according to existing guidelines.^{7,17,18} The goal in TeleCheck-AF is to make heart rate and rhythm information available, to allow a better assessment of the disease state of the patient and to support in treatment decisions through teleconsultation. The limited validity, regulated by a QR code, avoids unnecessary data-load. Additionally, maintenance costs associated with long term use of apps do not occur with an on-demand approach, which makes this TeleCheck-AF approach available for low costs.

An app-based approach has several advantages over device-based or wearable-based approaches during the COVID-19 pandemic. No hardware is required which has several hygienic and logistical advantages. The heart rate and rhythm monitoring infrastructure in TeleCheck-AF is a complete stand-alone unit, does not require any installation of software on a computer and can be combined in a flexible way with teleconsultation via telephone conversation, videoconferencing, or videotelephony. A potential disadvantage is, that an ECG cannot be provided; however, the FibrCheck app algorithm is able to validly inform about the presence of AF and current heart rate.⁶

The broad accessibility of the mobile phone app used in TeleCheck-AF allows a fast implementation of the herein described mHealth infrastructure during the COVID-19 pandemic. Currently, MUMC+ makes the TeleCheck-AF infrastructure available in numerous large European centres focused on AF management within the TeleCheck-AF project. The TeleCheck-AF project was initiated on the 04 April 2020. The motto is: 'Let's keep our AF patients out of the hospital during COVID-19!'. The goal is to maintain and secure AF care during COVID-19 and we are currently inviting other European centres to participate in this project.¹⁹ For more information visit our website: www.telecheck-af.com and follow #TeleCheckAF on Twitter.

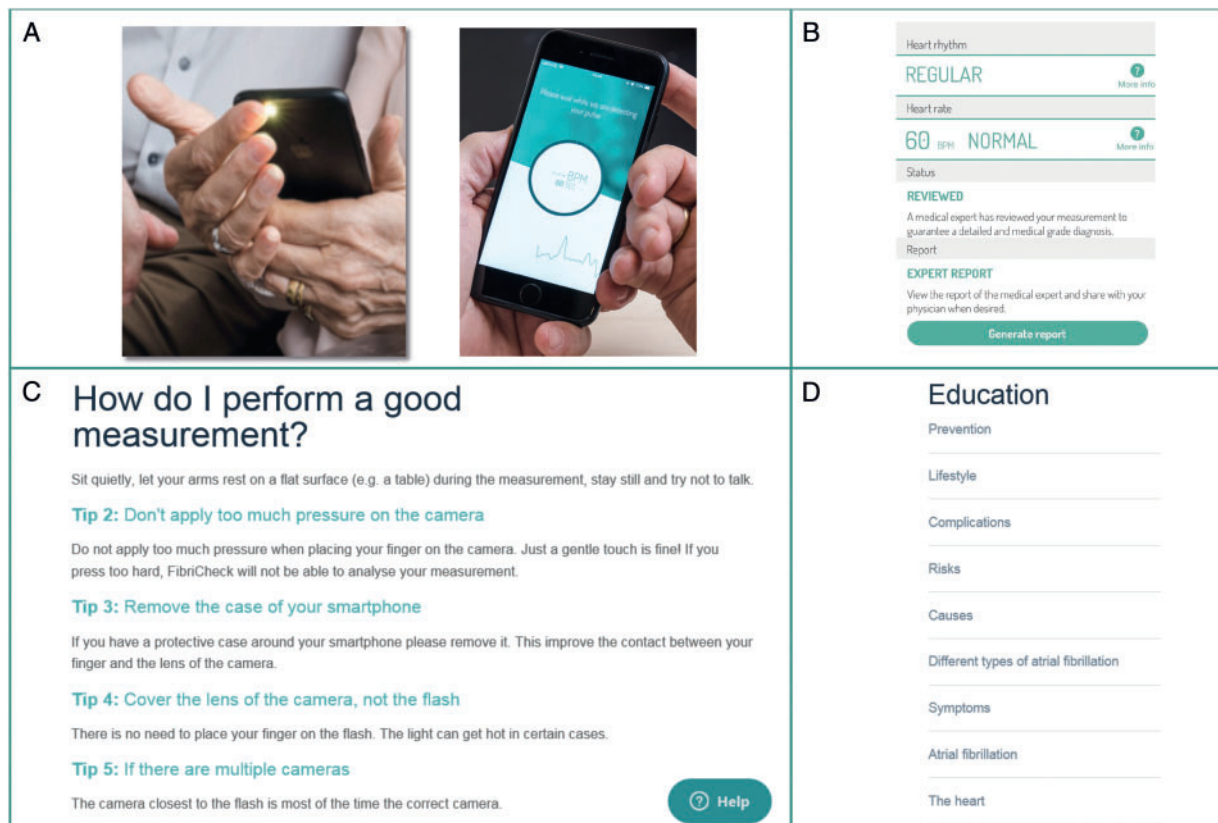


Figure 5 Usage of the FibrCheck. (A) An example of performing a measurement is shown. (B) A report after a measurement is shown. (C) Instructions to improve the quality of a measurement is shown. (D) Summarizes the topics of the education provided by the FibrCheck app.

Perspectives and challenges

In the TeleCheck-AF project, we aim to show that the TeleCheck-AF approach can be easily implemented and used in different European centres during the COVID-19 pandemic. Besides other factors, the lack of uniform European-wide legislation for teleprescription of drugs, digital health and reimbursement models have largely prevented the widespread use and broad clinical implementation of digital health services.²⁰ Hopefully, the challenges of COVID-19 may help speed up the discussions with health insurances, hospitals and industry partners are required to allow broader clinical implementation of this infrastructure in the future.²⁰ Whether TeleCheck-AF represents a streamlined and cost-effective monitoring system after the COVID-19 pandemic should be evaluated. For this further study is warranted to test for efficacy, safety and durability of this approach.

Conclusion

Herein, we describe a new mHealth approach facilitating AF management through teleconsultation. The TeleCheck-AF approach incorporates a structured teleconsultation, CE marked app-based on-demand heart rate and rhythm monitoring and integrated specialized AF management, and it can be easily implemented in European centres during COVID-19.

Funding

TeleCheck-AF was initiated by the Maastricht University Medical Center+ and is supported by FibrCheck and Biosense Webster.

Conflict of interest: none declared.

Data availability

There are no new data associated with this article. No new data were generated or analysed in support of this research.

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Erratum

doi:10.1093/europace/euaa364
online publish-ahead-of-print 6 January 2021

Erratum to: Implementation of an on-demand app-based heart rate and rhythm monitoring infrastructure for the management of atrial fibrillation through teleconsultation: TeleCheck-AF [Europace 2020; <https://doi.org/10.1093/europace/euaa201>]

Upon the original publication of this article, several errors regarding the placement of the following figures were noted: Figure 1, Figure 2, Figure 3, Figure 4 and Figure 5. These errors have now been corrected online. The publisher apologises for the error.

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