The use of mobile health to evolve outpatient thoracic surgical care: a focus on implementation, patient engagement, arrhythmia detection and cardiovascular risk reduction

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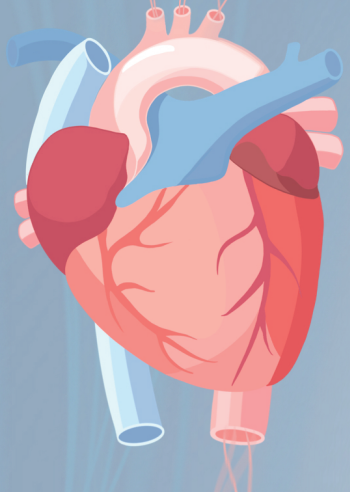

CHAPTER I

General Introduction

THE SETTING

Over the last decades, technology has changed the way we live. In the year 2000, 70% of all Dutch inhabitants were equipped with a personal computer, and 40% had an internet connection[1]. In 2020, 97% of all inhabitants above the age of 12 were connected to the internet, and 88% used it daily[2]. These numbers were comparable with other northern European countries and countries such as, but not limited to, South Korea, Saudi Arabia and Canada[3]. In the Netherlands, internet use among elderly people has increased over the last decade. In 2013, 39% of all people aged 75 years or older had used the internet at least once in their life, and 20% used it daily[4]. In 2021, 79.6% of all people aged 75 years or older were connected to the internet. More than 50% used it daily by reading news articles, finding information on the web, and using chat messaging services[2]. Digital literacy has become an important skill as it has become increasingly hard to, for instance, file taxes and transfer money offline. In the job market, specific hard skills and mastery of particular skill sets, with a focus on digital literacy, are in increasingly high demand[5].

In medicine, the use of electronic healthcare (eHealth) is a growing field, but lacks a clear definition. A total of 51 unique definitions were found and discussed by Oh et al[6], which showed no clear consensus; the terms 'health' and 'internet' were most often named, mostly followed by positive connotations such as 'benefits', 'improvements' and 'enabling'. One study suggests that eHealth allows patients and professionals to 'do the previously impossible'[7]. Due to the lack of consensus, however, eHealth remains an umbrella term. The number of publications listed on Pubmed containing the word 'eHealth' has increased by 500%: from 2,706 publications in 2010 to 13,661 in 2020[8]. Moreover, in 2020, app developers had created over 350,000 eHealth apps for Apple (Apple, Cupertino, CA, USA) and Android (Google, Mountain View, CA, USA) users. Over 250 new apps are available each day[9]. The clinical utility of apps has great potential, good examples being Headspace and the Mind Spot Clinic, both focusing on mental well-being. Both apps have been shown to be effective tools resulting in clinical significant improvements in psychosocial well-being, displaying the potential to increase the efficacy of existing mental health services[10-12]. Electronic health has also been considered to be beneficial in the hospital sector for both patients and healthcare providers, who use it in diagnostics and follow-ups, in monitoring chronic diseases, in rehabilitation, and in residential management of patient medication[13]. For instance, eHealth was found to be effective compared to standard care with respect to anticoagulant therapy[14], smoking cessation[15], blood pressure reduction and weight-loss[16].

Several concerns of eHealth have been reported in popular and scientific literature, such as data safety, the lack of a legal framework, and questionable added value of eHealth interventions[17]. Another concern is the unregulated market of eHealth apps, result-

ing in a low average quality of these apps[18]. Without clinical evaluation, eHealth apps could compromise user health and safety[19]. For instance, an app that was designed to help with opioid conversion calculations and an app for melanoma detection, both failing to follow evidence-based guidelines[20,21], are examples of suboptimal functioning eHealth. This may, as a result, provide inaccurate information with potential hazardous consequences such as incorrect diagnosis or drug overdose. Therefore, careful clinical evaluation of eHealth apps is needed before it is introduced within the target patient population.

Apart from eHealth *software*, which has seen growth in recent years, various *hardware* solutions have been released to the market as well. When hardware or software solutions are combined with the use of a mobile phone or other wireless technologies to support the achievement of health objectives, this is known as mobile health (mHealth)[22]. Mobile health technologies can often measure vital parameters, such as blood pressure or oxygen saturation, or register an ECG. Mobile health is believed to present opportunities to increase patient engagement, improve clinical outcomes and reduce healthcare costs by, among other factors, early illness detection and empowering patients to intervene in their own healthcare[23-25]. Mobile health therefore provides the possibility to redesign the follow-up of patients[26]. This was the objective of a randomized clinical trial *The Box*, which was introduced to the cardiology department of the Leiden University Medical Center, Leiden, The Netherlands (LUMC) in 2016[27]. A total of 200 myocardial infarction patients were randomized in a 1:1 fashion, the intervention group receiving a blood pressure monitor, pedometer, single-lead ECG device and a weight scale to track their vital parameters for the duration of one year. Also, during follow-up, two protocolled physical outpatient clinic visits were replaced by an eVisit. This meant that intervention group patients saved time and money by not having to come to the hospital, at the same time relieving pressure on the outpatient cardiology clinic. The mHealth intervention was hypothesized to improve clinical effectiveness, and patient satisfaction due to an increased engagement and empowerment as a result of individualized follow-up. A PhD student and nurse practitioner (NP) checked the measurements multiple times per week and contacted the patient in case of data irregularities, changing the medication regime if necessary.

After a successful start of *The Box*[28], it was unknown if other patient groups could also benefit from this mHealth intervention. As an improvement in ambulatory care may lead to a decrease in complications, the impact of mHealth may be especially large in high-risk patient groups, for instance those who underwent major surgery. After cardiac surgery, patients who are discharged in a clinically stable condition are still at risk to develop complications at home. The most frequent postoperative complications are rhythm disturbances such as atrial fibrillation, late tamponade, cardiac decompensation and sternal

wound infection. In approximately 25% of patients, one or more of these complications occur[29]. Early detection of complications is of vital importance to prevent or reduce morbidity as well as patient presentations to the emergency department, and *The Box* was hypothesized to fulfill these needs during the ambulatory follow-up period immediately after discharge from the thoracic surgery ward. The main goal of this thesis was to assess the effect of *The Box* on clinical outcomes and patient satisfaction after cardiac surgery. The research questions were:

1. Does *The Box* increase the detection of postoperative atrial fibrillation (POAF) compared to standard care?
2. Does *The Box* improve blood pressure, weight and lipid levels (cardiovascular risk management) compared to standard care?
3. Is *The Box* feasible to implement in daily outpatient care, and is patient satisfaction of care positively influenced by *The Box* compared to standard care?

The preliminary investigation of this thesis consisted of a systematic review of the diagnostic detection rate of atrial fibrillation by mHealth devices, compared to traditional outpatient follow-up, in patients with an indication for ECG follow-up. In **Chapter II**, the results of this systematic review are discussed. **Chapter III** provides an overview of the design of *The Box*, as well as the implementation and utilization in the ambulatory follow-up of all eligible patient groups of the department of cardiology of the LUMC, which started in 2016.

To assess the research questions mentioned above, an observational study consisting of a prospective mHealth intervention group and a historical control group was conducted. A total of 730 cardiac surgery patients were included and followed up for 3 months. The rationale and design of this study are discussed in **Chapter IV**, the outcomes regarding the detection of POAF and patient satisfaction are discussed in **Chapter V**, and the impact of mHealth on cardiovascular risk management is discussed in **Chapter VI**.

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