

School of Business, Economics and IT Division of Informatics

# “Does it help the patient and does it help the healthcare system?”

## - Assessment of automated self-monitoring eHealth applications from healthcare professionals’ perspectives

**Author: Kanniga Lakshmi Jagadeesan**



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Spring term 2022 Supervisor: Helena Vallo Hult Examiner: William Jobe

**Abstract**

The World Health Organization (WHO) defines eHealth as “the use of Information and Communication Technologies (ICT) for health”. Inadequate observation of vital signs, which can lead to failure to recognize deterioration, that could have been prevented otherwise is not only a cause for individual suffering but the society as well. One strategy to achieve sustainable care is through self-monitoring with the help of telemonitoring devices, a type of eHealth service, that has been found to reduce delivery costs and increase medical quality. According to a large number of studies, eHealth has the potential to enhance better communication between healthcare professionals and patients, increase awareness about the disease among patients and lead a healthy life. The WHO guidelines on digital interventions highlight how eHealth solutions act as a useful resource to improve health and access to health services. Nine semi-structured interviews were conducted to understand the benefits and challenges associated with automated self-monitoring health applications from healthcare professionals’ perspectives. Results indicate the perceived benefits, potential barriers, and organizational challenges that come along with the implementation. Viewpoints have been elucidated and discussed concerning previous research articles used during the study. The thesis concludes with the fulfillment of the goal by establishing a basis for further research, according to the author is probably needed.

**Keywords:** automated health applications, eHealth benefits, healthcare professional perspectives, challenges in eHealth implementation, mHealth adoption barriers, workflow changes

# Foreword

The author of this thesis would like to thank Helena Vallo Hult as supervisor of this thesis and Kristian Nilsson who initiated this study. Both provided ample guidance and support right from the initial phase.

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# List of Abbreviations

**ADR** Adverse Drug Reaction

**BP** Blood Pressure

**CARE** Congratulate, Ask, Reassure, Acknowledge

**CHF** Chronic Heart Failure

**COPD** Chronic obstructive pulmonary disease

**COVID** Corona Virus Disease

**EHR** Electronic Health Record

**EU** European Union

**HCP** HealthCare Professional

**HRMS** Health Remote Monitoring Systems

**ICT** Information and Communication Technology

**MDE** Major Depressive Episode

**mHealth** mobile health - medical solutions based on the use of mobile devices

**PHC** Primary Healthcare Center

**SALAR** Swedish Association of Local Authorities and Regions

**SUD** Substance Use Disorder

**VGR** Va¨stra G¨otaland Regionen

**WHO** World Health Organization

# Introduction

We live in a digital world. The impact of digitalization can be witnessed in several sectors intertwined with our everyday lives in one or the other way. Healthcare is one such domain where digital transformation has brought in many changes like Electronic Health Records (EHR), robot-assisted surgery, wearable health monitoring devices with built-in sensors to detect diabetes, blood pressure, muscle movements, and so on (Moisil, 2019). Telemedicine can be defined as the delivery of remote healthcare services by telecommunication systems. Telemedicine offers some beneficial outcomes such as improvements in patients’ health with proper access to healthcare and a reduction in hospital visits also. Remote monitoring falls under the category of telemedicine where technologies such as smartphones are involved in clinical data transfer. Either the patient or clinician or both respond and later the treatment regime faster when compared with regular face-to-face healthcare visits. Some remote monitoring systems are designed with algorithms that use automated voice response software to alert patients when the clinical data falls beyond the acceptable range. However, few systems are designed to alert healthcare professionals to intervene in an emergency (Flodgren et.al., 2015).

Peyroteo et.al. (2021) conducted a systematic review to bring out the crucial role of remote monitoring systems, especially during the COVID-19 pandemic. Usage of Health Remote monitoring systems (HRMS) not only reduces the healthcare and hospital visits but also improves assess to patients. To be specific, patients who fall under the categories of chronic disease and old age population are benefited from HRMS. With technological advancements, there is a rise in expectations among the society giving way to exploring unlimited opportunities. Digital transformation from one phase to another phase opens new challenges, socio-cultural changes, and organizational changes. Right at this junction, Informatics plays a greater role in the analysis and interpretation of the same to progress towards a healthier society (Vallo Hult et.al., 2019). At the same time, digital interventions such as health monitoring applications have their pitfalls. Among patients, there are chances to increase or initiate symptoms related to anxiety (Carlqvist et.al., 2021; Grainger et.al., 2020; Kerst, Zielasek & Gaebel, 2020; Patoz et.al., 2021). Although it helps healthcare professionals with remote monitoring and provides better insights into health data about pre and post-physical visits to healthcare centers, studies reported changes in workflow with an increased workload, additional training, and sessions to cope with the technical demands (Bradbury et.al., 2017; Carlqvist et.al., 2021; Fleddermann et.al., 2021; Grainger et.al., 2020; Hernández, Alonso & Barberà, 2018; Nguyen et.al., 2019; Nielsen et.al., 2020; Patoz et.al., 2021; Vallo Hult et.al., 2019)

## Problem background

Based on a statistical survey provided by the World Health Organization (WHO) in the year 2020, noncommunicable diseases (diabetes, chronic respiratory disease, cancer, and cardiovascular disease) have accounted for 71% of deaths at a global level. Studies show that smart health applications act as a preventive factor by bringing out the risk factors associated with patients’ data. This way rise in the number of deaths can be controlled (Peyroteo et.al., 2021).

There is an expected steep increase in the octogenarian population by the year 2030. One of the project initiatives proposed by V¨astra G¨otaland Regionen1 (VGR) is less intervention by healthcare professionals, and at the same time provide quality care to older adults as well as patients of any age group who are in dire need of healthcare service in the future. This in turn might lead to fewer hospital visits, thereby enhancing the healthcare professionals' focus on the needy patients. To meet this demand, one suggested solution is the implementation of *automated self-monitoring* applications that works with a smartphone. Automated self-monitoring is one step in advance of *self-monitoring* where the healthcare staff can access the patient’s medical data through the recommended medical devices linked with digital applications and advise accordingly. Automated self-monitoring acts based on self-measurement at a certain frequency. With these measurements, automated feedback is provided. This gives way for a non-active involvement of a health professional (Nilsson, 2022).

## Research motivation

This section has been written following the Swedish Government’s vision “e-health 2025” published by the Swedish eHealth agency in the year 2021 (S2020/07991). Although Sweden stands as one of the best countries in the world to embrace digitization, there is a gap in the healthcare sector utilizing the opportunities to create high-quality and wide accessible person-centered healthcare services. In simple terms, individuals can benefit by having greater control over their health. At the organization level, smart use of digital technologies gives free space for employees’ time and less processing time. In light of this strategy, the Swedish government and the Swedish Association of Local Authorities and Regions (SALAR) have joined hands to set a clear objective to make Sweden the world’s best platform in eHealth using digitization opportunities. Several initiatives have already been undertaken and the challenge lies with various actors (physicians, nurses, and patients) who should coordinate at each level to contribute to a gender-equal and sustainable development of eHealth. This promises easy access, user-friendly, and secured healthcare as well as social services for an individual (eHÄLSA 2025, 2020).

1h[ttps://www.vgregion.se/en/](http://www.vgregion.se/en/)

The shared vision for work on eHealth to 2025 decided by SALAR and the Swedish government is as follows (S2020/07991):

*“In 2025, Sweden will be best in the world at using the opportunities offered by digitisation and eHealth to make it easier for people to achieve good and equal health and welfare, and to develop and strengthen their own resources for increased independence and participation in the life of society.”*

## Purpose and research question

This section sets the scope of this study. Digital transformation in healthcare from self-monitoringto *automated self-monitoring* needs to be validated with research findings, available knowledge in this area, and accepted technology, preferably around the globe. This will help for a successful future implementation in VGR creating less or null intervention of the healthcare staff. Another purpose of this study is to assess the acceptability level, reliability, and effectiveness of the automated self-monitoring applications as a replacement for usual face-to-face healthcare visits from a healthcare professional’s point of view. This can benefit not only the forthcoming digital transformation in VGR but other regions as well in Sweden.

To sum up, the following research question forms the basis of this study given below.

*RQ - What are the benefits and challenges associated with automated self-monitoring eHealth applications from healthcare professionals’ perspectives?*

Much research and innovation tend to be technology-driven (deterministic) but studies have shown that social, organizational, and contextual aspects are equally important. Digitalization of healthcare means changes to practice and new ways of working, including legal, ethical, and privacy considerations where new skills and competence may be required. (Vallo Hult et.al., 2019). Therefore, it is interesting to understand the healthcare professionals (doctors) perspectives and views, especially regarding what benefits and challenges they see with automatic self-monitoring.

## Limitations

This study will focus only on the self-monitoring or remote monitoring digital health applications that have been persistently used and what impact they had on the healthcare professionals. Furthermore, this study focuses only on the benefits and challenges that will be speculated from healthcare professionals' perspectives on automated self-monitoring health applications and not on the design or features of any such application. Also,

this study is independent of any specific age group with health conditions and gender. Although the target group is the end-users of the application, only the qualitative opinions of healthcare professional towards these applications for future implementation has been taken into consideration.

# Related research

This section is presented with the specific themes that emerged from the selected number of previous research articles selected for this study. During the search, a prominent number of articles were found to focus on the end-users or patients’ attitudes or healthcare professionals’ and patients’ perceptions towards digital health applications. Few studies gave much importance to the validation of the applications through usability testing with app design and functionality. Limited studies focused either on the obstacles or enablers that promote the usage of mobile health applications that have already been developed or implemented. But no studies were found that aimed to capture the qualitative aspects of healthcare professionals blended with benefits and challenges before implementation of automated self-monitoring digital health applications. This literature gap that was found during the reading of previous research articles is thoroughly addressed in this study.

An inductive approach was used to present the themes in this section. The first section aims to present the age criteria that most of the studies focused on and perceived as hindrances to the adoption of mHealth technologies with the positive and negative aspects noticed among patients or users from the Health Care Professionals (HCPs) perspective. Secondly, on the adoption of these technologies, changes in HCPs' workflow have been figured out. Thirdly, it gives the reader an overview of HCP attitudes and opinions towards various health applications that were implemented during the study. Moreover, the term HCP refers to a group of doctors, nurses, or specific specialties such as orthopedics, psychology, or general practitioner. The list of studies with the research area, methods applied and the region covered in each of the studies has been outlined in table 1.

**Table 1:** List of articles selected for review

|  |  |  |
| --- | --- | --- |
| **Method used** | **Study focus on** | **Region** |
| Assessment of usability and viability in clinical practice of the Nabelia mHealthCare Platform to support integrated care management of patients with pulmonary hypertension (Hern´andez, Alonso & Barber`a, 2018) | | |
| Qualitative | Pulmonary hypertension | Catalonia |

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### Table 1 – continued from the previous page

|  |  |  |
| --- | --- | --- |
| **Method used** | **Study focus on** | **Region** |
| Attitudes among healthcare professionals towards ICT and home follow-up in chronic heart failure care (Gund et.al., 2012) | | |
| Quantitative | Chronic Heart Failure | Sweden |
| Clinician Perspectives on Barriers and Facilitators to Implementing e-Health Technology in Substance Use Disorder (SUD) Treatment Facilities (Fleddermann et.al., 2021) | | |
| Qualitative | Substance Use Disorder | United States |
| Evaluation of a telehealth solution developed to improve follow-up after kidney Transplantation (Nielsen et.al., 2020) | | |
| Qualitative | Kidney transplantation | Denmark |
| Healthcare professionals’ experiences of how an eHealth application can function as a value-creating resource - a qualitative interview study (Carlqvist et.al., 2021) | | |
| Qualitative | Telemonitoring in primary healthcare | Southern Sweden |
| Interest in a Mobile App for Two-Way Risk Communication: A Survey Study Among European Healthcare Professionals and Patients (de Vries et.al., 2018) | | |
| Quantitative | Adverse Drug Reaction | Croatia, The Netherlands, and the UK |
| Listen before you leap: Sri Lankan health professionals’ perspectives on m-health (Han, Subramanian & Cameron, 2019) | | |
| Qualitative | adoption of mHealth | Sri Lanka |
| Patient and clinician views on an app for rheumatoid arthritis disease monitoring: Function, implementation and implications (Grainger et.al., 2020) | | |
| Qualitative | Rheumatoid Arthritis | New Zealand |
| Patient and physician perspectives of a smartphone application for depression: a qualitative study (Patoz et.al., 2021) | | |
| Qualitative | Depression | France |

- - Continued on next page

### Table 1 – continued from the previous page

|  |  |  |
| --- | --- | --- |
| **Method used** | **Study focus on** | **Region** |
| Patients’ use of mobile health applications: what general practitioners think (Nguyen et.al., 2019) | | |
| Qualitative | Patient-focused apps | Australia |
| Smartphone applications for depression: a systematic literature review and a survey of healthcare professionals’ attitudes towards their use in clinical practice (Kerst, Zielasek & Gaebel, 2020) | | |
| Quantitative | Depression | The database used - PubMed, Cochrane Library, and Scopus |
| The provider perspective: investigating the effect of the Electronic Patient-Reported Outcome (ePRO) mobile application and portal on primary care provider workflow (Hans et.al., 2018) | | |
| Qualitative | patient self-management and guide care plans | Toronto |
| Understanding how primary care practitioners perceive an online intervention for the management of hypertension (Bradbury et.al., 2017) | | |
| Qualitative | Hypertension | Southern England |
| Flipped healthcare for better or worse (Vallo Hult et.al., 2019) | | |
| Qualitative | Changes in clinical practice | Western Sweden |

* 1. **Healthcare professionals’ perspectives on patients’ use of technology**

One of the factors that were highlighted when it came to adaptation and the adoption of technologies for use in self-health management through mobile apps was the *age factor*. Younger generations of people have a comfort zone in terms of accessibility, usability, and functionality of health applications (Hern´andez, Alonso & Barber`a, 2018; Kerst, Zielasek & Gaebel, 2020). On the other hand, older people have shown some reluctance to get acquainted with health applications (Fleddermann et.al., 2021; Patoz et.al., 2021). The likelihood of a patient’s inexperience with Information and Communication Technology (ICT) was related to the elderly age population by Gund et.al. (2012). Along with the older age population of 65 and above, economic factors like yearly income, limited technology in rural areas, and less experience in using health applications were reported by de Vries et.al. (2018). Qualitative interviews conducted by Grainger et.al. (2020) among respondents on

RAConnect, an application for Rheumatoid Arthritis, respondents aged 60 and above felt the urge to resist the flow of the app, while respondents aged 40 and below didn’t speak of any technical issues related to app usability (Grainger et.al. 2020, see table 2 in pp. 817-818).

Usage of ICT tools could lead to an increase in *self-awareness* and self-care among patients was reported by more than three-fourths of the healthcare professionals (Gund et.al., 2012). Self-management tools have the potential to empower *self-management* in chronic diseases such as diabetes, hypertension, and Rheumatoid Arthritis through better patient adherence as argued by Nguyen et.al. (2019), Bradbury et.al. (2017) and Grainger et.al. (2020) respectively. Looking at the other side of the developed app which was used to self-monitor data (Body temperature, weight, pulse, and blood pressure) post kidney transplantation and continuously followed a set of five questions before consultation, doctors reflected that it helped patients to prepare for consultations beforehand, fewer disruptions to daily life and spend ample time at home. Along with added advantages indicated by Nielsen et.al. (2020), *self-care* is yet another important aspect that was overviewed by doctors which paved way for dialogue improvement and collaboration between HCPs and patients. Nielsen et.al., (2020) also show that patients tend to become more active and show interest in their health with the use of self-tracking and monitoring applications.

Conversely, there was a downside reported in a few studies. Any health application on a smartphone would lead to a collection of health parameters at an advised frequency by the physician. In short, this can be described as quantified data that is being viewed by patients post data entry and evaluation of the same. HCPs believed that such a huge volume of data might have the probability of raising *anxiety* related to each disease which can be further worsened (Carlqvist et.al., 2021; Grainger et.al., 2020; Kerst, Zielasek & Gaebel, 2020; Patoz et.al., 2021).

* 1. **Changes in healthcare professionals’ workflow**

Bradbury et.al. (2017) used the term *organizational shift* to bring out the positive aspects of workflow changes among General Practitioners (GP). HOME BP, digital intervention for the management of hypertension had an option to send e-mail alerts in case of poorly controlled blood pressure (Bradbury et.al., 2017). This helped the practitioners to prescribe medication, thereby *saving time*. mHealth platform to manage pulmonary hypertension was perceived as integrated care management that helped to facilitate frequent follow-ups which helped further in monitoring and improved coordination at various levels in the healthcare system (Hern´andez, Alonso & Barber`a, 2018). The developed app and new

workflow such as training sessions and phone consultations was seen as a *new approach* to their existing workflow. Moreover, it helped HCPs to plan before face-to-face or virtual consultations on how to initiate the conversation with the patients based on the app-reported data and questions (Nielsen et.al., 2020). Some of the implications on GPs' daily practice were brought forward by Nguyen et.al. (2019) with future use of mobile health applications when rolled out among patients. It might help to *review* the patient’s data regularly during consultations along with an added advantage to *track multiple patients* through a remote portal.

While there was a positive attitude shown among healthcare professionals towards the use of ICT tools by Gund et.al. (2012), there were few additional methods indicated such as video consultations, e-mail, and home follow-up by healthcare professionals. There was a disruption in the daily workflow of clinicians as argued by Fleddermann et.al. (2021), HCPs have several jobs to fulfill, and their organizations have expectations for treatment processes like safety planning and documentation through clinical notes. As a result, finding time to present the RISE Iowa app to their patients and answer their worries about using it was difficult, and physicians were frequently unable to encourage patients to use the app.

The use of telemonitoring in primary healthcare as shown by Carlqvist et.al. (2021) with a qualitative analysis was seen as a new way of digital communication with patients with a meaningful work task, but other critical factors such as incorrect data reported by patients were not well perceived by HCPs. They found it as an *additional task* to their daily work and required them to act immediately. While RAConnect for Rheumatoid Arthritis had a potential benefit of rheumatologists viewing the daily experience of the patients, few reported workflow changes such as increased workload caused by monitoring and responding to health data of patients (Grainger et.al., 2020). This can be further strengthened with the explicit study conducted by Vallo Hult et.al. (2019) where additional burden and workload were overviewed as a primary concern in physicians' workflow.

Although an app was seen as a progressive replacement for physical visits for treating depression, there were some strong limitations put forward by Patoz et.al. (2021) during the interviews conducted among physicians. Notable constraints were *uncertainty* with the integration of apps into their daily practice and usage of an app might lead to increased *time consumption* in addition to their daily tasks. Physicians' feelings towards patient-centric technologies can rightly be told as a *responsibility shift* where patients provide information and data for physicians to work on and provide their insights. Such type of data sharing was not to be expected out of regular working hours i.e., weekends or nights (Vallo Hult et.al., 2019).

## How do healthcare professionals perceive digital health applications?

Practitioners and nurses stated that the integrated care management facilitated communication with patients through remote monitoring was well coordinated at various levels and information sharing about the treatment prescription while attempting to assess the feasibility and usability of the mobile healthcare platform to manage patients with pulmonary hypertension (Hernández, Alonso & Barberà, 2018). A survey of healthcare professionals’ attitudes conducted by Gund et.al. (2012) about ICT in the context of home monitoring of Chronic Heart Failure (CHF) patients showed that healthcare professionals responded positively to current and future ICT tools in healthcare. There was also a higher rate of confidence. Home monitoring was mentioned as a way to increase patient involvement and improve delivery care.

Doctors discovered that patient data (i.e., data generated through health apps by patients) helped patients reflect on their status and prepare for consultations, as well as supporting self-care, which is critical for kidney transplanted patients. The patient data function was beneficial to doctors, although it’s worth varied depending on the sort of consultation. Even if the patients did not address the issues directly, their voice was heard through the app’s provided statistics. By providing patients a voice and starting the conversation based on their reported data and queries, the telehealth solution brings a fresh approach to treatment and care in the transplantation process (Nielsen et.al., 2020). de Vries et.al. (2018) pinpointed the use of mobile applications for reporting Adverse Drug Reactions (ADR) by patients. Doctors showed a positive side of the app such as easy and faster access to ADR reports, storing previous data with pictures at various stages that can be used at future consultations, possibility to use the app in offline mode and send data later. However, the validation on a larger population of all the mobile app aspects needs to be validated with further improvements (de Vries et.al., 2018).

Healthcare Professionals recognized that their present and future patients will expect to use apps as part of their Rheumatoid Arthritis treatment. However, HCPs were afraid that technical demands might outstrip their own and their patients’ capacities, particularly in terms of app download and training. Rheumatologists recognized a possible benefit in learning more about their patients’ daily lives (Grainger et.al., 2020). But, in a study that involved primary care providers to reflect on their attitudes and opinions about a mobile application linked to their portal, through three-stage interviews (pre-visit, during the visit, and post-visit), on a general note practitioners remained neutral by not rejecting the new technology but were also not keen to use the app to its capacity (Hans et.al., 2018).

Some patients and doctors were skeptical about the usefulness of apps developed to treat depression among their patients. They said it did not make any sense to use the connected device for psychotherapy, so there was no benefit to it. They also emphasized the already wide range of apps for depression and said the new apps would not improve the care of Major Depressive Episode (MDE) patients. Some doctors have suggested that psychosocial interventions such as psychoeducation cannot be performed without medical professionals and have questioned the patient’s understanding of the information provided by the app (Patoz et.al., 2021). On the contrary, in a systematic literature review conducted by Kerst, Zielasek, and Gaebel (2020) for depression, it was implied that apps appear to be a promising self-management tool for reducing depressive symptoms and seem to be acceptable for both app users and professionals. Despite some concerns mentioned previously, healthcare professionals’ attitudes towards the use of mobile interventions in clinical practice are rather positive.

HOME BP was analyzed by an iterative approach to overcome the clinical inertia, and improve acceptability and feasibility between patients, general practitioners, and nurses. Time efficiency was a notable factor recognized among practitioners. Patients’ self-involvement in the usage of such online intervention which prepares them to be wary of their blood pressure conditions was encouraged among practitioners, forming an important aspect of the study (Bradbury et.al., 2017).

# Methods

In this section, the methodological approach chosen for this study with the preparatory work, collection of data, and how it will be processed and analyzed along with the ethical considerations is discussed.

## Research approach

The research question emphasizes the attitudes and feelings of healthcare professionals towards digital health applications rather than deriving a hypothesis and accepting or rejecting it later. So, qualitative interviews have been considered for this study. Bryman (2012) shows that interview is one of the widely used methods in qualitative social research. Moreover, interviews give an elbow room for the researcher to capture respondents' points of view with elaborate and rich answers (Bryman, 2012). Another two factors that can be justified for using a qualitative approach are, firstly, 70% of the previous research articles tend to focus on the opinions gathered from healthcare professionals (Bradbury et.al., 2017; Carlqvist et.al., 2021; Fleddermann et.al., 2021; Grainger et.al., 2020; Han, Subramanian & Cameron, 2019; Hans et.al., 2018; Hernández, Alonso & Barberà, 2018; Nguyen et.al., 2019; Nielsen et.al., 2020; Patoz et.al., 2021; Peyroteo et.al., 2021; Vallo Hult et.al., 2019).

The second reason, each of the interviewees belongs to different departments and varied experience levels. Although a similar professional pattern can be observed, respondents’ experience with patients and digitalization is invariably dynamic. Therefore, it felt important to capture the emotional feelings and bring out quality views onto the table from the respondents.

## Search queries

University West’s library database was used and a few scientific articles that were provided beforehand were also considered for writing in section 2. Some of the keywords that have been picked from the research question and their related synonyms were used to yield a good number of articles.

**Search Term 1 (S1):** “healthcare professional” OR doctor OR physician OR “healthcare personnel”

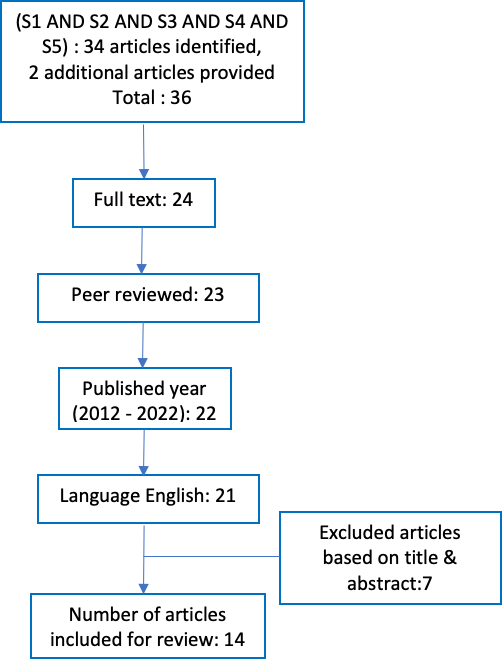
**Search Term 2 (S2):** perspective\* OR attitude\* OR view\* OR opinion\*

**Search Term 3 (S3):** “automated self-monitor\*” OR “home monitor\*” OR “remote patient monitor\*” OR “remote monitor\*” OR “self-monitor\*”

**Search Term 4 (S4):** “eHealth” OR mobile OR smartphone OR “mhealth” **Search Term 5 (S5):** app\* OR program\* OR technolog\* OR intervention

### Search strategies

The obtained results were further refined with inclusion criteria such as only “Full text”, “Peer reviewed”, English as the language, and articles not older than 10 years were taken into the search process. With this result, based on the title and abstract, few articles were excluded not relevant to this study. A schematic representation of the article selection process is given in figure 1.

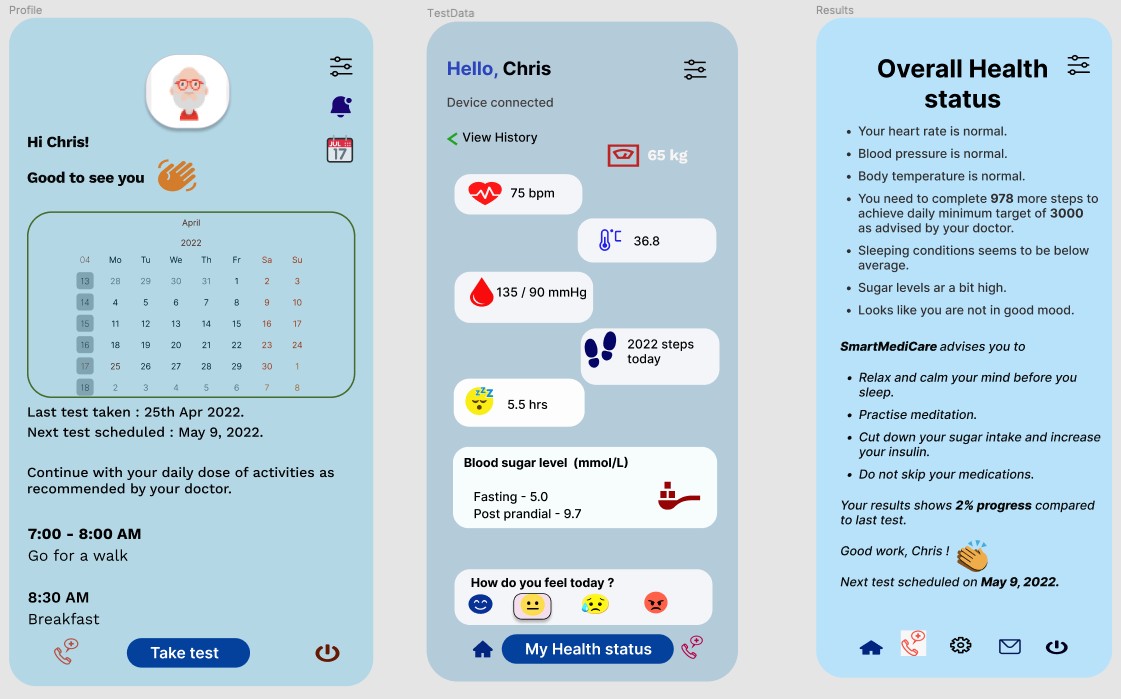


**Figure 1:** Schematic representation of article selection process

## Preparatory work

More than half of the articles that have been included in this study used one or the other form of a digital health application (Bradbury et.al., 2017; de Vries et.al., 2018; Fleddermann et.al., 2021; Grainger et.al., 2020; Hern´andez, Alonso & Barber`a, 2018; Nguyen et.al., 2019; Nielsen et.al., 2020; Patoz et.al., 2021). Therefore, to give the participants an idea of how an automated self-monitoring health app, a basic non-interactive mock-up of a mobile health application was designed using Figma2. It is shown in figure 2. The main intention to use the mock-up was to give the respondents about the non-interference of a healthcare professional, and self-measurement with an automated response rather than the app design, features, or functionality. Existing digital health applications were not considered to be used, one reason each of the apps focused on only one health parameter like diabetes or BP. Also, to answer the research question, this mock-up could help the respondents in one way to quickly identify which specific age or patient group might benefit and the speculated challenges in the implementation or usage of such apps in the future.

2h[ttps://www.figma.com](http://www.figma.com/)



**Figure 2:** Non-interactive mock-up of an automated self-monitoring mobile application (slides in the order of 2,3 and 4 from left to right)

### Presentation of the mock-up

This was done using Microsoft PowerPoint. Slides 2,3 and 4 had the pictures as shown in Figure 2 on each of the slides along with the presented text below.

➥ Slide 1: Basic functionality of the designed mock-up.

**–** Assuming that the application (non-interactive mock-up) works on a smartphone. It is designed with artificial intelligence and efficient algorithms. There is no intervention of a healthcare professional at any stage while using the app.

➥ Slide 2: After login, users can view the last test took date and the next scheduled date along with the recommended set of daily activities.

➥ Slide 3: The user enters the data manually or data automatically fed from the connected devices via Wi-Fi or Bluetooth.

➥ Slide 4: Based on the current health data, automated voice response or textual feedback is given to the patient. Also, the change in progress trends compared to the last test with few suggestions for improvement can be viewed.

## Data collection and analysis

Semi-structured interviews were used for data collection in this study. Data collection began on April 30th and ran for two weeks until May 17th. Digital interviews via Zoom or Microsoft Teams were scheduled with 9 respondents. One advantage of a digital interview is the possibility to get detailed replies with a clean transcript, there is an offset in spontaneity (Bryman, 2012). Obtained data were transcribed verbatim to maintain transparency and avoid translational error. The thematic analysis approach was used to analyze qualitative data as shown by Bryman (2012). Categorical constructs identified as codes were obtained by a thorough reading of transcripts to capture the specific themes that emerged from the questions in the interview guide.

### About the participants

Healthcare professionals who work as doctors at hospitals and primary healthcare centers (PHC) in VGR were chosen for this study. One reason for this particular selection group is to better understand the current healthcare system in VGR, another interesting reason is that few respondents are still in their training phase toward specialist competence (Residents), while few of them work as specialists in their domain. The professional background of each respondent at the time of the interview along with the interview length is presented in table 2.

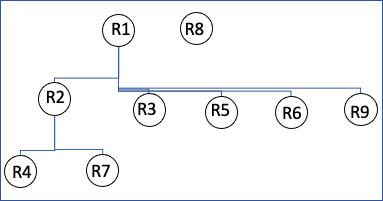
**Table 2:** Respondents and their professional background

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Respondent 1 (R1) | Resident doctor in Geriatric medicine, works with elderly fragile patients in the age group of 65 and above. | 53 min | |  |
| Respondent 2 (R2) | Emergency care specialist, also involved in innovation and technology areas. | 37 min | |  |
| Respondent 3 (R3) | Cardiologist mainly focuses on intensive care. | 26 min | |  |
| Respondent 4 (R4) | Junior physician, works with internal medicine, psychiatry, surgical department, and General Practitioner (GP). | 33 min | |  |
| Respondent 5 | Resident doctor working with primary healthcare | 32 | min | (8 |
| (R5) | center. | min | break | in |
| between) | | | | |

|  |  |  |
| --- | --- | --- |
| Respondent 6 (R6) | Resident doctor, works at a primary healthcare center, specializing in General medicine. Involved with patient care of different age groups. | 25 min |
| Respondent 7 (R7) | Resident in Family medicine, works at a primary healthcare center. | 37 min |
| Respondent 8 (R8) | Medical advisor, Family medicine specialist, works at the primary healthcare center, involved with home visits to elderly age group. | 53 min |
| Respondent 9 (R9) | General practitioner, works as a part of the mobile team, mainly involved with home visits to the elderly population and emergency care. | 45 min |

### Sampling

The selection of samples for interviews was based upon Snowball sampling, a feasible approach for qualitative research strategy. Snowball sampling is one type of non-probability sampling where the researcher makes initial contact with a set of respondents relevant to the study and then further contacts are provided to conduct the research (Bryman, 2012). The representation of respondents for this study is shown in figure 3 with R1 and R8 being the initial



**Figure 3:** Snowball sampling representation of respondents

contacts. Furthermore, interviews were stopped when reasonable insights were collected to avoid information redundancy with too much data collection.

### Semi-structured interview

Bryman (2012) argues that semi-structured interviews give the respondents a good amount of leeway to respond. Moreover, the list of questions or topics was not followed in the same order during each interview. Few additional questions that were not present in the interview guide (see attachment 1) were also raised based on the interviewee’s response. However, it is to be noted that, there were not too much of deviations in the questions because questions were rephrased with synonymous words. All the interviews were conducted in English to avoid any errors during translation.

### Kind of questions in the interview guide

The interview guide (see attachment 1) was framed based on previous studies and with the kind of questions that could be used during a qualitative interview (Bryman, 2012).

* + - 1. **Introducing questions:** Respondents were asked about their professional background and a typical work day at the hospital.
      2. **Direct questions:** Post presentation of the mock-up, respondents were asked whether this type of app would be recommended to patients and for which age group.
      3. **Indirect questions:** This was more related to the research question which discussed potential barriers, challenges, and enabling criteria to use such apps.
      4. **Structuring questions:** Questions related to their day-to-day workflow changes on the usage of these types of apps, organizational challenges, and consideration of technical aspects.
      5. **Interpreting questions:** Respondents were asked to interpret the responsibility shift due to this digitalization.

## Ethical considerations

Bryman (2012) shows that while conducting social research, ethical issues may arise at several stages. Core issues like how the researcher should treat the research participant and certain activities or circumstances that make the relationship between the researcher and the respondents be involved or ignored should be carefully looked upon. However, four main ethical principles are to be given high importance while conducting social research (Bryman, 2012). This can be related to this study as outlined below.

1. **Harm to participants -** As the interview was conducted online, neither physical nor emotional disturbances were caused to the participants.
2. **Informed consent** - A clear verbal consent was agreed upon between the researcher and the respondents before the start of the interview.
3. **Invasion of privacy** - Participants were informed that the data collected would always remain anonymous and the transcription process also. Also, the participants were informed about their right to withdraw their participation at any moment during the interview, which would not lead to any negative consequences.
4. **Deception** - The purpose of the study was clearly stated, However, too much detailed background information and research question was not directly asked to

avoid participant bias towards the research area. It was intentionally followed to bring genuine thoughts and feelings toward automated self-monitoring health apps.

## Evaluation criteria

Two primary criteria to assess a qualitative study in a social research setting have been proposed. One is trustworthiness and the other is authenticity (Bryman, 2012). Given below four criteria contributes to the trustworthiness of this study.

1. **Credibility -** The findings have enough feasibility to understand the context of the thesis and can be assured that the research has been conducted with good practice. This criterion implies that the interviewer has understood the social world correctly.
2. **Transferability -** Here, a thick description of the findings acts as a database to judge the findings where the knowledge gained from the interviews is transferred from one social setting to another.
3. **Dependability -** Complete records of the research process right from the initiation have been placed in an accessible manner.
4. **Confirmability -** It can be strongly argued that the interviews conducted did not have any personal values or theoretical inclination in favor of acceptance or rejection of automated self-monitoring apps.

**Authenticity -** This study aims to confide with different viewpoints among all the respondents which can help to converge on a better understanding of the same throughout the study. Additionally, it can be told confidently that this study might open for future research work.

# Results

## Experience with patient self-monitoring

Question 3 in the interview guide was posed to each participant to give an overview of their attitudes toward their current work experience. The first choice among most of the respondents was self-measurement of Blood Pressure (BP) except Respondent 3 who mentioned no practical experience in the workplace. Respondent 1 mentioned not having personal experience with patients but had an experience of self-monitoring in the Emergency Room. Other health parameters that were identified were body temperature, pulse, weight, breathing activity, and sleeping behavior. Usage of smartwatch, apple watch, insulin pumps, and recommended BP monitors from Primary Healthcare Center (PHC) were some of the technologies widely used among their patients as mentioned by doctors.

Respondents 2, 8 & 9 very clearly mentioned about the *white coat syndrome* was prominently noticed among their patients in their presence, but self-measurement at home or in their absence was normal. Respondent 6 specifically mentioned about Chronic Obstructive Pulmonary Disease (COPD) and CHF patients were supposed to avoid home monitoring. Table 3 presents some of the respondents’ previous experiences with patient self-monitoring of health parameters.

**Table 3:** Previous experience with patient self-monitoring among doctors

**Respondent 2** “ *Either they have very high blood pressure, they stayed home and then they come in here and it’s normal, for example, but it can also be the opposite, that we take a blood pressure here and it turns out to be very high. And then they were home, they would say no, it’s a low and that I would say is more common. And of course I mean part of that is explained by science that what they call the White Coat syndrome...*”

**Respondent 6** “ *I think the patients check their temperature and if they have fever, they, they put a very high value on it. If they have fever or not, they usually they say that, oh, it’s normal for me to have such ..... And now I have 37.6. So it’s fever for me. And they’re very, they’re conscious about the temperature, but they rarely think about things like breathing frequency or pulse. I think that’s quite normal, but we don’t have any at the primary healthcare center, we don’t monitor the patients, if we have chronic patients with chronic diseases, like COPD, or CHF, we don’t monitor them at home, which we maybe could.*”

## Themes

Empirical data of this study that has been collected from the interviews are presented in this section. Firstly, previous experience of doctors with patients' self-monitoring is presented with their reflections with relevance to their personal experiences (see 4.1). Followed by the presentation of the mock-up (see section 3.3.1), questions that were raised during the interview (see attachment 1) are presented with overarching themes as each subheading within this section (see 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5). Lastly, doctors’ perspective about the future role and additional comments that were given at the end of the interview pertinent to automated self-monitoring eHealth applications is presented (see 4.2.6 and 4.3).

### Variation in acceptance criteria

After the presentation of the mock-up, the immediate question that was posed to all respondents was about the age group that comes to their mind who could find it useful. Few respondents gave their thoughts in terms of app design and its related functionality and usability. Few respondents thought in terms of the patient group and expressed their views. Respondents 2,4,7 & 9 spoke about the ease of usability of technology for the younger generation and elderly patients who might have some difficulties with technology-related issues.

*“Maybe the younger age group. It might be difficult for senior, like 75 plus you have different user profile of smart devices. So maybe they have a bit harder to understand and to use this. So /..../ from young age until like 55 ish. I think that would be a nice group. And of course, people older than 55 could use the app of course.... ”* **(Respondent 4)**

Respondents 2 and 8 had no differences in patients' age group but mentioned that anyone who is acquainted with the technology should be able to use the apps without any difficulty. On the other hand, respondent 7 confidently expressed his thoughts clearly about healthy patients don’t need any such apps.

*“.... really depends on what kind of measurements you’ll get from them. But of course, it will be much easier for the younger people to use it, of course, but at the same time, it’s the older people that get its benefit, not the younger ones in that regard. I would ... use them for older patients. As a health professional, I see the use for it may be more in the older patients.”* **(Respondent 8)**

Respondent 6 voiced her opinion for chronic patients and the age group of 70 and above who are active, but such type of apps is not required for people who go to work as they keep up with the daily routine.

*“Yes. For chronic patients, I think it would be good. I mean, patients with chronic diseases like diabetes type two, or congestive heart failure, and it seems like it takes a bit of time to follow ... maybe for patients who don’t work anymore. But sure that, I think for some patients that would be good support ....patient group maybe 70, 70 plus, people who are still active and, and can go for walk and still have good control over their chronic diseases could be a very good suggestion.”* **(Respondent 6)**

Respondent 9 was skeptical in the beginning but based on her professional experience and day-to-day workflow, she expressed that, it would be preferred for patients with age around 95 with dementia (but the app must be simple with not too much information), patients with diabetes and patients who know how to take care of themselves. She also

stated that this type of app would be highly efficient for patients with heart failure when the apps give information about their weight gain and are helpful for patients with BP also. Respondent 1 did not express anything about their age but mentioned that the app might be helpful for patients with diabetes. The duality of the app acceptance between patients and the healthcare system was also mentioned by respondent 1. Respondent 5 plainly expressed the need for more studies to validate such apps.

“ *it’s hard to say because that really depends on which patient I have in front of me*

*.... it’s a good way for me to see in which time did the patient take the medicine. And*

*it’s too much information for 95 year old with a mild dementia or something like that to cope with all this information. And sometimes we have patients with a lot of anxiety and things like that, that then it could be hard because you can say you have a little bit high*

*blood pressure, maybe it’s something wrong. But I think the patients that are normally taking care of themselves, they can understand that ’Okay, today have to take some more insulin or something like that, because it’s not that good or things like that, I think this patient could have a lot of use of it .... And I think like blood pressure and I think as well like pulse or things like that if I have patients that I want to like see for weight maybe it’s a good one as well. These patients with heart failure ..... that are tied with weight, I think I could say like ’okay, you take an extra tablet when you have the weight of 59 kilos.*” **(Respondent 9)**

### Perceived benefits

After the discussion of age and patient group, participants were asked to express the improvements that could be foreseen when automated self-monitoring apps are recommended to their patients. All the doctors highlighted patients who get themselves more involved with their care routine, are more conscious about their health data and are aware of any deviating health data except respondent 5 who requested a good number of studies to check reliability and validity. Respondent 1 also mentioned that when patients get to know about their health status, they feel safer and more controlled and patients with chronic diseases have a better plan when to contact their doctors.

“*Yeah,... There are potential benefits, and that they feel safer, more in control of the disease, and potentially more interested or, more knowledgeable about their disease, as well.*

*... the other way around that I that I can’t really say. ..... they don’t have to go to the, to the caregiver to make certain tests. And maybe in a perfect world, they can, because nowadays, if you have a chronic disease, they always have some kind of contact plan, like yearly visits or things like that. And then of course, in a perfect world you can make or if the patient wants or doesn’t have the need to meet the caregiver, then they re- ally don’t have to, and you still can know that the patient has control over the disease,*

*because that is like a problem. Now if you don’t go to the caregiver, or if you skip your yearly visits, that is often a sign that you don’t so much care ... maybe have bad compliance for the medication and maybe that this group that could benefit ...* ” **(Respondent 1)**

Respondents 1, 6, and 9 mentioned how apps can improve medication compliance among their patients and stay on par with their good routines like recommended physical activities. Respondent 9 gave her opinions about the app design initially but later said that patients get self-engaged in using such apps.

“*... we know for sure that the adherence to medications is low. I mean, among patients with chronic diseases, I think physical activity in order to, to prevent for, for the diseases and in order to, to keep their diseases under control.. / / patients remember to*

*take their medication and remember physical activity, that would be, I mean, it’s absolutely needed in society.../. / I mean, if they could use an app like this, that reminds them every*

*day to keep their good routines.*” **(Respondent 6)**

“*yeah I think so. Because if you have like a bigger screen not just a small smartphone a bigger screen and you have like some like not so many different things that you should follow, I think that’s really good ... I think they can feel self-engaged* ” **(Respondent 9)**

From a wider perspective, Respondents 7 and 8 spoke about how patient data can be a valuable source of information for doctors.

“*Yeah. But I think that would be what kind of measurements you will get. For example, for diabetes patients, for me, it would be great, if they could measure ... that it’s possible to measure. And they will, of course, know the sugar in the blood.... Yes. And if I, for example, get that information directly to my computer. And they can just send it to me. Yes, it’s perfect. So when we were talking to phone, I can see exactly how the glucose levels look like over the day of the day, that is very useful. Depends on what kind of measurements to get. It’s more of a matter how the information goes to me. And ....when I see the patients on my computer ... get blood pressure directly into the journal, that would be great for me. Now, that’s not possible either ... need to manually write it from the patient’s recording to the journal.. So that would be great. I think the improvements would be our information goes from a patient’s device to my journal. If that could be automated, automated somehow. Great for me, I think...* ” **(Respondent 8)**

### Potential barriers to adoption

Every digital application has some ups and downs when it comes to adoption and adaptation. Given this, doctors were asked to express their attitudes on what might be a

potential barrier that can make the patient not use such apps or may limit their usage. Quite a good number of mixed responses were collected during the interview. While digital literacy in relation use of smartphones and other technology-related issues was considered a major obstacle among respondents 2, 4, 6, 7, and 8, there were other notable factors also.

“*I think if they don’t have a smartphone and if they have a smartphone, but they’re not using it too much, maybe an 80-year-old, if you’re 80 or 85, you might not be super smartphone focused, that might be a reason. And also if it’s too complicated, if you need to engage much in this application every day, several times per day, that would be maybe an obstacle. If you need to provide data by yourself, it could be an obstacle.*”**(Respondent 4)**

“*Well, if they are digitally illiterate, I think that’s a term if they if they are used to using smartphones or digital tools, that will certainly be a problem. If they are unmotivated, the overall they want to live their own lives, they want to smoke as much as they want, and they want to eat whatever they want, then maybe an application could work, but there has to be some kind of motivation. Otherwise, it will just give them more bad conscience or they will just not care about it at all. So that is probably two situations where it could be hard to get any results.*”

Interviewer - What I understand is like these type of applications may also interrupt with their freedom of choice to live, eat, and with their lifestyle?

“*Absolutely*.” **(Respondent 7)**

Respondent 3 did not mention digital competence but highlighted that it purely depends on the patients’ interests and those who already use a smartwatch might be hesitant to use such apps. Additionally, on using these types of apps over time, patients might not be very keen on focusing on the data no matter how it is, it just becomes a normal part of their life.

“*Well, I think it will be based on an interest or .... patients have to see that this is something that I’m interested in and want to do. So I don’t think all patients, some patients do not want to think about their health status, they just want to live as if everything is good. And if it’s not, they will be aware of that because they will not feel good. So for some patients, it might be good and they will like to use such device seeing some people ... it’s interesting to wear a smartwatch and they have the health applications running on their smartwatches.. some patients turn on to these applications when their smartwatch is off because they’re not interested and don’t want that information. So it’s very much dependent... what kind of person you’re dealing with, I would say. But I think it will be more and more patients are normal people that are interested in measuring their health status. Because due to what we are able to do with, for example, smartwatches it*

*will be similar I think a part of normal life to have a device that measures a lot of health data. And we’ll get used to that and get used on handling that and to not be worried about what we see. So I think more and more common will be thought of normal life for many people.*” **(Respondent 3)**

Respondent 1 looked on the other side such as patients who think that their symptoms are under control may not use it further and the feedback that the app provides may not be sufficient enough for patients with chronic disease.

“*.... there is always risks. And maybe sometimes the patient just should use it for a certain period of time, if they are worse in their disease and you want to follow or make sure that that is followed up and the patient is better than now, maybe they use it for just a while. And then when your symptoms are under control, you don’t have to use it anymore. Or if there is a chronic disease, the risk is always that you of course don’t see the benefit or don’t get enough feedback from the system, that you forget and ..... compliance, that is always a problem. .... certain patients doesn’t do as their as the healthcare suggests.*” **(Respondent 1)**

Laziness to use the app was pinpointed by respondent 6. Respondent 7 also gave additional thoughts about people who are not self-conscious by citing an example of smoking and their eating behavior might find unmotivated to use such apps. When the interviewer prompted that it would be seen as an interruption in their freedom of choice, respondent 7 agreed with the statement. Conversely, patients who think that smartphones have already invaded their personal lives may show some uncertainty to use apps despite the benefits. Respondents 4 and 9 gave their views on app design which might pose a possible barrier to use such as complicated design, the small size of the screen, manual entry of data, engagement with the app several times a day, and patients who have difficulty with their vision.

### Change in workflow

When it comes to digital health applications, there exists a relationship between the patient, patient data, and healthcare professionals. This speculates on how the apps can play a vital role to bring any remarkable changes in doctors’ workflow. Positive outcomes were spoken off by respondents 2, 4, 6, 8, and 9. Automated apps can help with remote monitoring, but if it goes in a good direction, they can replace the role of hospitals as well as primary healthcare centers in the future provided the apps are validated enough and doctors place their trust in the data, as mentioned by respondent 2.

“ *... in the short term, I definitely mean if we can trust the data that they give*

*us. Of course that could have a big impact how we treat patients because in many cases we don’t have to do tests in hospitals, then we can just trust the smartwatch or whatever...... I mean, when it comes to again to the Apple Watch and stuff, I mean, they’ve done a lot of research. I know as especially in the States and stuff like when it comes to. So .... I think we are pretty close. The next step I think see in this is kind of when we were able to connect all these sensors and all that to our healthcare system. So we kind of can remotely monitor patients for example stuff like that. That’s when it starts to get really interesting in course because then we kind of hate to help patients in real time. Over time, of course, replacing the role of hospitals and also and primary care So, I see enormous potential, of course, when it comes to this over time.*” **(Respondent 2)**

Respondent 4 spoke vibrantly about how symptom-specific information can lead to closer follow-ups with the help of data transfer. Respondent 8 also expressed how doctors can become more effective, when they already have the data which can save their time by reducing healthcare visits, at the same time spare resources also.

“*we can also become more effective, For example, if the patient has their own measurements, already needed ... Great for us to save time ... spare resources*” **(Respondent 8)**

While respondent 9 talks about a typical day workflow that involves more home visits, usage of these apps can reduce in-house visits with the help of information that is collected from the app. She also mentioned the network issue that she often faces while visiting patients at home.

“*I think that should change a little bit. Like now, I if we are uncertain, I have to go with one of my nurses like doing a visit the day after or two days after. Maybe we could have this, Check through that instead? So I think it could change my work. Yes, I think it could reduce our visits sometimes, in some cases. And maybe it could also change the things we do. Like if you have to say it again, because it’s easy to have that example, and like the blood pressure. It’s really high because they are nervous and the doctor here and things like that. And then they check it by themselves for a couple of days in the middle of the day. I can see okay, it’s okay when I’m not there. It’s better so ever to do anything, a lot of things or maybe it’s too low when I’m not there. That’s why they are falling and things like that. So it could maybe, I can get some more information I think.*”**( Respondent 9 )**

Respondent 6 instantly pointed out that this can enhance the prescription of medication at a faster rate when there is a deviation in the health data reported through the app, and also pointed out that doctors need not be as initial point of contact, instead nurses can be the initial point of contact to overview the health parameters and advise. This can further

help with patients who are already deteriorating.

“ *I think we, know for sure that the adherence to medications is low. I mean, among patients with chronic diseases, I think physical activity in order to prevent the diseases and in order to keep their diseases under control. So of course this is I mean, the way the act looks at if it can help patients to, to remember to take their medication and remember to do physical activity ...... it’s absolutely needed in society. So this is, I mean, this is what we try to remind our patients about, but we see them maybe 2, 3, 4 times a year. I mean, if they could use an app like this, that reminds them every day to keep their good routines. I mean, I think it would be absolutely....It would save time for patients and for us.*” **(Respondent 6)**

Respondents 1 and 3 were very neutral when they gave their concerns while the former response was more about dependency on the patients' group that use and the latter viewed data as a piece of objective information that can either be good when combined with the patients' history but bad in the aspects of reliability and validity respectively.

“*Yes, it could, because we get more, more objective and more and more information, more data when patients come to see us. That could be both good and bad, because we don’t know the reliability and validity of that data. But in combination with the patient history, that could be good. And it could also be implemented in the healthcare system, you could add on these kind of devices to what we use in the healthcare in healthcare.*”**(Respondent 3)**

Respondent 7 argued about how the information should be correct, relevant, and also on the feasibility of the user interface. This will deviate from the everyday task when data is manually fed into existing systems but enthusiastically suggested an option of automatic data entry from apps.

“*It depends a lot on the user interface for the doctor, would this information be directly implemented in my electronic health record, for example. Or would I manually have to transcribe everything from a piece of paper or from the block or something like that, it would take a lot of time and would not be feasible during under the current conditions. But if it would be automatically downloaded into them, an electronic health record, it could be of great use. It could also, of course, be a question of data overload. So there is a question of how to filter the data in the case of the patients. We cannot go through like the blood pressure for each day, during the last half-year, I will not have time to see any other patients that we see, that is also a question I think, for the doctor to not be overloaded with information, but the information that we get should be correct and relevant. We’re*

*not artificial intelligences, we cannot handle big data, fortunately.*” **(Respondent 7)**

Respondent 5 did not wish to give any opinions related to this question.

### Technical and organizational challenges

In the context of current healthcare systems, it was interesting to know about the challenges faced by doctors in the implementation of this app. Although the question was asked about organizational challenges faced, most of the respondents related it to the existing EHR system. It can be argued that the centralization of the existing journal system in Sweden was an instantaneous response from respondents 1, 3, 4, 6, and 7. Accessibility of patient records between each region in Sweden is restricted and centralizing it would benefit the doctors but it’s a very time-consuming process and difficult to implement.

“*Yeah, a lot, as I said the data issue, who is owning the data? Is it within the healthcare? Is it the patient, is the company that provides the app? That is, of course, a very, very important thing to think about. Because we have thought about that too little, maybe not in the healthcare but in, like, in general, like, who owns our data online? .... then I think the organisation has to adapt and like centralize that or how to how do we handle all that data? And that I think, I don’t know how to do it, but it seems smart to centralise that in some way, on some level. Because otherwise, there will be too much for each caregiver or each individual to handle I think. Yeah, that is one organizational thing.*” **(Respondent 1)**

”*But to be implemented in healthcare, I think it must be connected in some way to our so called journal system*” **(Respondent 6)**

“*That’s probably the biggest problem I would guess. Not at least, not least, because the healthcare system and Electronic Health Record system is so diverse, I think maybe in all countries. Definitely in Sweden, we have a specific electronic health record that is also used in Sk˚ane, but it’s not used in any other part of Sweden. So if you were to sell this or implement this healthcare application, you would have to tailor it to each Electronic Health Record system, I would suppose it’s the question of procurement and all of that. I’m not an expert in those questions, but I would suppose it will take quite a lot of time, and it will be difficult and you will have to focus on different kinds of electronic health record systems ….*”**(Respondent 7)**

Other than this, respondent 9 who works in a mobile emergency team indicated that the technical system which she uses often disrupts the workflow at least two or three times a week. Sadly, she said that the reasons remain unknown when prompted

to further discuss what type of disruption and indicated that it would be nice if technical issues are fixed first before implementation.

“*...think, I should need to have like smartphones or things like that to, to have to give to the patients. But it doesn’t feel like it should be a big problem. But I can see what I have problems with my computer, I have one computer to have on with me in the car. And it’s like, two or three weeks times a week I had problem with not giving the smartphone to the patient, that isn’t a problem, but to have it to work. And who should look into that? I think it could be a problem..... Maybe they don’t have a smartphone or things like that. So we have to have, like 10 or 15 in the team. And I know that would be a problem today because a lot of problems with other things are technical. The systems I think maybe it’s not a big problem, I don’t know. It’s hard to get all these things working. Because it’s you can’t just text me. You have to see it like a secret system. Do you know when we had that, it’s a lot of problems between the patient’s home and I can’t explain it, I think in another way. And maybe the system would be easier when it’s an app, I don’t know. But nowadays, now it’s a big problem for me. My daily work but maybe that’s possible.*” **(Respondent 9)**

On the other hand, data that is handled by the app was a major concern among respondents 1 and 8. It was more about who handles and owns the data with legal, privacy, security, and ethical considerations in mind.

“*Yes, it’s probably quite difficult, I would guess because of the laws and who owns the data, stuff like that. The securities is that you can’t spare the data. So someone owns the data, whose data is it? Is it the patient’s data? Is it our data? Our guess it’s not that easy to do. The laws and also technical but I don’t think it’s impossible. Big organization and their data systems are wide and then they will come out even wider to include everything. So it’s technically demanding. But I don’t think it’s possible now. If you want, if you wouldn’t like to do, it’s impossible.*”**(Respondent 8)**

Respondent 4 with fresh, but little work experience in healthcare had a lot of expectations about existing systems. She wished that the systems were user-friendly and advanced and that any technical considerations should be well adapted to Sweden legislation.

“*It would be the different systems. So we have different healthcare systems in different regions and those are not integrated with each other. And that’s a really big challenge to have that. And also those systems we’re using are super old. They’re super old and not user-friendly...... It’s gonna be tough to integrate the different systems. It would be great if Sweden had a national wide same system, and it would be great if Sweden could develop it by itself and not buy it from another country, because when you buy the healthcare*

*system from another country, it’s based on that their country and their conditions. And we are providing healthcare but in a bit different setting organization focus. So it would be nicer to do things here. It would be nice to also be able to send the data from the app to the healthcare system in some way. It’s super not possible maybe, but I’m sure utopia, maybe”* **(Respondent 4)**

Respondent 3 implied about CE marking of the app before implementation and there are a lot of challenges that would take a long time.

”*well, if the app should be implemented in the healthcare system, that could be very much challenging, because that is a long story to deploy the app in the healthcare system itself, it would take too long, you would have to have this kind of app tested to see that it fulfils the criteria for CE marking and so on. And then it’s it must be decided that this is something to use in the healthcare system and it should be in competition with other companies that also have the same kind of medical device. You buy an app in the App Store or anywhere. That is something else that the person buying that app to decides for him or herself.*” **(Respondent 3)**

While all the respondents voiced out the existing technical challenges at the organization level, respondent 2 with a specialist background and quite a good years of experience brought out the cultural differences that exist within their profession. He remarkably told that few doctors who are old and well experienced never open to new technologies, instead of relying on the stethoscope and not the data. It is very important to make these types of doctors place trust in technologies and also the people who use them.

“*Yeah. I think there were several. I think one is kind of maybe a describe more in the terms of cultural .... kind of a barrier in the in the sense that I think a lot of physicians are hesitant to use technology that’s not trusted, not verified because it comes very close to kind of you know as has a doctor signs and being validated is something that’s kind of very close.*” **(Respondent 2)**

However, respondent 5 was not very keen to answer this question but he did mention that there are a lot of implications and needs more research.

### Future responsibility shift

This section is based on the opinions gathered when respondents were asked to reflect upon their future perspectives about the digital transformation with a timeline of 10 to 15 years. This could also be considered more of when a healthcare professional should intervene with patients getting adapted to automated self-monitoring health apps. Respondent 1 spoke about the limits that should lie with data sharing and data handling. He also pointed out whether the responsibility lies within all people in the society or is limited to a certain group or with healthcare.

“*... where is the limit?..... Well, I think that we are doing things now that could be automated But then we also have like, other things that we can take into account that*

*I haven’t didn’t mention it before, I think and that is like the primary or secondary. Like, prophylactic work or I’m thinking that if we get a lot of data about the patient, maybe that technique, we’ll be able to see patterns that we can see. And thereby, like, pretty risks of things, risk of stroke and in a better way than we can do now. But it’s, of course, 10 years, or more into the future? I think about that. That is very interesting. I think what things you can do about that with that information in, in prophylactic work? Where’s the limits? I don’t know, wellness and health... when does the responsibility of the common or all people in the society? Where is that line? And that may be affected?* ” **(Respondent** **1**)

From a broader perspective, Respondents 2, 4, and 9 were optimistic about such technologies. Respondent 2 stressed how this kind of new digital technology can empower patients to become smart about their illness. This might further renegotiate the relationship that exists between the doctor and patient. Remarkable differences in diagnostics will be noted, because not all patients need only medical decisions, sometimes a holistic approach is expected which can only be provided by doctors.

“ *Balance. How do we use technology in a smart way and kind of helping the patient and helping ourselves? And of course, empowering them. I don’t know, we don’t know the answers to that. That’s kind of something we have to have test away, I think partly, but in doing it in a safe way. I mean that’s kind of the trick* ” **(Respondent 2)**

Respondent 4 viewed digitalization as a support aid to doctors’ decisions, at the same time, cannot replace doctors or doctors’ assessments.

Respondent 6 gave a cautious sign of sensible implementation that could act as an educational tool to teach patients about what conditions are normal under different circumstances, one reason being a lot of patients are having difficulties reading their bodies.

“*I think within 10 years, for sure it will come, but it must be implemented sensibly. If the automated responses are good enough, healthcare personnel don’t have to reply every time that the parameters not normal, if their automated responses can take care of that, it’s fine. That would be good to, to teach people what’s a normal body reaction and, and*

*what’s not, what’s the disease. It would be perfect* ” **(Respondent 6)**

Respondent 7 described that doctors should adapt to this responsibility shift by transforming from being analytical to socially skilled professionals who can take the initiatives to assist patients pedagogically and also empathically.

“*Yes, yes, most definitely .... and one of the biggest questions may not be technical, but ethical. ..... So where would the responsibility lie? I think that the doctors will have to adapt from becoming very analytical to becoming more socially skilled in delivering, listen to the patients' understanding, the patient condition, making use of artificial intelligence and self-monitoring systems to analyse their specific conditions. And then, in a pedagogical and empathetic way, inform the patients on the best course of action*” **(Respondent 7)**

Respondent 8 had a very interesting view on how the organization is not affected but the shift needs to be managed, not by doctors though.

“*It could go either way.... Lately, that’s a shift where our responsibility is increasing and the patient’s responsibilities decreasing. And so if you’re going that way, in this matter to know that it will be our responsibility to gather the measurements to evaluate the measurements that the patient sends to us or will it be more that? ... And the patient has the responsibility to do what is needed to do with it? Or not? ..... It probably has some something to do who owns the data? I guess that the responsibility to act is associated with who owns the data. It will still be a thing, mostly between the doctor and the patient. It wouldn’t affect the organization much believed to a great extent I mean, probably someone would need to work with how to use all this data. Listen to us. And that might not be the doctors, someone else. But there is a shift.*”**(Respondent 8)**

Respondent 9 wished that such technological developments could help the patients to self-measure their health parameters like diabetes, and BP at home instead of regular physical visits to hospitals. This will help both the doctors and patients. But respondent 3 gave a strong notion of strict boundaries that exist and will exist between the patient and doctors' way of handling data. The responsibility lies within the patient to use the device and data handling and sharing but to follow up with the patient’s health parameters and how they use it is the responsibility of the doctors indeed.

“*Well, I don’t think it will, because there will be strict boundaries between what the patients are using themselves and what the healthcare professionals are using and the responses are responsible. I just see it as a device either for the patient to use for their own information collection or for the healthcare services for their information collection and when it’s*

*used as part of the healthcare system, the healthcare professionals are responsible for how it is used. And to follow up based on the on the data collection, and many patients use these applications and these devices, it’s the patients are responsible for handling the information.*”**(Respondent 3)**

## Other suggestions and recommendations about the study

This section has been written not as a theme but rather as value-added suggestions and recommendations from doctors about the study at the end of the interview. Respondent 1 was very keen to know about what happens with new responsibilities when new techniques are introduced which has an impact on their profession also. Care should be taken as there is always risks associated with technology, so that there is no harm to patients, as mentioned by respondent 2. He recommended that the trickiest part is maintaining the balance between the doctor and the patients. This is an interesting area for further research and development which would be faced with challenges of data sharing and handling, in the eyes of respondent 3. Respondents 4 and 7 highlighted the active involvement of healthcare professionals in such types of projects. With regards to the app design and features, respondents 2, 4, and 7 provided some valuable inputs like gamification of apps by using a reward system can attract more users and respondents wished that aggregation of parameters with progress trends would help with consultations.

Another interesting thought that was brought up by respondents 4 and 8 was about the anxiety, these types of apps could bring and patients must not lose their self-control. Despite the benefits that can be gained from these types of apps, patients who show non-adherence to medication or treatment may not find it useful, says respondent 8. But he also mentioned that self-measurement in the future and everyone should know how to deal with it. Respondent 8 clearly stated that there is a dual responsibility to act upon the measurement and evaluation of data. A scenario presented by the respondent about a previous eHealth implementation in PHC exemplified the careful analysis of adoption, where the company responsible was actively involved only during the development phase. Post-implementation, doctors faced quite a lot of difficulties while using the services and at one point in time, doctors took the entire responsibility to halt the services.

# Analysis and Discussion

This section aims to elucidate and discuss the correlation between the empirical findings from the previous section and the research articles that have been presented in section 2.

## Healthcare professionals’ perceptions of automated health

**monitoring applications**

The given subheadings under this section give readers a generalized overview of attitudes among doctors in VGR with foreseen emotional and behavioral changes among patients, acceptance level criteria, benefits, and existing and anticipated barriers that accompany the implementation of automated self-monitoring health applications.

### The difference in acceptance level

A similar pattern of variation in age factors has been observed in this study and previous research articles. Respondents 4, 7, 8, and 9 stated that younger people might find it easier to use, similar arguments can be found in research findings of section 2.1 (Fleddermann et.al., 2021; Grainger et.al., 2020; Hern´andez, Alonso & Barber`a, 2018; Kerst, Zielasek & Gaebel, 2020; Patoz et.al., 2021). This could be due to one reason younger people are already used to handling such technologies and often do not encounter any technical difficulties. But respondents 8 and 9 stood out in their views, by clearly considering their work experience and not in terms of app usability. Respondents 3 and 8 specifically mentioned that as a doctor, these type of digital applications would find their use in an elderly population. Respondents 6 and 7 made a difference in their views by expressing the redundancy of such applications with a healthy and active population. But both the respondents had a similar opinion that as age increases, there is a higher possibility of chronic diseases and obesity, etc. But respondent 2 compared his current work experience and that a lot of differences can be seen since his graduation (10 years ago) and everyone who knows how to use technology and is interested to use may not have any difficulty with these types of applications. The author agrees with this notion of technology acceptance criteria. A similar finding has been reported by de Vries et.al. (2018) who argue that patients who are familiar with the usage of health applications will not have any difficulties coping with new digital interventions.

Respondent 9 expressed her thoughts in terms of application design and usability. Given the technical constraints like this, Nguyen et.al. (2019) and Vallo Hult et.al. (2019) shows that doctors should be consulted during the design of such health applications, despite the involvement of IT people involved with design. Suggestions given by respondents 1, 4, and 9 by keeping the application to be simple at the initial stages and not very complicated design is also a welcoming approach. Another interesting aspect that must be acknowledged is the socio-economic status of people who intend to use it. When a person has a lower economic status, it may affect the acceptance level as mentioned by respondent 4. This could be related to the usage of ICT tools to monitor CHF patients where cost was also considered as one of the factors in adoption by Gund et.al. (2012).

But, from a societal perspective, Carlqvist et.al. (2021) argues that each patient varies with their unique needs and preferences and it is not the responsibility of the public healthcare to fulfill the need of individual patients at each stage. But technology can be simplified and patients with chronic diseases might get the maximum benefits (Carlqvist et.al., 2021). Carlqvist et.al. (2021) proposed an alternate solution by involving the private sector as digital technologies steer clear of the geographical boundaries. Also, the expected risk of creating inequalities within the society expressed by respondents 3 and 4 should not be avoided.

### Behavioral and emotional changes in patients

On a positive note, doctors reflected upon behavioral changes such as self-awareness, self-control, and self-consciousness of their health that can be brought out by automated health applications. Changes in their lifestyle can be improved. This can be related to the research findings by Nguyen et.al. (2019), Bradbury et.al. (2017), Grainger et.al. (2020), Gund et.al. (2012), and Nielsen et.al. (2020). But a notable difference that was indicated by respondents 6 and 9 during this study was adherence to medication and laziness to use these apps which were missing in the reviewed articles. Anxiety-related problems due to the enormous amount of data or the signals that the app notifies the user and patients who lose self-control was reported by respondents 4 and 8 when patients view their health data. A similar pattern of anxiety was reported in 2.1 (Carlqvist et.al., 2021; Grainger et.al., 2020; Kerst, Zielasek & Gaebel, 2020; Patoz et.al., 2021). However, the author agrees with the opinion of respondent 6 who mentioned that these apps should rather serve as an educational tool to tell them the difference between normal and deviated health parameters. She also stated that the biggest problem is patients are not educated enough and suggests for repeated training sessions be given by the healthcare. This approach could alleviate the anxiety problem and get patients back to normal life.

### Current and anticipated impediments to adoption

Based on the experience of each personal and professional experience, subsisting and forthcoming challenges by doctors will be presented in this section. Few solutions that have been indicated by authors of reviewed articles have also been discussed. The biggest impediment that was highlighted among most of the respondents was the centralization of the current healthcare system. Respondents 2, 3, and 8 with specialist backgrounds gave a hint that it might take a long time to achieve this, but the forthcoming benefit of data sharing and transfer between the patient and HCPs can be made easier irrespective of the geographical divide. It is worth mentioning at this point about the current technical system is not on par with advanced digital technologies respondents 4 and 9. Although it can be commented that these two aspects form a basic prerequisite criterion before implementation, this might

seem to be a success factor that can be achieved over time and benefit both the patients and the healthcare system.

Respondents 1 and 6 pointed out the temporary usage of such applications by adhering only to a certain period until there is a difference from worse symptoms to better symptoms among patients. Patients being not very ambitious and non-recommendation of these apps by doctors to patients by respondents 7 and 8 respectively can also be seen as one of the impediments. But the author would like to cite an approach shown by Fleddermann et.al. (2021), where the involvement of a healthcare professional with the app has a probability of patients to adhere with the apps also. But apps can get the maximum benefit when combined with treatment rather than using it as a stand-alone approach as shown by Nguyen et.al. (2019). A similar approach was pointed out by respondent 3 provided doctors place their trust once the app confines with the medical standards of reliability and validity as mentioned by respondent 2. While additional training sessions were shown by Fleddermann et.al. (2021) and Nielsen et.al. (2020), it does have an impact on the workflow, where few doctors mentioned it as an additional workload and time-consuming process argued by Carlqvist et.al. (2021) Fleddermann et.al. (2021) Grainger et.al. (2020) and Vallo Hult et.al. (2019) also.

The second most spoken of the barrier by doctors was digital competence among patients by respondents 2, 4, 6, 7, and 8. The author of this study argues that Sweden is one of the countries in the U, with high eHealth indicators. This higher score is directly proportional to the progress and development of the digital economy-related to eHealth. Internet usage rate among the older population stands at 80% in Sweden topping among other EU countries (Tavares, 2020). With an acceptable digital literacy rate and high eHealth score, proper planning of the same can overcome this impediment. Future benefits of automated applications being a support aid in combination with doctors’ assessment assessments as indicated by respondents 2, 4, 6, 8, and 9 outweigh the technical and non-technical constructs that can be seen as impediments. However, the holistic approach and the relationship between the doctor and patient should always be well-maintained as denoted by respondents 2 and 5.

Impediments can be overcome by step-by-step careful adoption and over time can be seen as progress. As rightly said by George Orwell,

*“Progress is not an illusion, it happens, but it is slow and invariably disappointing”*

### Organizational and workflow changes

Despite perceived benefits and potential barriers to adoption, there exist some organizational structural changes where the need for an IT or Health Informatics expert is required for data handling and imparting knowledge about data to patients. Respondent 6 explicitly discussed the ability of a nurse to handle the data and advise unless there is a real need for the doctor to intervene and deal with medication. She also mentioned that it would be great if there is some person who can teach the patients about normal and deviated data (i.e., health parameters), it could help patients not to worry too much about their own body (anxiety). While respondents 1, 4, 6, 7, and 8 did always mention the difficulties encountered due to data overload, and that it should not interrupt their daily workflow also, respondent 7 provided a feasible solution that can be used in the Swedish healthcare system. *Assistant nurse*3 who are less skilled than a nurse can help doctors, nurses, and patients when training is imparted to them about the digital application and its working to work with the data.

On the contrary, respondent 8 predicted the future responsibility shift and some person has to be involved when it comes to data handling but felt the uncertainty for additional training to patients or doctors when prompted during the interview. The reason is people are well acquainted with technologies. Only one article suggested that any change in the organizational structure or protocol in connection with physicians’ work was considered an impediment during the digital app implementation (Fleddermann et.al., 2021). Be it an initiative from the public or private sector, Han, Subramanian, and Cameron (2019) emphasize the need for step-by-step adoption of mHealth which acts as a linkage between old and new healthcare systems.

While some sort of neutral resistance was observed during the interview, where doctors neither completely rejected the adoption of new technology nor showed their willingness to use the health application to its full potential. Respondents 4 and 6 suggested their views on app efficiency to provide automated feedback, it might not be a disruption to the workflow, thereby helping healthcare professionals to minimize their interaction with the app or active monitoring of patients. However, these findings do not override the advantageous factors noticed among healthcare professionals such as preparedness before a patient’s consultation, better contact plan, and improved dialogue collaboration mentioned in sections 2.2 and 2.3 (Bradbury et.al., 2017; de Vries et.al., 2018; Hernández, Alonso & Barberà, 2018; Kerst, Zielasek & Gaebel 2020; Nguyen et.al., 2019; Nielsen et.al., 2020). That being said, the author of this study argues that the adoption of automated self-monitoring health applications may prove to be fruitful if the systems are better aligned

3undersk¨oterska in Swedish as told by respondent 7

and a well-defined change management process or strategies with required support at each stage from the concerned departments that can be utilized to create a safe environment. To be precise, when there is an unwillingness to adopt innovative eHealth solutions and integrate the same in the workflow, it cannot be considered disruptive.

# Future Research

This was a pilot study based on the collective subjective measurements of the respondents during the entire study. Several factors such as the mock-up design, workplace environment, and the questions posed during the interview could affect the respondents' thoughts and feelings. Although few generalizations can be made concerning perceived benefits, potential barriers, and age group, it would be interesting to know about healthcare professionals’ opinions on a specific patient group. Also, intriguing trust factors related to the reliability and validity of such health applications as mentioned by doctors during the interviews would be something important to focus upon. It would be informative for future researchers to know about the efficient ways to overcome the technical and non-technical barriers to the implementation of these types of digital interventions. Lastly, as one of the respondents asked, “Does it help the patient and does it help the healthcare system”, future studies may give better insights.

# Conclusion

This study was conducted to capture the healthcare professionals' thoughts and attitudes towards automated self-monitoring eHealth applications along with the risks and benefits associated with it. This by letting the respondents express their previous experiences and later proceeded with the interview based on a mock-up. The results indicate beneficial factors among patients such as self-care, self-management, medication compliance and improvements in lifestyle were well thought off. Benefits associated with doctors can be linked to better contact plans, support aid, time efficiency, and resource utilization. However, as an organizational construct, the biggest challenge comes with the existing Electronic Health Record (EHR) system in the current healthcare model and technical systems. In general, respondents could correlate the health application-specific to an age group but not with a patient group. The study results also indicated the impact on workflow, organizational changes, and behavioral outcomes such as anxiety among patients. Although the benefits and challenges have been outlined in consideration of the individual, workplace, and society as a whole, it cannot be concluded that patients' benefits are relatively more highly perceived than the doctors or the other way around. Any digital intervention should not disrupt the holistic relationship between the patient and doctor.

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# Attachments

## Attachment 1: Interview Guide

✎ **Purpose:** What are the benefits and challenges associated with automated self-monitoring eHealth applications from a healthcare professionals’ perspective?

✎ **Location:** Digital meeting via zoom or Microsoft Teams.

✎ **Preparations:** Exact purpose of the study was not mentioned, but the only generic purpose was informed to the respondents to not reduce the validity of the responses and avoid certain influential thoughts during the interview.

✎ **Estimated time:** Approximately 40 - 50 minutes.

✎ **Method used: Semi-structured** interview.

### Interview process:

**A.Introduction and consent**

✎ Self-introduction with current academic background.

✎ Aims of the interview outlined.

✎ Logistical details outlined:

1. Recording and transcription of the interview.
2. De-identification of the responses, confidentiality, and security of information.

3. Withdrawal of consent and discontinuation of the interview at any time with

no impact on the respondent or profession.

4. Freedom to take a break or exit from the interview.

On complete verbal agreement of the above-stated consents, between the interviewer and the respondent, the interview will begin.

### B.Questions

The following questions were grouped by certain topics that were explored in the interview. These questions may vary from person to person. In addition to questions, generic prompts (like please brief on your experience, could you elaborate, in what way) were used to elicit more detail. Sometimes, the questions may have to be paraphrased what a participant has said to check to understand ( eg: what I understand is that.......). To avoid biasing in responses with participants, neutral language will be used when attempting questioning strategies. The questions listed below give an outline of the interview with key concepts indicated in italics.

✎ Could you give a brief introduction to your professional background?

✎ How does a typical day at the clinic look for you?

✎ Do you have any *experience with patient self-monitoring*?

✎ What do you think of patients who are more engaged with smartphone health apps? Let’s say they identify symptoms from the internet and self-measure their health data and approach you for consultation.

**–Presentation of the mock-up (see section 3.3.1** - The interviewer screen was shared.

✎ Now that you have a generic idea of the app, do you find it useful to *recommend* it to your patients? (Why / Why not?)

✎ Which *age group* of patients would you recommend using? Why was this group chosen?

✎ What *improvements* would you see in patients on the usage of this app without your intervention?

✎ Can you think of any *potential barriers* that limit or nullify the usage factor among patients?

✎ What *changes* could be foreseen in your *day-to-day workflow* on the recommendation of this app to your patients?

✎ Do you forecast any *organizational challenges* within the healthcare system in VGR on the implementation of this app?

✎ Would you like to briefly talk about *technical problems* that could be overviewed from healthcare professionals’ perspectives?

✎ In what way might this *digital shift* bring any remarkable change in *responsibilities*

for healthcare professionals in the *future*, let’s say 10 years from now?

✎ Is there anything else that you would like to add if I missed something important to know?

—————————————————————————

**End of the interview:** A thank you note to the interviewee.

# Peer review

### Topic: Challenges of adopting blockchain technology in Higher Education Institutions

The thesis gives an overall impression to the reader about a challenging and fresh topic in the digital world. It also provides valuable insight and I am convinced with the study's purpose. The abstract should invoke more curiosity to proceed the reading further, but well written. All the references need a proper Harvard style (refer to Elizabeth’s lecture in the previous course or University West’s library guide), but the references have been used appropriately in the text and the usage of references in the methods section needs to be highly appreciated. It shows that you have done a lot of studies and justified with the implied research approach. In this opposition report, the analysis of each section has been done in the same order as in the thesis. In addition to that, I have left comments in the PDF file. Further comments are added below to encapsulate the study for improvements.

* To make the whole reading sensible, try to use past tense in the whole study with a passive voice, as the study has been conducted.
* be clearer in your language and a few sentence structuring needs to be corrected. Either they should be fragmentized or use the correct formatting. Reading the text aloud by yourself or using the text-to-speech application in MS Word could help.
* All the formatting and typo errors have been highlighted in another pdf document. Is the list of abbreviations followed in any order? Going by alphabetical order may look good. (Include HE and MDPI)

**Abstract** - The abstract gives a crisp summary of the article with the aim and methods, but the findings and concluding remarks should be well related. A good selection of keywords has been provided to mirror the contents of the study.

**Introduction** - General background of the study has been presented with the problem background. While the aim and research questions form the core of the study, the limitations of the current study provided could be elaborated to give a clear picture.

**Method and material** - Fantastic representation of methods with the careful representation of figures and several articles to make the study reliable. However, please be specific with the search queries to give more transparency. Figure 1, 2, and 3 shows the reliability and credibility of the study. The literature review process deserves appreciation and the literature gap has been well-defined. Figure 2 can be renamed because the review process is different from the article selection process.

**Theoretical framework** - Table 1 gives a clear representation of the TOE framework with relevance to the study.

**Result** - The study results have been well presented with 14 themes about the theory. But how the themes match exactly match with the TOE framework awakens curiosity. The findings are well supported by respondents' quotes. But where is your analysis of the findings with the qualitative aspects of the study?

**Discussion** - The findings have been well related to the research articles used, but trying to be more clear and own perspectives might add more weightage to the existing challenges mentioned in the previous section. From a broader perspective, could you not relate this with another theory?

**Conclusion** - Well concluded but keeps the readers wondering why is this a conclusion? one suggestion is to be more clear and steer clear of confusion. Are the challenges of the adoption of a technology to be considered good or bad? why / why not?

**References** - Good usage of references and well claimed at appropriate places in each section.

### Questions asked in a seminar

**Abstract** - Do you plan to give some concluding remarks about your study?

**Introduction** - By internal process - what are you referring to? Make it clear by specifying what type of process you are referring to about blockchain in HEI.

* Do you have any limitations to be added in the intro section to your study?
* Blockchain characteristics (3.1.4) can be added before explaining about types (3.1.1
* 3.1.3), a lot of technical terms are used. The reader had to go back and forth to understand 51% of technical attacks, and decentralization before knowing what it is.

**Previous work** seems to be concise. is it due to a limited number of studies or any other criteria?

* Can you state the reason why the number of studies seems to be increasingly low? was there a technical constraint or adaptation to it in the IT world that was not welcomed?
* Also, do the included studies focus only on HEI? - How did you arrive at the themes - inductive or deductive analysis?

**Methods** - good to mention about the sampling - purposive or snowball or.. ? - semi-structured interview - ‘individual’ word should be mentioned at least in the beginning - while mentioning about the respondents, good to be transparent about the duration of each interview.

**Results** - I see the usage of numbers in a qualitative study, but in terms of a general reader’s perspective, mention the correct reference and what was the intention to represent the opinions in %. It is presented on how you achieved this but maybe a screenshot or a small transcription text could add value.

### Discussion

* To me, the discussion part was not very clear, I felt the need for more of your arguments or your opinions to be presented here, at least with 1 or 2 sub-headings, to give the reader a clear understanding
* I am confused about where you have presented your analysis - is it included along with the results or discussion? good to show the reader the respondents' qualitative aspects during the interview at least here or in the findings.
* you have already mentioned about TOE Framework and related that to your themes. do you think of any other theory that could be related to the whole study or with the whole findings? - why / why not?

### Limitations and challenges, Future work

* I am not convinced by the stated limitations. with 14 respondents, what was the need to attain more opinions or specify what could have been done to get the saturation of findings. Despite mentioning the interview and general details about the study, how can the geographical or time constraint act as a limitation in your study? - Justify it.
* Why do you see the challenge as a negative aspect? the word looks very strong, instead, try to shape the study by defining challenges in the other way. (of course, be neutral as a social researcher.)

### Final remarks

You did a commendable job on this study and deserve a pat on the back. The report shows your determination and keen interest to present a techy fresh topic beautifully. The overall comments and suggestions may help to enhance the precise reading, specificity, and flow of the challenges presented in the adoption of blockchain.

A big thank you for an interesting report. Wish you all good luck!