eHealth for all? Towards usable and effective ehealth services in different health care settings

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General Introduction

eHealth in a changing health care landscape

The health care landscape is evolving, which can be attributed to several key factors. First, the number of patients who need care is increasing [1]. Second, the care that patients need is becoming increasingly complex due to aging and an increasing number of chronic diseases, including obesity [2]. Third, due to high-quality health care, patients with chronic diseases also live longer, and thus, they have a growing need for care over their lifetime [3]. Beyond the impact of an aging population, there is also a greater emphasis on early diagnosis and prevention [3, 4]. Moreover, societal changes are reshaping the health care landscape, with an important shift toward the provision of care in non-hospital settings, such as homes and primary care settings. This shift is primarily driven by financial considerations and limitations in staffing [3, 4]. All of the aforementioned elements highlight the increasing demand for health care services as well as the need for transformative changes in the health care sector. This challenge is especially acute in primary care, where an aging population and a rising incidence of chronic diseases are leading to increased workloads. Consequently, there are risks of diminished health care quality, increased time constraints per patient (resulting in higher work pressure), and reduced access to health care services [5]. In short, these ongoing changes are creating an unsustainable situation for the future of health care; therefore, implementing the necessary changes is crucial to ensure the sustainability of health care [6].

A potential solution for making health care more accessible is digitization in health care (also called eHealth; see Textbox 1). Digitization has been growing in importance in society for decades. In addition, the COVID-19 pandemic improved technology in health care in both quantity and quality [7]. Factors including the changes in society and COVID-19 have increased patients' willingness to use digitization, be more in charge of their health care, and self-manage their health care [7-9].

The definition of eHealth according to Eysenbach: *"e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state of mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology. " [10]*

Textbox 1. What is eHealth?

In short, problems with the accessibility of health care, high work pressure on health care professionals, and a greater willingness to use eHealth reveal opportunities for the growth of digital solutions for managing health care. eHealth provides possibilities to reduce the work pressure in (primary) care, increase patients' self-management, and improve the accessibility of care. On the one hand, eHealth can support specific

processes of care delivery, such as digital consultations or online triage, enabling care to be provided more efficiently. On the other hand, eHealth can support self-management and reduce health care demand [11]. Some potential benefits of eHealth are provided as follows through various examples. One example is the Dutch website Thuisarts.nl [12, 13], a non-commercial website developed by general practitioners (GPs) to enable citizens to obtain reliable health information [13, 14]. Research has demonstrated that since the launch of the website, the number of 'normal' consultations has decreased [13, 14]. Consequently, the work pressure in primary care may be lower because fewer consultations are necessary. Another example is LIVA Health Care [15, 16], an international digital program with online lifestyle coaching to help people change their behavior. LIVA helps patients to self-manage their disease and takes over some tasks from GPs. Research has indicated that the service has a positive effect on users, such as weight loss in diabetes patients, with the potential to help with the secondary prevention of chronic disease [15, 17]. These two examples illustrate how eHealth has the potential to enhance various aspects of health care, including the facilitation of self-management through a variety of services, applications, and websites and increased access to health care services [8, 16, 18].

Self-management

eHealth is expected to play a major role in increasing self-management among patients and citizens [19]. A definition of self-management is provided in Textbox 2. Increasing self-management can lead to health improvements in chronically ill patients as well as reduce their demand for health care [11]. Especially today, where much pressure exists on primary care, self-management can help to bridge the gap between patients' needs and the capacity of health services to meet those needs [20]. In addition, it can lead to more accessible health care by matching the needs of patients (eg, the provision of online information) [21]. Noteworthily, while self-management is frequently discussed within the context of individuals with chronic illnesses, its relevance also extends to the broader population of healthy citizens.

The definition of self-management according to Barlow et al.: "*The individual's ability to manage the symptoms, treatment, physical and psychosocial consequences and lifestyle changes inherent in living with a chronic condition.*" [20]

Textbox 2. What is self-management?

Self-management focuses on education and information provision. When patients are well informed, they are better equipped to make informed decisions and adhere to their treatment plans. This, in turn, empowers patients to take a more active role

in managing their health conditions. The development of digital tools designed to aid patients in managing their health conditions could also prove beneficial for GPs. These tools can complement and support various aspects of a GP's responsibilities, ultimately enhancing the quality of care they provide. In short, self-management has the potential to enable patients to take greater control of their health and manage it or their disease more effectively. In addition, self-management can lead to increased access to health care services and a reduced need for frequent medical consultations and interventions, thereby alleviating the workload on health care professionals.

Currently, many eHealth services (hereinafter "online services") that support, empower, and help patients and citizens to self-manage their health (with or without chronic disease). However, online services are rarely extensively validated scientifically [16]. Oftentimes, developed online services end up in the metaphorical "Valley of Death," where many technologies end after research funding ends [22, 23]. This could be due to time limitations, resources, or policy [24]. Sometimes, online services are implemented but not researched, or they are researched in a research setting and not used in daily practice. The online services examined in this thesis have already been implemented or piloted in daily practice. Thus, it is possible to research them in real-life settings, as opposed to only theoretically. Consequently, they are less likely to end up in the Valley of Death.

Challenges to the usability and accessibility of online services

Scientific research could contribute to the investigation of (a) the efficacy of online services; (b) the alignment of their intended purpose (ie, do they do what they are intended to do?); and (c) the impact of these services on quality health care [16]. Other reasons to scientifically validate online services are user-centered – namely to increase reliability and overcome barriers for users [25]. Some known barriers to the use of online services for users are security problems, low usability, and complexity [25, 26]. Addressing such barriers before such services are implemented on a larger scale can increase their usability. The usability of an online service for health care professionals is equally significant when it is deployed. The online service must fit within the organization and in the daily routine of the health care professional [27].

Accessibility also presents a barrier to the adoption and utilization of online services. Due to factors that influence citizens' access to online services, their use can exacerbate disparities in health care access [28, 29]. Differences in people's educational level and age play roles in their use of online services [30]. In general, higher age and lower educational level result in lower use of online services [28, 30]. Although older people who use online services are increasing in number, they remain the group that uses online services the least [28]. Moreover, income is a factor that contributes to the use of online services; that is, low income leads to fewer possibilities for Internet

access [28]. To ensure that online services work in practice, they should be accessible to everyone and not increase health care differences.

All of the services examined in this thesis are researched as services in real-life settings, which makes it an interesting and relevant study. On the one hand, it is imperative to examine whether online services fulfill their intended purpose. On the other hand, ensuring that the online services are practical, user-friendly, and used as intended is also crucial to this thesis. This thesis aims to collect additional insights regarding the characteristics of online service users and their experiences. It delves into the usability of the various services across diverse patient and citizen groups in various health care settings. The online services researched in this thesis have the potential to empower patients and citizens by enhancing their self-management capabilities and supporting health care professionals in their daily efforts.

Thesis objectives

The general objective of this thesis is to investigate whether different online services that offer direct access to care are usable, effective, and safe for patients and citizens for self-managing their health care with or without the involvement of health care professionals. Chapters 2 through 5 specifically investigate the use and usability of direct access to different diagnostic test services (in)dependent of a health care professional. Then, Chapter 6 specifically investigates the effectiveness of an online self-management and support tool for asthma and chronic obstructive pulmonary disease (COPD) patients supported by health care professionals.

Thesis outline

This thesis primarily focuses on evaluating online services for enhancing self-management among patients and citizens through various online services. What unites all of these online services is their shared objective of assisting patients or citizens in effectively managing their health and/or disease.

The remainder of this thesis is organized as follows. Chapter 2 presents an overview of methods available to patients for direct online access to diagnostic testing and results independent of a health care professional in primary care. This systematic review includes studies that have focused on digitization in one or more phases of laboratory diagnostic testing, namely (a) triage and advice on diagnostic testing, (b) testing itself, and (c) the communication of test results.

Chapter 3 researches the first phase of direct access to diagnostic testing, namely the triage service. This **online triage service** is also part of the services researched in Chapters 4 and 5. Chapter 3 compares the online triage service with the decision-

making process of GPs. The online triage service advises whether and what types of diagnostic tests fit a patient's complaints. Such an online service makes laboratory diagnostic testing accessible and has the potential to reduce the work pressure for GPs, as a patient could perform the triage online instead of visiting their GP. If the online triage tool confirms that no consultation is required, unnecessary consultations with the GP can be avoided. To allow direct access to a diagnostic test service with an online triage work in practice, the advice of the online tool must be in line with the advice of the GP. A qualitative vignette study is presented that compares the advice of the online service with that of GPs and to identify their decision-making factors. The online triage tool can be used in primary care settings as well as in services for citizens independently of a health care professional.

Chapter 4 discusses the service **Directlab Online,** where the online triage service is included. Directlab Online is an online service that enables citizens to request diagnostic tests online, such as diagnostic tests for sexually transmitted infections, without the involvement of a health care professional. Through self-testing and self-sampling, individuals can access information about their health and make informed decisions about whether they want to consult a health care provider. It is important for citizens to pay for the service themselves, and the results are communicated to them online [31]. The chapter evaluates the experiences of Directlab Online through focus groups with potential users. In addition, facilitators, barriers, usability and needs related to the use of such a service are identified.

Chapter 5 examines **Homelab**, which is comparable with Directlab Online but embedded in the GP's online environment. Only patients of general practices affiliated with Homelab can request a diagnostic test online. The GP of a patient can see what tests have been ordered and approve or decline the request. Patients can only perform a diagnostic test with the approval of the GP. The results are communicated to the patient and GP online. It is always the responsibility of the GP to ensure that the patient receives and understands the results. The diagnostic services of Homelab are covered by health care insurance in the Netherlands. A quantitative questionnaire implemented after patients used Homelab was used to research the use, usability, and user characteristics of Homelab. In addition, the research aimed to evaluate whether Homelab could replace an appointment with a GP.

Chapter 6 focuses on the assessment of the effectiveness of a platform called **SARA**, which is intended for patients with asthma or COPD. SARA is an online self-management portal developed by the Dutch pharmacy company Service Apotheek. SARA provides information about inhaled medication and its usage as well as supports patients when they have any questions about their medication or disease. While SARA was initially developed for asthma and COPD patients, the platform's core concept could apply to various chronic diseases and their corresponding medications. Chapter 6 examines whether this self-management support system could contribute to patients' improved health. The service is fully embedded in the health care system of

patients. A pre–post study that employed medication dispensing data was conducted to calculate exacerbation rates and medication adherence among patients who used SARA and those who did not.

To conclude, Chapter 7 provides a main summary of the findings and puts the results into context. In addition, it describes the study's strengths and limitations, its implications, and suggestions for further research.

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2

Direct access for patients to diagnostic testing and results: A systematic review on eHealth and diagnostics

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Abstract

Background: The number of people with chronic diseases and the subsequent pressure on health care is increasing. eHealth technology for diagnostic testing can contribute to more efficient health care and lower workload.

Objective: This systematic review examines the available methods for direct web-based access for patients to diagnostic testing and results in the absence of a health care professional in primary care.

Methods: We searched the PubMed, Embase, Web of Sciences, Cochrane Library, Emcare, and Academic Search Premier databases in August 2019 and updated in July 2021. The included studies focused on direct patient access to web-based triage leading to diagnostic testing, self-sampling or testing, or web-based communication of test results. A total of 45 studies were included. The quality was assessed using the Mixed Methods Appraisal Tool.

Results: Most studies had a quantitative descriptive design and discussed a combination of services. Diagnostic test services mainly focused on sexually transmitted infections. Overall, the use was high for web-based triage (3046/5000, >50%, who used a triage booked a test), for self-sampling or self-testing kits (83%), and the result service (85%). The acceptability of the test services was high, with 81% preferring home-based testing over clinic-based testing. There was a high rate of follow-up testing or treatment after a positive test (93%).

Conclusions: The results show that direct access to testing and result services had high use rates, was positively evaluated, and led to high rates of follow-up treatment. More research on cost-effectiveness is needed to determine the potential for other diseases. Direct access to diagnostic testing can lower the threshold for testing in users, potentially increase efficiency, and lower the workload in primary care.

Keywords: eHealth;systematic review;diagnostic testing;home-based test;self-test

Introduction

Background

As the population ages and the number of people with chronic diseases increase, the pressure on the health care system continues to rise [1,2]. This increased pressure is particularly noticeable in primary care where, over the years, the workload had already increased because of health care transformations. Primary care physicians, for example, are required to perform more preventive and complex care, work more according to evidence-based guidelines, and focus on person-centered care delivery [3,4]. Thus, physicians are required to do more in less time, and this increased workload can negatively affect the quality of patient care [4,5] and result in lower levels of job satisfaction of health care professionals (HCPs) [6,7]. Care delivery needs to be reformed to meet the needs of an aging population.

eHealth has been identified as a potential method to make health care delivery more efficient and can thereby help to decrease the workload [8,9]. eHealth can be defined as "health services and information delivered or enhanced through the Internet and related technologies" [10,11]. Currently, different eHealth applications are used to different extents in primary care. The advantage of eHealth applications is that health care delivery can be more efficient and can operate partially, or even completely, independent of the HCP. Gaining more insight into how eHealth is used in primary care can help to identify promising approaches that may help to lower the workload in primary care and contribute to better health care quality.

Requesting laboratory diagnostic testing, which refers to testing to determine the presence of a disease, and the communication of the results has shown promise for digitization. Indeed, eHealth technology has been applied successfully in the three stages of laboratory diagnostic testing. The first stage is *triage and advice on diagnostic testing*, where typically an HCP asks the patient a set of questions to determine whether and what diagnostic tests are relevant. An example of web-based triage was provided by Polilli et al [12], who used a web-based questionnaire (ie, triage) to determine an individual's risk for HIV and sexually transmitted infections (STIs). On the basis of the calculated risk, individuals were automatically linked to nearby testing and counseling facilities. The second stage is the actual *testing* (eg, a blood test is performed to determine the presence of an infection). There have now been initiatives where laboratory tests can be ordered on the internet and are shipped to the individual for self-testing or self-sampling [13,14]. Self-testing refers to an approach in which individuals can collect their specimen (eg, blood) and interpret the results using a rapid diagnostic test. In self-sampling, individuals collect their specimens, but the specimen is tested elsewhere (eg, laboratory). The third stage is the *communication of test results* to the patient. A course of action is then determined based on the results. Instead of having the HCP communicate the results, it can also be communicated on the web or via an app, independent of the professional. Automated SMS text messages can be used to

deliver tuberculosis testing results [15] or negative HIV test results can be automatically reported using the internet or a voicemail system. To our knowledge, a comprehensive overview of the different methods used to provide patients with direct web-based access to laboratory diagnostic testing and results is not yet available.

Objective

The aim is to conduct a systematic review to identify and summarize the available methods for direct web-based access for participants to diagnostic testing and results in the absence of an HCP in primary care. The available reviews show promise (eg, suggesting that self-tests are acceptable and can increase the uptake and frequency of testing) [16,17], but are limited to self-sampling and self-testing and do not include other forms of digitization. Moreover, the existing reviews focus on specific populations such as men who have sex with men (MSM) [18,19] or on specific health conditions such as HIV or chlamydia [20,21]. To widen the scope, this systematic review will include studies focusing on digitization in one or more phases of laboratory diagnostic testing. Specifically, studies that focus on direct access for patients to (1) web-based triage that leads to diagnostic testing, (2) self-sampling or testing, or (3) the test results are included (or both). The review was not restricted to specific populations or health conditions. Identification and summary of possible methods for direct access to diagnostic testing and result services will help identify usable and effective methods that can potentially increase the accessibility and cost-effectiveness of health care and simultaneously reduce the workload of primary care professionals.

Methods

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for reporting systematic reviews were used [22]. The systematic review was not registered, but a strict protocol was used to search and select studies and to select data.

Search Strategies

PubMed, Embase, Web of Science, Cochrane Library, Emcare, and Academic Search Premier were searched on August 16, 2019, to identify publications about digitization in the laboratory diagnostic setting (ie, web-based triage that leads to laboratory testing, self-sampling or testing, or web-based communication of laboratory test results). The search was updated on July 21, 2021. Search terms related to laboratory diagnostics and eHealth were combined (see Multimedia Appendix 1 for the full search strings). The search was limited to peer-reviewed publications. The reference lists of relevant reviews and the selected publications were also searched.

Study Selection

The titles and abstracts of the identified publications were screened for relevance. The full text was screened when it concerned potentially relevant publications or when there was insufficient information in the abstract to adequately assess the relevance. Several inclusion criteria were used to select the relevant publications. First, the publication should focus on a *specific* web-based laboratory diagnostic service. The service could be (1) a web-based questionnaire or triage that directs users to a laboratory test (in the clinic or at home), (2) an ordered self-sampling or testing kit, or (3) a system for web-based communication of laboratory test results to users. Second, the laboratory diagnostic service should be (partly) independent of an HCP (eg, the questionnaire or triage should not be administered over the phone by the HCP; the test kit should not be provided in-person; administering the test should not require assistance from an HCP; and the test results should not be communicated through a phone call). Regarding the latter, the publication was included when it discussed a result service that was partly independent of an HCP (ie, negative test results were automatically communicated and, in case of positive test results, there was contact between the HCP and patient). Third, the publication should focus on primary care settings; however, this exclusion criterion was omitted for studies conducted in Africa (as there is no clear distinction between primary and secondary care). Fourth, the study outcomes should specifically examine the laboratory diagnostic service (ie, the triage, test, or web-based communication of the test results) and not the surrounding procedures (eg, the acceptability of the consent procedure or the development of the service). Relevant outcomes included actual use or uptake, feasibility and acceptability, and effectiveness (eg, the time taken to test for diagnosis, understanding of test results, and the accuracy of triage). Publications were excluded if the laboratory diagnostic service focused on (national) screening campaigns, the monitoring of disease progression, or retesting or increasing retesting rates. Reviews, trial protocols, non–peer-reviewed papers, non-English papers, and publications without data or with only hypothetical data were also excluded. AV screened all the titles, and AV and ET independently screened the abstracts and full-text publications. For the second search, which was used to update the data, KS screened all the titles. The screening of abstracts was performed independently by AV and KS, and full-text publication screening was performed independently by KS and ET. Discrepancies were resolved through discussion.

Coding

A standardized coding form was used to extract all relevant information from the identified publications. The following information was extracted: (1) the first author and publication year, (2) the country in which the study was conducted, (3) the type of study design (using the classification by Hong et al [23]), and (4) sample characteristics (ie, target group, sample size, age, and gender). It was then determined which laboratory diagnostic service was studied (ie, web-based triage, self-sampling or test-

ing, web-based result service, or any combination of the former three options). The names of the web-based laboratory diagnostic service and the recruitment method were also coded. The different recruitment methods were categorized as social marketing (eg, media, social media, magazines, flyers, advertisements, or promotion in target groups), community outreach (eg, face-to-face recruitment and community events), health service recruitment (ie, direct recruitment by the service provider in past service users), and other recruitment strategies. Details of the laboratory diagnostic services were extracted. Different data were collected based on what services or combinations of services were studied. For the web-based triage service, the aim of the triage was extracted, and it was determined whether it resulted in clinic- or home-based testing (ie, self-sampling or self-testing). For the self-sampling or self-testing service, the following information was extracted when applicable: (1) type of test (ie, self-sampling or self-testing); (2) for what disease; (3) type of specimen (eg, urine specimen); (4) method of how the test kit was ordered, delivered, and how the specimen could be returned; (5) method of instruction (ie, written or video); and (6) costs. For the web-based result service, we coded the method of result notification (eg, on the web or email), whether the notification was entirely or partially independent from an HCP, the average number of days before results were communicated, and whether individuals with positive results were linked to follow-up confirmatory testing or treatment. Results were then extracted, specifically results related to the service evaluation (see the Study Selection section) and not, for example, the characteristics of the service users. AV carried out the coding, and ET independently coded a subsample. There was substantial agreement between the 2 authors (ie, 77%). For the second search, the update, coding was done by KS.

Quality Assessment

The quality of the included studies was assessed using the valid Mixed Method Appraisal Tool (MMAT) [23]. This tool was able to assess the quality of different study designs. The MMAT was chosen because it can be used to assess the methodological quality of 5 different study designs, specifically qualitative, randomized controlled, nonrandomized, quantitative descriptive, and mixed methods studies. The design was determined for each publication, and 5 corresponding quality criteria were rated. The criteria are shown in Multimedia Appendix 2. Each item was rated with yes (ie, indicative of good quality), no (ie, indicative of poor quality), or can't tell (ie, insufficient evidence to determine the quality). Furthermore, a numeric score was calculated to provide insight into the overall quality of each study. The AV conducted the complete quality assessment, and ET assessed a 10% subsample. The average Cohen κ was 0.80, indicating strong interrater reliability [24]. For the second search, KS completed the quality assessment of the studies (n=6).

Data analysis

Data were extracted from the results sections of the studies, as described in the coding paragraph. Relevant outcome measures were extracted verbatim and added to the database, enabling the clustering of different outcome measures. The main findings are presented separately for the different service types. A detailed description of the findings of the included studies is provided in Multimedia Appendix 3 [12-15,25-65].

Results

Study selection

As shown in Figure 1, the 2 search strategies resulted in 1671 publications after removing duplicates. The titles and abstracts were screened for relevance, and the full texts of 141 publications were checked. A total of 96 publications were excluded, most frequently, because the publication did not report on a (web-based) diagnostic laboratory service (n=36), it concerned a national screening campaign (n=19), or the service was not independent of an HCP (n=15). Finally, 45 publications were included in the qualitative synthesis, and 6 studies were included in the second search.

Study characteristics

Most of the included studies had a quantitative descriptive design (n=28) [12,13,15,25-50]. In the remaining studies, a (quantitative) nonrandomized design was reported 6 times [32,51-55], a randomized controlled design was reported 5 times [56-60], a mixed methods design was reported 3 times [14,61,62], and a qualitative design was reported 3 times [63-65]. In 29 studies, a combination of services was offered; specifically, triage, testing, and a result service in 14 studies [13,28,40,42,46,49,51-53,56,57,59,60,63], triage and testing in 9 studies [26,27,29-33,35,37], and testing and a result service in 6 studies [41,44,45,48,61,64]. Furthermore, 8 studies discussed a testing service [14,25,34,38,43,47,58,62], 7 discussed a result service [15,35,39,50,54,55,65], and 1 discussed a triage service [12]. In the included studies, the testing service was evaluated most often (ie, 82% of the studies). Triage was evaluated in 2 studies [12,29] and the result service, in 11 studies [15,35,39-41,44,46,50,54,55,65]. The services were evaluated in the United States (n=15), the United Kingdom (n=9), Canada (n=6), Australia (n=2), Sweden (n=2), the Netherlands (n=2), and China (n=2). The remaining studies took place in Belgium, Brazil, Denmark, Estonia, France, Italy, and Uganda (ie, all n=1). The sample sizes ranged from 10 to 37 in the qualitative studies, with a mean of 21.60 (SD 9.7). The sample size ranged from 102 to 1736, with a mean of 2205.90 (SD 3514.0) in the quantitative studies. Almost half of the studies included both men and women (n=22) [12,13,25,29,36,38,39,48,50-57,59-62,64,65], 11 studies included

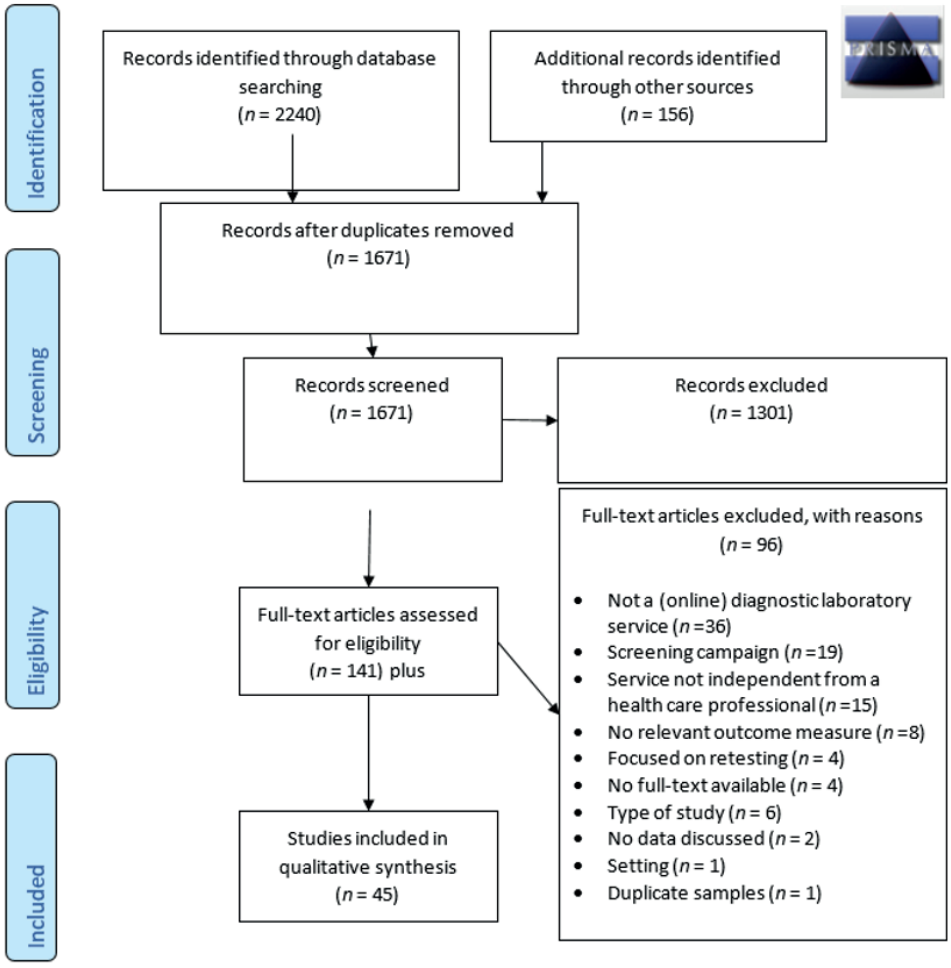

Figure 1. PRISMA (Preferred Reporting Item for Systematic Reviews and Meta-Analyses) flow diagram for study inclusion.

MSM [27,28,34,35,41-43,45,47,49,63], 7 studies included only women [30-33,37,44,46], 2 studies included only men [26,58], 1 study included both MSM and transgender people [14], 1 study included adults with presumptive tuberculosis [15], and 1 study included past service users [40]. The mean percentage of male participants was 62.34% (SD 35.1%), and the mean age was 27.37 years (SD 4.7 years) (the average across the 15 studies that reported a mean) and ranged from 20.70 to 37.90 years. The study characteristics are shown in Table 1.

Table 1. Study characteristics.

First author, year, and country	Study design	Study population	Sample size, n	Males, n(%)	Age (years)	Service type
Ahmed-Little, 2015 [61] UK	Mixed-methods	Persons aged ≥16 years	2247	1043 (46.41)	Mean 22.60	Testing[a] Result
Andersen, 2001 [25] Denmark	Quantitative descriptive	Persons aged 21-23 years	183	64 (34.9)	-[b]	Testing
Babirye, 2019 [15] Uganda	Quantitative descriptive	Adults with presumptive tuberculosis	233	114 (48.9)	IQR 27 - 50	Result
Barnard, 2018 [51] UK	Quantitative non-randomized	Persons aged ≥16 years	5747	2489 (43.31)	IQR 23 - 32	Triage Testing[a] Result
Brown, 2018 [56] UK	Quantitative RCT[c]	High-risk persons ≥16 years of age	8999	7015 (77.95)	72% aged between 16-34	Triage Testing[a] Result
Chai, 2010 [26] US	Quantitative descriptive	Men aged ≥14 years	501	501 (100.00)	IQR 21 - 30	Triage Testing[a]
de Boni, 2019 [27] Brazil	Quantitative descriptive	MSM[d] aged≥18 years	3218	3218 (100.00)	IQR 22 - 31	Triage Testing[a]
Dulai, 2019 [49] Canada	Quantitative descriptive	Men who are gay, bisexual, and MSM aged ≥18 years	1272	1272 (100.00)	53% aged between 18 – 39	Triage Testing[a] Result
Elliot, 2016 [28] UK	Quantitative descriptive	MSM	17361	17361 (100.00)	-	Triage Testing[a] Result
Grandahl, 2020 [64] Sweden	Qualitative	Persons aged ≥15 years	20	9 (45)	Mean 30.8	Testing[a] Result
Grandahl, 2020 [48] Sweden	Quantitative descriptive	Persons aged ≥15 years	1785	546 (30.58)	Mean 27.3	Testing[a] Result
Gaydos, 2016 [30] US	Quantitative descriptive	Women	102	0 (0)	64% aged between 18-29	Triage Testing[a]
Gaydos, 2016 [29] US[e]	Quantitative descriptive	Persons aged ≥ 14 years	1394	558 (40.02)	Mean 28.13	Triage[a] Testing

Table 1. Continued

First author, year, and country	Study design	Study population	Sample size, n	Males, n(%)	Age (years)	Service type
Gaydos, 2011 [32] US[e]	Quantitative non-randomized	Women aged ≥ 14 years	1171	0 (0.00)	Mean 25.00	Triage Testing[a]
Gaydos, 2009 [31] US[e]	Quantitative descriptive	Women aged ≥ 14 years	1203	0 (0.00)	Median 23	Triage Testing[a]
Gaydos, 2006 [33] US	Quantitative descriptive	Women aged ≥ 14 years	400	0 (0.00)	Mean 26.10	Triage Testing[a]
Gilbert, 2019 [52] Canada	Quantitative non-randomized	Persons aged ≥ 14 years	381	270 (70.86)	Range 18 – 74	Triage Testing[a] Result[a]
Gilbert, 2017 [13] Canada	Quantitative descriptive	Persons aged ≥ 14 years	868	619 (71.31)	Median 32	Triage Testing[a] Result
Jin, 2019 [34] China	Quantitative descriptive	MSM aged ≥ 16 years	879	879 (100.00)	IQR 24 – 34	Testing
Kersaudy-Rahib, 2017 [57] France	Quantitative RCT	Persons aged 18-24 years	11075	5152 (46.52)	Mean 20.70	Triage Testing[a] Result
Knight, 2018 [63] Canada	Qualitative	MSM aged ≥ 15 years	37	37 (100.00)	Mean 37.90	Triage Testing[a] Result
Koekenbier, 2008 [35] Netherlands	Quantitative descriptive	MSM	898	898 (100.00)	-	Result
Kuder, 2015 [53] US	Quantitative non-randomized	Persons aged ≥ 14 years	1211	484 (39.97)	Mean 27.47	Triage Testing[a] Result
Kwan, 2012 [36] Australia	Quantitative descriptive	Persons aged ≥ 16 years	377	206 (54.64)	71% were aged <30	Triage Testing[a]
Ladd, 2014 [37] US[e]	Quantitative descriptive	Women	205	0 (0.00)	Mean 25.80	Triage Testing[a]

Ling, 2010 [54] US	Quantitative non-randomized	Men and women	9056	5196 (57.37)	85% were aged ≥ 20	Result
Mák, 2015 [55] Canada	Quantitative non-randomized	Persons aged ≥ 18 years	3292	1244 (37.79)	62% were aged ≥ 55	Result
Martin, 2009 [38] Australia	Quantitative descriptive	Persons aged 16-24 years	413	224 (52.24)	67% aged between 16-24	Testing
Morris, 2010 [39] US	Quantitative descriptive	Persons aged ≥18 years	3138	2563 (81.67)	62% aged between 25-44	Result
Nadarzynski, 2018 [40] UK	Quantitative descriptive	Service users	115	-	-	Triage Testing Result*
Platteau, 2015 [41] Belgium	Quantitative descriptive	MSM aged ≥18 years	1071	1071 (100.00)	Mean 33.82	Testing Result[a]
Polilli, 2016 [12] Italy	Quantitative descriptive	Men and women	5000	-	-	Triage
Reagan, 2012 [58] US	Quantitative RCT	Men aged 18-45 years	200	200 (100.00)	Mean 30.75	Testing
Ricca, 2016 [42] US	Quantitative descriptive	MSM aged ≥18 years	896	896 (100.00)	Mean 30.00	Triage Testing[a] Result
Robinson, 2019 [65] Canada	Qualitative	No inclusion criteria	21	12 (57.14)	38% aged between 60-69	Result
Rosengren, 2016 [43] US	Quantitative descriptive	Black and Hispanic MSM aged ≥18 years	125	125 (100.00)	63% aged between 18-30	Testing
Rotblatt, 2013 [44] US	Quantitative descriptive	Women aged 12-25 years	2659	0 (0.00)	Median 22.3	Testing[a] Result[a]
Rüütel, 2015 [45] Estonia	Quantitative descriptive	MSM aged ≥18 years	265	265 (100.00)	53% were aged ≥30	Testing[a] Result
Spielberg, 2014 [46] US	Quantitative descriptive	Women aged 18-30 years	217	217 (100.00)	Median 25	Triage Testing[a] Result[a]

Table 1. Continued

First author, year, and country	Study design	Study population	Sample size, n	Males, n(%)	Age (years)	Service type
Talboom-Kamp, 2020 [50] NL	Quantitative descriptive	No inclusion criteria	354	-	-	Result
Wilson, 2019 [60] UK	Quantitative RCT	Persons aged 16-30 years whom had never had an STI test	528	254 (48.11)	Mean 21.30	Triage Testing[a] Result
Wilson, 2017 [59] UK	Quantitative RCT	Persons aged 16-30 years	2063	846 (41.01)	Mean 23.00	Triage Testing[a] Result
Witzel, 2019 [14] UK[g]	Mixed-methods	MSM and transgender people aged ≥16 years	1035 / 10	1035 (100.00)/ 10 (100.00)	IQR 26 - 42 or 60% aged between 26-40	Testing
Witzel, 2021[62] UK[g]	Mixed-methods	Transgender people aged ≥16 years	118/20	94 (79.66)/12 (60)	IQR 22 -37 or 35% aged between 16-25	Testing
Zhong, 2017 [47] China	Quantitative descriptive	MSM aged ≥18 years	380	380(100.00)	54% aged between 25-34	Testing

[a]When multiple services were discussed in a study, footnote a identifies the service for which data was reported.
[b]—: data not available.
[c]RCT: randomized controlled trial.
[d]MSM: men who have sex with men.

Service provider characteristics

Within the 45 studies included in this review, 31 different providers were examined. The characteristics of the service providers are shown in Table 2, and more details are provided in Appendix 4 [12-15,25-65]. About half of the service providers offered a combination of services. A total of 9 providers offered a triage, testing, and result service, 5 offered a testing and result service, and 2 offered a triage and testing service. The remaining providers offered a single service (ie, testing [n=7], result [n=7], or triage [n=1]). Social marketing was most often used to recruit service users or study participants, with 16 providers using it as the sole recruitment strategy and 5 providers combining it with community outreach. The health service recruited 7 providers, and 3 studies reported no information on the applied recruitment strategy.

Triage was offered by 12 different service providers, either alone or in combination with other services. Triage aimed to estimate the risk of having a disease and identify individuals who need to test. The aim of the triage, however, was not specified for 5 providers. In most cases, web-based triage directed users to home-based testing (83%). A total of 23 providers offered testing as a service (alone or in combination with other services); 12 providers offered testing for 1 disease, and 11 offered testing for >2 diseases (ie, ranging from 2 to 6). Testing was most often available for chlamydia (n=13), HIV (n=12), and gonorrhea (n=10). Providers also tested for trichomonas (n=3), syphilis (n=3), hepatitis B (n=1), hepatitis C (n=1), lymphogranuloma venereum (n=1), and mycoplasmosis (n=1). Most of the tests were performed with a self-sampling test (n=18), whereby the samples were returned to the laboratory and analyzed according to the gold standard. All laboratories provided high-quality analysis with accredited and certified equipment. Self-testing was offered by 5 providers and targeted HIV (n=5) and syphilis (n=1). The testing service was almost always free of charge (87%). A small shipping fee was charged by 1 provider, and 1 provider charged US $23 that would be refunded after the user had shared the test results with the staff. A result service was offered by 20 providers (alone or in combination with other services). Different methods were used to communicate the test results, with 8 providers relying on a single method and 10 providers using different methods for result communication. Test results were most often accessible on the internet (n=12) or communicated over the phone (n=10). The results could also be communicated using SMS text messaging (n=6) or email (n=2). The communication of the test results was, in most cases, not completely independent from an HCP (70%). Often, the results were presented on the web, but users were called by the HCP when they had a positive result [39,63], or users were called when they had not checked their results on the internet [41].

Table 2. A description of the diagnostic testing and result service provider.

		Triage	Testing			Result	
Service provider	**Recruitment methoda**	**Type of follow-up testing**	**Disease(s)**	**Type of home-based test**	**Cost**	**Method**	**Independent HCP**
Triage service							
Fai il test anche TU project [12]	Social	Clinic	HIV, hep B and C, syphilis	-[b]	-	-	-
Testing service							
C-project [38]	Social	-	Chlamydia	Self-sampling	Free	-	-
Easy test [34]	Social Community	-	HIV	Self-testing	$2-3	-	-
UCLA free HIV self-test program [43]	Social	-	HIV	Self-testing	Free	-	-
Social entrepreneurship testing [47]	··	-	HIV Syphilis	Self-testing	$23 (refunded)	-	-
SELPHI [14, 62]	Social	-	HIV	Self-testing	Free	-	-
Unknown [25]	Social	-	Chlamydia	Self-sampling	Free	-	-
Unknown [58]	Social Community	-	Chlamydia Gonorrhea	Self-sampling	Free	-	-
Unknown [48, 64]	Health service	-	Chlamydia Gonorrhea	Self-sampling	Free	-	-
Result service							
GxAlert [15]	Health service	-	Tuberculosis	-	-	SMS	Yes
Syfilistest.nl [35]	Social	-	Syphilis	-	-	Online	Yes
Early test [39]	Social	-	HIV	-	-	Online Phone	Partly
Result system of Denver Metro Health Clinic [54]	Health service	-	Chlamydia, gonorrhea	-	-	Online	Partly
Excelleris [55]	Health service	-	Not limited to a specific disease	-	-	Online	Yes
Patient portal [50]	Health service	-	Not limited to a specific disease	-	-	Online	Partly
myCARE [65]	Health service	-	Not limited to a specific disease	-	-	Online	Partly
Triage & testing service							
A hora é Agora [27]	Social	Home	HIV	Self-testing	Free	-	-
Online Chlamydia Testing program [36]	Social	Home	Chlamydia, gonorrhea	Self-sampling	Free	-	-

Testing & result service							
Swab2Know [41]	Social	-	HIV	Self-sampling	Free	Online Email Phone	Partly
Don't think, know [44]	Social Community	-	Chlamydia, gonorrhea	Self-sampling	Free	Online Phone	Partly
Testikodus [45]	Social	-	Chlamydia, gonorrhea, trichomonas, LGV[c], mycoplasmosis	Self-sampling	Free	Online	Yes
RUClear [61]	-	-	HIV	Self-sampling	-	Phone SMS Letter	Partly
Triage, testing & result service							
DS@H [28]	Social	Home	HIV	Self-sampling	Free	SMS Phone	Partly
GetCheckedOnline [13, 49 52, 63], [d]	Social	Home Clinic	Chlamydia, gonorrhea	Self-sampling	Free	Online Phone	Partly
Let's talk about it NHS [40]	Health service	Home	Chlamydia, gonorrhea, HIV, syphilis, hep B and C	Self-sampling	Free	SMS Phone	Partly
Checking In [42]	Social	Home	HIV	Self-sampling	Free	Phone	Partly
eSTI [46]	Social Community	Home	Chlamydia, gonorrhea, trichomonas	Self-sampling	Free	Online	Yes
SH:24 [48, 59, 60][d]	Social Community	Home	Chlamydia, gonorrhea, HIV, syphilis	Self-sampling	Free	SMS Phone	Partly
Freetesting.hiv [56]	-	Home	HIV	Self-sampling	Free	SMS Phone	Partly
Chlamyweb [57]	Social	Home	Chlamydia	Self-sampling	Free	Email Postal service	Partly
I Want The Kit [26, 29-33, 37, 53][d]	Social	Home	Chlamydia, gonorrhea, trichomonas	Self-sampling	Free	Online	Yes

[a]The methods used to recruit participants or service users was reported; specifically, social=social marketing, community=community outreach, and health service=health service recruitment.

[b]Data not available.

[c]Lymfogranuloma venereum.

[d]The service provider was investigated in multiple studies. The specific characteristics of each study are presented in Multimedia Appendix 3.

Table 3. Quality assessment of the included studies using the Mixed Method Appraisal Tool (MMAT).

	MMAT quality criteria[a]					
Included studies	**1**	**2**	**3**	**4**	**5**	**MMAT scores[b]**
Qualitative						
Knight et al. [63]	+[c]	+	+	+	+	5
Grandahl et al. [64]	+	+	+	+	+	5
Robinson et al. [65]	+/-[d]	+	+	+	+	4
Average MMAT score						4.67
Quantitative randomised controlled trials						
Brown et al. [56]	+	+	+	+/-	+	4
Kersaudy-Rahib et al. [57]	+	+	-[e]	+/-	+	3
Reagan et al. [58]	+	+	-	+	+	4
Wilson et al. [59]	+	+	+	+	+	5
Wilson et al. [60]	+	+	+	+	+	5
Average MMAT score						4.20
Quantitative non-randomised						
Gaydos et al. [32]	+	+	+	+/-	+	4
Barnard et al. [51]	+	+	-	+	+	4
Gilbert et al. [52]	-	+	+/-	+	+	3
Kuder et al. [53]	+	+	-	-	+	3
Ling et al. [54]	+	+	+	+	+	5
Mák et al. [55]	-	+	+	+	+	4
Average MMAT score						3.83
Quantitative descriptive						
Polilli et al. [12]	+	+	+	+/-	+	4
Gilbert et al. [13]	+	+	+	+/-	+	4
Babirye et al. [15]	+	+	+	+	+	5
Andersen et al. [25]	+	+	+	+/-	+	4
Chai et al. [26]	+	+	+	+/-	+	4
de Boni et al. [27]	+	+	+	+/-	+	4
Elliot et al. [28]	+	+	+	+/-	+/-	3
Gaydos et al. [29]	+	+	+	+/-	+	4
Gaydos et al. [30]	+	+	+	+/-	+	4
Gaydos et al. [31]	+	+	+	+/-	+	4
Gaydos et al. [33]	+	+	+	+/-	+	4
Jin et al. [34]	+	+	+	+/-	+	4
Koekenbier et al. [35]	+	+	+	+/-	+	4
Kwan et al. [36]	+	-	+	+/-	+	3
Ladd et al. [37]	+	+	+	+/-	+	4
Martin et al. [38]	+	-	+	+/-	+	3
Morris et al. [39]	+	+	+	+/-	+	4
Nadarzynski et al. [40]	+	+/-	+	+/-	+	3
Platteau et al. [41]	+	+	-	+/-	+	3
Ricca et al. [42]	+	+	+	+/-	+	4
Rosengren et al. [43]	+	+	+	+/-	+	4

	MMAT quality criteria[a]					
Included studies	**1**	**2**	**3**	**4**	**5**	**MMAT scores[b]**
Rotblatt et al. [44]	+	+	+	+/-	+	4
Rüütel et al. [45]	+	-	+	-	+	3
Spielberg et al. [46]	+	+	+	+/-	+	4
Zhong et al. [47]	+/-	+	+	+/-	+	3
Grandahl et al. [48]	+	+	+	-	+	4
Dulai et al. [49]	+	+	+	-	+	4
Talboom-Kamp et al. [50]	+	+	+	-	+	4
Average MMAT score						3.78
Mixed-methods						
Witzel et al. [14]	+	+	+	+	-	4
Ahmed-Little et al. [61]	+/-	-	+	+	-	2
Witzel et al. [62]	+	+	+	+/-	+	4
Average MMAT score						3.33
Average MMAT score across all designs						3.86

[a]The criteria differed according to the design. A description of the criteria is provided in Multimedia Appendix 2.
[b]The average Mixed Method Appraisal Tool score across all designs is 3.86. The overall grade is the sum of the number of quality criteria that were assessed as good.
[c]Good quality.
[d]Insufficient evidence to determine the quality.
[e]Poor quality.

Quality assessment

Quality assessment using the MMAT of the studies is shown in Table 3. The quality of the included studies was good, with an average score of 3.86 (SD 0.6; on a scale from 0 to 6). The average quality score ranged from 3.33 (SD 1.5) for mixed methods studies to 4.67 (SD 0.57) for qualitative studies. A shortcoming was that, in the studies using a quantitative descriptive design, the nonresponse was not clearly reported in 23 of the 25 studies. Therefore, it is unclear if these studies were at risk of nonresponse bias.

Findings by type of service

The findings are discussed separately for triage, testing, and result service. For clarity, the findings of follow-up testing and treatment are jointly discussed for the testing and result service. A more detailed description of the findings is provided in Multimedia Appendix 4.

Triage service

A total of 2 studies evaluated the triage service, which showed that the use of web-based triage services could be quite high with those completing the web-based triage and booking an appointment for a test (more than 50%). Notably, most of the individuals who tested positive were also linked to treatment. Furthermore, the predic-

tive value of triage showed a prediction of STI positivity in women. For more detailed information, see Table 4.

Testing service

For the test service, different outcome measures were found with different objectives. Studies with outcomes focusing on the test services, which were home-based (eg, self-testing or self-sampling), were discussed. The test use was reported to be high (above 50%), and test uptake was higher among those offered home-based tests than clinic-based tests. The number of returned specimens was discussed frequently and showed very different results with a wide range of percentages of returned specimens. The acceptability and usability of the test service scored high on the convenience of performing home-based tests with easy instructions. The cost-effectiveness of home-based tests showed lower or similar prices compared with clinic-based testing. Furthermore, motivations for self-testing were discussed. Ease of use, privacy, and anonymity were identified as reasons to perform these tests. Important barriers for these services were potential costs, accuracy, unreliable postal service, insecurity about handling data, and self-interpreting the results. For more detailed information, see Table 4.

Result service

For the result service, different types of outcome measures were found with different objectives. The use of the result service exceeded 69%. Research showed that most participants viewed their results on the same day as they were posted on the web, and comprehension of these web-based results was high (above 75%). The acceptability of direct access to results using the website was high, and the participants were satisfied with this process. Direct access to diagnostic results led to shorter waiting times for the results than for participants who did not receive their results on the web. Limited access to the internet was a reason for preferring to call the clinic for the results. For more detailed information, see Table 5.

Test and result services: follow up testing and treatment

Follow-up testing and treatment have been discussed in several studies. These studies showed that receiving web-based results led to high treatment rates (mean 93%, SD 9.9%), and the frequency of confirmatory testing after a self-test was above 68%. For more details, see Table 5.

Table 4. Results of the triage and test services per specific outcome measure.

Service and general outcome	Specific outcome measure	Results
Triage		
-[a]	Use	• Use of web-based triage services can be quite high; more than 50% (3046/5000) of those who completed the web-based triage also booked an appointment for HIV clinic-based testing. Notably, the majority also presented for testing (87%), and most of the individuals who tested positive were also linked to treatment (93% [12]
	Predictive value	• Gaydos et al. [29] found that the score on the risk assessment predicted STI[b] positivity for females but not males
Test		
Usage		
	Return specimen	• The percentage of returned tests or specimens for analyses was frequently reported [13, 25, 26, 28, 37, 38, 42, 44-46, 48, 51, 56, 61] • Range: 24 [45] to 85% [42, 48], with an average of 52.8%(SD = 19.6%)
	Used tests	• In 4 studies, the percentage of used home-based tests was given [14, 36, 43, 47]. • Range: 56 [36] to 100% [43], with an average of 83% (SD = 19.3%) • The highest percentage might be an overestimation of the actual use because people had to self-report the usage of the tests in a follow-up survey [43]
	Comparison home-based testing versus clinic-based testing	• In four studies, home-based testing was compared to clinic testing [57-60]. • The average percentage of test usage was higher among those who were offered a home test compared to those who were offered a test at the clinic (respectively 49% [SD = 17.8] vs 27% [SD = 16.1%).
	Other	• Home-based test uptake was highest when the results would be presented through the internet [53] • When users received primers before the arrival of the test kit at home (eg, set aside a time to complete the test) and behavioral insight reminders [56]
Acceptability /usability	Home-based testing versus clinic-based testing	• Eight studies examined whether there was a preference for home-based or clinic-based testing [26, 30, 32, 33, 43, 46, 63] • Range: 62 [30] to 95% [46], with an average of 81% (SD = 12.7%) who preferred home-based testing • One study reported a barrier to clinic-based testing: that it was easier to stay at home than go to the clinic [49]
	Easy to perform	• Seven studies reported how easy it was to perform home-based testing [14, 26, 30, 32, 33, 36, 43]. • Range: 88 [26] to 97% [14, 32], with an average of 94% (SD = 3.5%).
	Acceptability instructions	• Five studies examined the acceptability of the instructions for home-based testing [14, 27, 30, 58, 61] • On average, 93% (SD = 5.3%) considered the instructions to be easy.

Table 4. Continued

Service and general outcome	Specific outcome measure	Results
	Acceptability in general	• In 3 studies, the acceptability of the home-based test service, in general, was reported [59-61] • Mean 75% (SD = 4.5)
	Recommendation	• The percentage of participants who would recommend the service of testing at home to a friend was 98 percent in two studies [36, 46], and in Gaydos et al., it was 77% [30]
	Other	• The perceived reliability of the test results was reported in Gaydos et al. [30]: 97% of the users trusted the results of the home-based test service • Chai et al. [26] found that 85% found it a safe way of testing • Witzel et al. [14]. found that 97% had an overall good experience with the home-based test service • Chai et al., Gaydos et al. and Dulai et al. [26, 32, 49] both reported that around 90%would use the home-based test service again • Gaydos et al. [33] report that 86% would use this home-based testing method in daily life • De Boni et al. [27]. reported that 91% found it (very) easy to use the website • Grandahl et al.[48] reported that more than 90% found the overall home-based test service good or very good. • Grandahl et al. [64] reported that most users highly appreciated the service and found the service easy to use, convenient and confidential. They would use the service again in the future, even if the costs were higher.
Cost-effectiveness	Cost-effectiveness	• Kersaudy-Rahib et al. [57] reported that the price for home-based testing was three times lower compared with clinic-based testing • Ahmed-Little et al. [61] showed that the costs for HIV testing per person were around €27 (US $ 30.45), which is in line with testing costs in national HIV testing pilots
Other outcomes	-	• Reasons to self-test were that it reduced HIV testing barriers, desire to use new technology, and altruistic motivation [14]. • Other reasons mentioned for HIV self-testing were inaccessible and inappropriate clinical services[62]. In Martin et al. [38] users reported that they did the test because it was easy and it was for free • Zhong et al. [47] reported convenience and to save time, protection of privacy, ease of use and accuracy as reasons to perform a home-based self-test. *Facilitators* were ease of use, anonymity, and the ability to test alone. *Barriers* were concerns about accuracy, potential costs, and concerns about self-interpreting the results • Dulai et al. [49] reported that 20% were *worried* about their online information privacy, and 5% had low trust in this service. • Some *barriers* mentioned in Grandahl et al. [64] were the use of complicated language, uncertainty about the procedure, unreliable postal service, and insecure data handling.

[a]No general outcome measure.
[b]STI: sexually transmitted infection.

Table 5. Results of the test and result services per specific outcome measure.

Service and general outcome	Specific outcome measure	Results
Result		
Usage	Retrieved results online	• The usage of a result service was assessed in six studies [35, 39, 41, 44, 46, 54] • The percentage of people who retrieved their results online varied from 69 [39] to 97% [35], with an average of 85% (SD 11.2%) • The service with the lowest retrieval rate called all users with a positive test result and, if users were not called within 2 weeks they could access their results online • Spielberg et al. [46] found that 88% viewed their test results on the same day they were posted • Platteau et al. [41] showed that significantly more people collected their test results when the test was ordered online compared to testing during outreach activities
	Waiting time	• Gilbert et al. [52] showed significantly shorter waiting times for those who used an online platform compared to clinic clients
Comprehension	-[a]	• Babirye et al. [15] found that everyone could accurately relay the content of an SMS that contained the tuberculosis test result • Comprehension was slightly lower in the other 2 studies: 75% and 87% understood the content of the test result message (respectively [55,40]) • Mák et al. [55] showed that comprehension was significantly higher in the group that did not receive their results online • Robinson et al.[65] showed that comprehension of the results differed from difficulty with the understanding of the results to no difficulty. However, when difficulties were there, the users pointed out that the reference range was helpful.
Acceptability	Comfortable with online results	• Acceptability was examined in 4 different studies [39, 41, 46, 54] • Only 1 study specifically examined how comfortable users were with receiving their results online, and 87% was (very) comfortable with this process [39]
	Ordering a test and receiving results online	• Two studies examined the acceptability of ordering a test kit online and receiving the web-based results • Platteau et al. [41] found that 96% of the users were satisfied with this process • Spielberg et al. [46] reported that 98% of the users found the service website easy to use
	Reasons	• The two main reasons for choosing to receive web-based results were having access to the results any time of the day and the belief that results would be communicated faster via the internet • A preference to call the clinic for results and limited access to the Internet were reasons to opt-out of web-based results[54] • Reasons for having web-based results were reported by Robinson et al. [65] as: better communication with the HCP[b], convenience, and being a steward of own health care

Table 5. Continued

Other outcomes	-	• The *feasibility* of using SMS to communicate tuberculosis test results was examined in Uganda and scored relatively low; (ie, an SMS text message was online transmitted to 62% of those who were eligible to receive an SMS text message with test results [15]). • One study found that users waited significantly shorter for web-based results than users who did not have web-based access [55]. Furthermore, this study showed that the majority (ie, 86%) experienced no or low *anxiety* after receiving their test results, and the level of anxiety was not different between those with or without internet access • Another study examined *user preferences* for the content of text messages conveying the test results, and the majority preferred that the results of all tested STIs[c] were discussed in one message and that the names of the STIs tested should be included in the message [40] • One study reported that patients feel more *comfortable and engaged* with their health care when they see the results themselves [65]. Besides, they reported that it had no adverse effects. • Two domains of the eHIQ[d] were researched in one study to determine patient's attitude towards an online results service [50]. This eHIQ showed positive results for the criteria easy to use, trustworthy and appropriate.
Test and result		
Follow up testing and treatment	Confirmatory testing	• The frequency of confirmatory testing for positive or uncertain/invalid test results was described in 4 studies [27, 35, 43, 61] • Range from 68 [27] to 100% [43, 61], with an average of 85% (SD 17.7%)
	Follow up after positive result	• Follow up treatment after a positive test result was described in 10 studies [26, 31, 32, 34, 36, 41-44, 46] • Receiving online test results led to high treatment rates, with an average of 93% (SD 9.9%)
	Confirmatory testing and treatment	• In 2 studies, confirmatory testing and treatment were described [28, 47] • In Elliot et al. [28], 67% of the reactive samples were confirmed, and all received treatment. For 10% of the reactive samples, treatment could not be confirmed • In Zhong et al. [47], everyone with a reactive test did confirmatory testing and was linked to treatment
	Other	• In 3 studies, different groups were compared to each other. It was shown that the treatment rate was higher when users (1) had the option to receive their results web-based versus communicated over the phone (not significant) [54], (2) received their test kit at home instead of at the primary care setting [57], and (3) received their results through an automated result access system compared to service were participants had to call for their test result [53]

[a]Data not available.
[b]HCP: health care professional.
[c]STI: sexually transmitted infection.
[d]eHIQ: e-Health Impact Questionnaire.

Discussion

Principal Findings

This systematic review aimed to gain insight into the available methods for direct web-based access to patients for diagnostic testing and results. A total of 45 studies were included. Most of the studies used a quantitative descriptive design. Most of the studies investigated a test or result service related to STIs. In the 45 studies, 31 different providers were discussed. Half of the providers offered a combination of services. Of the 3 different services, the test service was most often evaluated. This review showed that direct patient access to testing and result services was positively evaluated. The use of triage, test, and result services was high, and the acceptability among patients was high. Moreover, follow-up confirmatory testing and treatment rates were high with home-based testing.

An update of the literature search was performed after the third wave of the COVID-19 pandemic. However, no studies were found regarding direct access to diagnostic testing and results services for this disease. This could be because free tests were often offered by the governments of countries. There have been commercial companies offering tests for SARS-CoV-2; however, scientific research has not yet been performed.

This review found that the use rates of home-based tests were high and that direct web-based access to results was appreciated and generally well-understood. An overall preference for home-based testing versus clinic-based testing was found. Importantly, follow-up treatment after a positive home-based test was high and, in some studies, was even higher when tests were performed at home compared with the clinic. The overall positive findings of this systematic review contradict earlier voiced concerns about self-testing and self-sampling, such as that users would be insufficiently linked to follow-up testing or treatment [66,67]. It was reported in 1 study that 70% of participants were afraid to carry out the self-test properly [67]. This contrasted with our findings, which indicated that users found self-tests easy to use and that the instructions were clear and reliable. Nevertheless, it is important to include end users in the design phase when setting up such services to ensure usability and acceptability [68]. In addition, although most studies reported high acceptability and comprehension of test results communicated on the web, 1 study reported that interpreting the results was easier when they were communicated in person (vs via the internet). This contradictory finding might be because this study discussed a general result service portal and not a portal specifically for STI results. To minimize the risk of misunderstanding, it is important that future research examine the content and how this content can best be presented to users [50].

Furthermore, the quality of the laboratory tests used in these studies was high. Therefore, this review disproves the aforementioned concerns about home-based diagnostic tests [66,67] and shows that these tests with direct access to web-based result services could contribute to easily accessible diagnostic testing [69].

The high acceptability of the test and result services and the high rates of follow-up for treatment create opportunities for primary care. The workload for primary care is high [3,4]. eHealth technologies can make health care delivery more efficient, and therefore, the adoption of eHealth is being stimulated worldwide [9]. By providing patients with direct access to web-based testing and results, patients would not need to visit their HCP, potentially lowering the number of consultations in primary care. Consequently, it would leave HCPs with more time to focus on complex health care and consultations that cannot be executed via the internet. Another reason for home-based diagnostic testing is to lower the testing threshold. Patients can experience feelings of embarrassment or shame for tests such as STI, which can result in delays in testing [70]. Allowing individuals to order tests on the web can make it more convenient for them to get tested and may help diagnose and treat diseases sooner. However, future research should investigate whether these types of test services lead to excessive use. At the same time, it is important to emphasize that this review identified that direct access to diagnostic testing exhibited benefits for patients, such as comfort, ease, and time-saving. A few barriers should be addressed to allow home-based diagnostic testing in practice. An important barrier to eHealth adoption in primary care is, for example, the cost [71]. In the Netherlands, diagnostic tests ordered by a primary care physician are covered by health insurance. However, home-based diagnostic testing has not yet been covered by insurance. To stimulate home-based testing, the costs of home-based diagnostic testing should be covered by an individual's health care insurance. Therefore, it would be useful to investigate the cost-effectiveness of home-based diagnostic testing compared with clinic-based testing. In this review, only 2 studies discussed cost-effectiveness, more insight into how valuable home-based diagnostic testing could be in the future could be provided. Furthermore, home-based diagnostic testing could work more efficiently in primary care if implemented for a variety of conditions [72]. However, more research is needed to elaborate on home-based diagnostic test services for diseases other than STIs.

Strengths and Limitations

The strengths of this review lie in several aspects. First, the study search strategy was comprehensive and not limited to a specific disease or population. Second, a quality assessment was performed for all included studies, and the quality of the included studies appeared to be relatively high. However, it is essential to consider that the MMAT was scored using a yes or no score without nuances. Third, a comprehensive overview of the study and service characteristics provided detailed insight into the included studies.

This review has several limitations. First, there was heterogeneity in the included outcome measures, which resulted in a low number of studies reporting the same outcome. Therefore, it was not possible to examine the pooled effect using a meta-analysis. As the field advances quickly, more studies are likely to become available soon, and a meta-analysis might be possible. Second, almost all studies focused on STIs. For

that reason, it was unknown whether the findings regarding usability and acceptability would generalize to test and result services that target diseases other than STIs. Nevertheless, our review provided insight into the potential of direct web-based access to diagnostic testing, which could translate to other diseases. Even for test results that were not dichotomous, which was the case in STI testing, test results could be presented in a web-based portal, for example, the identification of abnormal and normal values for a test result with an option to contact a physician [50]. A third limitation was that the mean age in the included studies was relatively low, which could have led to bias because a different, older population could have evaluated these services differently [73]. Although eHealth services have shown good use and result in older adult populations, it remains to be determined whether this is also the case for web-based diagnostic testing and results services [74]. There was a large portion of the quantitative descriptive design studies (28/45, 62%) that constituted the fourth limitation to this review. Only 5 studies had a randomized controlled trial design. Therefore, selection bias cannot be ruled out, including sample representativeness. Nevertheless, all studies underwent quality assessment and scored relatively high.

Conclusion

Home-based testing showed higher use rates and follow-up treatment rates compared with clinic-based testing. It was demonstrated to be acceptable, safe, and convenient for users, which could lower the threshold for testing. Future research on diagnostic testing for diseases other than STIs and cost-effectiveness evaluation is needed. To conclude, this review showed that eHealth technologies for diagnostic testing could contribute to easy direct access to high-quality diagnostic testing for patients and has the potential to increase efficiency and possibility to reduce workload in primary care. In conclusion, direct web-based access to diagnostic testing showed promising results.

Conflicts of Interest

None declared.

List of abbreviations

HCP = health care professional
MMAT = Mixed Method Appraisal Tool
MSM = men who have sex with men
PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analyses
STI = sexually transmitted infection

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Appendix 1

Search terms for this systematic review.

PubMed

http://www.ncbi.nlm.nih.gov/pubmed?otool=leiden

(((("Clinical Laboratory Techniques"[majr:noexp] OR "Laboratory Technique"[tw] OR "Laboratory Techniques"[tw] OR "laboratory diagnosis"[tw] OR "Clinical Laboratory Tests"[tw] OR "Laboratory Test"[tw] OR "Laboratory Testing"[tw] OR "lab test"[tw] OR "lab tests"[tw] OR "lab testing"[tw] OR "Laboratory Examination"[tw] OR "diagnostic tool"[tw] OR diagnostic tool*[tw] OR "diagnostic assessment"[tw] OR diagnostic assessment*[tw] OR "diagnostic system"[tw] OR diagnostic system*[tw] OR "diagnostic test"[tw] OR diagnostic test*[tw] OR "self-test"[tw] OR self test*[tw] OR "home-based test"[tw] OR home-based test*[tw] OR "self-sampling"[tw] OR postal test*[tw] OR test kit*[tw] OR testing kit*[tw] OR tests kit*[tw] OR STI test*[tw] OR STD test*[tw] OR testing program*[tw] OR "HIVST"[tw] OR "self-swabbing"[tw]) AND ("health information technology"[ti] OR "health information systems"[ti] OR "interactive health communication"[ti] OR "patient portal"[ti] OR "Telemedicine"[majr] OR web portal*[ti] OR telemed*[ti] OR "ehealth"[ti] OR "e-health"[ti] OR "mhealth"[ti] OR "m-health"[ti] OR "mobile health"[ti] OR "telehealth"[ti] OR "tele-health"[ti] OR "tele health"[ti] OR "webbased"[ti] OR "web-based"[ti] OR "telemedicine"[ti] OR "tele-care"[ti] OR "telecare"[ti] OR "website"[ti] OR "websites"[ti] OR "webpage"[ti] OR "webpages"[ti] OR "web application"[ti] OR "web applications"[ti] OR "web access"[ti] OR "Internet"[majr] OR "internet"[ti] OR "online communication"[ti] OR "on-line communication"[ti] OR "on line communication"[ti] OR text message*[ti] OR "sms"[ti] OR "smart message service"[ti] OR "short message service"[ti]) NOT ("Animals"[mesh] NOT "Humans"[mesh])) **OR** "DirectLab"[all fields] OR "swab2know"[all fields] OR "getcheckedonline"[all fields] OR "e-STI"[all fields] OR "WeTest"[all fields] OR "SELPHI"[all fields] OR "eSexual"[all fields] OR "chlamyweb"[all fields]**)**

Embase

http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=main&MODE=ovid&D=oemezd

((("Laboratory Technique".ti,ab OR "Laboratory Techniques".ti,ab OR exp *"laboratory diagnosis"/ OR "laboratory diagnosis".ti,ab OR "Clinical Laboratory Tests".ti,ab OR "Laboratory Test".ti,ab OR "Laboratory Testing".ti,ab OR "lab test".ti,ab OR "lab tests".ti,ab OR "lab testing".ti,ab OR "Laboratory Examination".ti,ab OR "diagnostic tool".ti,ab OR diagnostic tool*.ti,ab OR "diagnostic assessment".ti,ab OR diagnostic assessment*.

ti,ab OR "diagnostic system".ti,ab OR diagnostic system*.ti,ab OR exp *"diagnostic test"/ OR "diagnostic test".ti,ab OR diagnostic test*.ti,ab OR "self-test".ti,ab OR self test*.ti,ab OR "home-based test".ti,ab OR home-based test*.ti,ab OR "self-sampling".ti,ab OR postal test*.ti,ab OR test kit*.ti,ab OR testing kit*.ti,ab OR tests kit*.ti,ab OR STI test*.ti,ab OR STD test*.ti,ab OR testing program*.ti,ab OR "HIVST".ti,ab OR "self-swabbing".ti,ab) AND ("health information technology".ti OR "health information systems".ti OR "interactive health communication".ti OR "patient portal".ti OR exp *"Telemedicine"/ OR exp *"Telehealth"/ OR "web portal*".ti OR telemed*.ti OR "ehealth".ti OR "e-health".ti OR "mhealth".ti OR "m-health".ti OR "mobile health".ti OR "telehealth".ti OR "tele-health".ti OR "tele health".ti OR "webbased".ti OR "web-based".ti OR "telemedicine".ti OR "tele-care".ti OR "telecare".ti OR "website".ti OR "websites".ti OR "webpage".ti OR "webpages".ti OR "web application".ti OR "web applications".ti OR "web access".ti OR exp *"Internet"/ OR "internet".ti OR "online communication".ti OR "on-line communication".ti OR "on line communication".ti OR text message*.ti OR "sms".ti OR "smart message service".ti OR "short message service".ti) NOT (exp "Animals"/ NOT exp "Humans"/)) **OR** "DirectLab".af OR "swab2know".af OR "getcheckedonline".af OR "e-STI".af OR "WeTest".af OR "SELPHI".af OR "eSexual".af OR "chlamyweb".af**)**

NOT (conference review or conference abstract).pt

Web of Science

http://isiknowledge.com/wos

((TS=("Laboratory Technique" OR "Laboratory Techniques" OR "laboratory diagnosis" OR "laboratory diagnosis" OR "Clinical Laboratory Tests" OR "Laboratory Test" OR "Laboratory Testing" OR "lab test" OR "lab tests" OR "lab testing" OR "Laboratory Examination" OR "diagnostic tool" OR "diagnostic tool*" OR "diagnostic assessment" OR "diagnostic assessment*" OR "diagnostic system" OR "diagnostic system*" OR "diagnostic test" OR "diagnostic test" OR "diagnostic test*" OR "self-test" OR "self test*" OR "home-based test" OR "home-based test*" OR "self-sampling" OR "postal test*" OR "test kit*" OR "testing kit*" OR "tests kit*" OR "STI test*" OR "STD test*" OR "testing program*" OR "HIVST" OR "self-swabbing") AND TI=("health information technology" OR "health information systems" OR "interactive health communication" OR "patient portal" OR "Telemedicine" OR "Telehealth" OR "web portal*" OR telemed* OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "webbased" OR "web-based" OR "telemedicine" OR "tele-care" OR "telecare" OR "website" OR "websites" OR "webpage" OR "webpages" OR "web application" OR "web applications" OR "web access" OR "Internet" OR "internet" OR "online communication" OR "on-line communication" OR "on line communication" OR "text message*" OR "sms" OR "smart message service" OR "short message service")

NOT ti=("veterinary" OR "rabbit" OR "rabbits" OR "animal" OR "animals" OR "mouse" OR "mice" OR "rodent" OR "rodents" OR "rat" OR "rats" OR "pig" OR "pigs" OR "porcine" OR "horse" OR "horses" OR "equine" OR "cow" OR "cows" OR "bovine" OR "goat" OR "goats" OR "sheep" OR "ovine" OR "canine" OR "dog" OR "dogs" OR "feline" OR "cat" OR "cats")) **OR** ts=("DirectLab" OR "swab2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb")**)**

Cochrane Library

https://www.cochranelibrary.com/advanced-search/search-manager

((("Laboratory Technique" OR "Laboratory Techniques" OR "laboratory diagnosis" OR "laboratory diagnosis" OR "Clinical Laboratory Tests" OR "Laboratory Test" OR "Laboratory Testing" OR "lab test" OR "lab tests" OR "lab testing" OR "Laboratory Examination" OR "diagnostic tool" OR "diagnostic tool*" OR "diagnostic assessment" OR "diagnostic assessment*" OR "diagnostic system" OR "diagnostic system*" OR "diagnostic test" OR "diagnostic test" OR "diagnostic test*" OR "self-test" OR "self test*" OR "home-based test" OR "home-based test*" OR "self-sampling" OR "postal test*" OR "test kit*" OR "testing kit*" OR "tests kit*" OR "STI test*" OR "STD test*" OR "testing program*" OR "HIVST" OR "self-swabbing"):ti,ab,kw AND ("health information technology" OR "health information systems" OR "interactive health communication" OR "patient portal" OR "Telemedicine" OR "Telehealth" OR "web portal*" OR telemed* OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "tele-health" OR "tele-health" OR "tele health" OR "webbased" OR "web-based" OR "tele-medicine" OR "tele-care" OR "telecare" OR "website" OR "websites" OR "webpage" OR "webpages" OR "web application" OR "web applications" OR "web access" OR "Internet" OR "internet" OR "online communication" OR "on-line communication" OR "on line communication" OR "text message*" OR "sms" OR "smart message service" OR "short message service"):ti) **OR** ("DirectLab" OR "swab2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb"):ti,ab,kw**)**

Academic Search Premier (full text search)

http://search.ebscohost.com/login.aspx?authtype=ip,uid&profile=lumc&defaultdb=aph

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nostic test" OR "diagnostic test" OR "diagnostic test" OR "self-test" OR "self test" OR "home-based test" OR "home-based test" OR "self-sampling" OR "postal test" OR "test kit" OR "testing kit" OR "tests kit" OR "STI test" OR "STD test" OR "testing program" OR "HIVST" OR "self-swabbing") AND TI("health information technology" OR "health information systems" OR "interactive health communication" OR "patient portal" OR "Telemedicine" OR "Telehealth" OR "web portal" OR telemed OR "ehealth" OR "e-health" OR "mhealth" OR "m-health" OR "mobile health" OR "telehealth" OR "tele-health" OR "tele health" OR "webbased" OR "web-based" OR "telemedicine" OR "tele-care" OR "telecare" OR "website" OR "websites" OR "webpage" OR "webpages" OR "web application" OR "web applications" OR "web access" OR "Internet" OR "internet" OR "online communication" OR "on-line communication" OR "on line communication" OR "text message" OR "sms" OR "smart message service" OR "short message service") NOT TI("veterinary" OR "rabbit" OR "rabbits" OR "animal" OR "animals" OR "mouse" OR "mice" OR "rodent" OR "rodents" OR "rat" OR "rats" OR "pig" OR "pigs" OR "porcine" OR "horse" OR "horses" OR "equine" OR "cow" OR "cows" OR "bovine" OR "goat" OR "goats" OR "sheep" OR "ovine" OR "canine" OR "dog" OR "dogs" OR "feline" OR "cat" OR "cats")) **OR** TI("DirectLab" OR "swab2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb") **OR** KW("DirectLab" OR "swab-2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb") **OR** SU("DirectLab" OR "swab2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb") **OR** AB("DirectLab" OR "swab-2know" OR "getcheckedonline" OR "e-STI" OR "WeTest" OR "SELPHI" OR "eSexual" OR "chlamyweb")**)**

Appendix 2

Mixed Method Appraisal Tool (MMAT)

In this table specific criteria per study design are described to assess the quality of study based on the MMAT.

Study designs	Quality criteria
Screening for all types	1.Are there clear research questions?
	2.Do the collected data allow to address the research questions?
Qualitative	1.Is the qualitative approach appropriate to answer the research questions?
	2. Are the qualitative data collection methods adequate to address the research question?
	3. Are the findings adequately derived from the data?
	4. Is the interpretation of results sufficiently substantiated by data?
	5.Is there coherence between qualitative data sources, collection, analysis and interpretation?
Quantitative randomized controlled (trials)	1.Is randomization appropriately performed?
	2.Are the groups comparable at baseline?
	3.Are there complete outcome data?[a]
	4.Are outcome assessors blinded to the intervention provided?
	5.Did the participants adhere to assigned intervention?
Quantitative non randomized	1.Are the participants representative of the target population?[b]
	2.Are the measurements appropriate regarding both the outcome and intervention (or exposure)?
	3.Are there complete outcome data? [a]
	4.Are the confounders accounted for in the design and analysis? [c]
	5.During the study period, is the intervention administered (or exposure occurred) as intended?[d]
Quantitative descriptive	1.is the sampling strategy relevant to address the research question?
	2.Is the sample representative of the target population?[e]
	3.Are the measurements appropriate?
	4.Is the risk of nonresponse bias low?
	5.IS the statistical analysis appropriate to answer the research question?
Mixed-methods	1.Is there an adequate rationale for using a mixed methods design to address the research question?
	2.Are the different components of the study effectively integrated to answer the research question?
	3.Are the outputs of the integration of qualitative and quantitative components adequately interpreted?
	4.Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?
	5.Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?

[a] The study scored a 'no' when the attrition or dropout is higher or equal to 20% (23)

[b] The study could have scored a 'no' for two reasons. First, when clear description of target population of target population and sample is given (by describing in and exclusion criteria), but reasons why people choose not to participate were not described. Second, the collected sample is not in line with target population (e.g., target population was 20-24 years old but a large proportion of sample is older than 24 years).

[c] The study scored a 'yes' if age, ethnicity and sexual orientation is taken into consideration.

[d] The study scored a 'yes' if the intervention or test kit was delivered in experimental group. The study scored a 'no' if the intervention or test kit was not properly delivered.

[e] The study could have scored a 'no' for two reasons. First, clear description target population or sample is missing and reasons are not discussed for why eligible participants choose not to participate. Second, collected sample is not in line with target population (e.g., target population was 20-24 years old but a large proportion of sample is older than 24 years).

Appendix 3

Service provider characteristics per study

		Testing					Result			
Service name	**Studya**	**Disease(s)**	**Type of home-based test**	**Type specimenb**	**Order, deliver, and return methodc**	**Instruction method**	**Method of notifi-cation**	**Independent HCP**	**Average delivery time in days**	**Linked to care or follow -up testingd**
Triage service										
Fai il test anche TU project	Polilli et al. [12]	HIV, hepatitis B and C, syphilis								
Testing service										
C-project	Martin et al. [38]	Chlamydia	Self-sampling	Urine	O: Online D: Postal service R: In-person	..				
Easy test	Jin et al. [34]	HIV	Self-testing	Blood	O: Online D: Postal service R: n/a	Written				
UCLA free HIV self-test program	Rosengren et al. [43]	HIV	Self-testing	Oral	O: Online D: Postal service or pick-up R: n/a	..				
Social entre-preneurship testing	Zhong et al. [47]	HIV Syphilis	Self-testing	Blood	O: Online D: Postal service R: Postal service[e]	..				

SELPHI	Witzel et al. [14]	HIV	Self-testing	Blood	O: Email D: Postal service R: n/a	Written, online videos			
	Witzel et al. [62]	HIV	Self-testing	Blood	O: Email D: Postal service R: n/a	Written, online *videos*			
Unknown name	Andersen et al. [25]	Chlamydia	Self-sampling	Vaginal (F) Urine (M)	O: Email or phone D: Postal service R: Post service	Written			
Unknown name	Reagan et al. [58]	Chlamydia Gonorrhea	Self-sampling	Urine	O: Phone D: Postal service R: Post service	Written			
Unknown name	Grandahl et al. [48]	Chlamydia Gonorrhea	Self-sampling	..	O: online D: Postal service R: ..	..			
	Grandahl et al. [64]	Chlamydia Gonorrhea	Self-sampling	..	O: online D: Postal service R: ..	..			
Result service									
GxAlert	Babirye et al. [15]	Tuberculosis				SMS	Yes	..	Yes
Syfilistest.nl	Koekenbier et al. [35]	Syphilis				Online	Yes	7 days	Yes
Early test	Morris et al. [39]	HIV				Online Phone	Partly	2-7 days	Yes

Table Continued

		Testing					Result			
Service name	**Studya**	**Disease(s)**	**Type of home-based test**	**Type specimenb**	**Order, deliver, and return methodc**	**Instruction method**	**Method of notifi-cation**	**Independent HCP**	**Average delivery time in days**	**Linked to care or follow -up testingd**
Result system of Denver Metro Health Clinic	Ling et al. [54]	Chlamydia, gonorrhea					Online	Partly	7 days	Unclear
Excelleris	Mák et al. [55]	Not limited to a specific disease					Online	Yes	..	No
Patient portal	Talboom-Kamp et al. [50]	Not limited to a specific disease					Online	Partly	..	Yes
myCARE system	Robinson et al. [65]	Not limited to a specific disease					Online	Partly	..	Yes
Triage & testing service										
A hora é Agora	De Boni et al. [27]	HIV	Self-testing	Oral	O: Online D: Postal service or pick-up R: n/a	Written				
Online Chlamydia Testing program	Kwan et al. [36]	Chlamydia, gonorrhea	Self-sampling	Vaginal (F) Urine (M)	O: Online D: Pick-up service R: In-person	Online				
Swab2Know	Platteau et al. [41]	HIV	Self-sampling	Oral	O: Online D: Postal service R: Post service	Online video	Online Email Phone	Partly	7 days	Yes

Don't think, know	Rotblatt et al. [44]	Chlamydia, gonorrhea	Self-sampling	Vaginal	O: Online, phone D: Postal service R: Post service	Written, online video	Online Phone	Partly	7 days	Yes
Testikodus	Rüütel et al. [45]	Chlamydia, gonorrhea, tricho-monas, LGV, myco-plas-mosis	Self-sampling	Urine	O: Online D: Postal service R: Post service, in-person	..	Online	Yes	5 days	Yes
RUClear	Ahmed-Little et al. [61]	HIV	Self-sampling	Blood	O: Online D: Postal service R: Post service	Written, online video	Phone SMS Letter	Partly	..	Yes
Triage, testing & result service										
DS@H	Elliot et al. [28]	HIV	Self-sampling	Oral, blood	O: Online D: Postal service R: Post service	Written	SMS Phone	Partly	1 day after sample received	Yes
GetChecked Online	Gilbert et al. [13]	Chlamydia, gonorrhea	Self-sampling	Urine, oral, rectal	O: Online D: Pick-up R: In-person	Written	Online Phone	Partly	7-14 days	Yes
	Gilbert et al. [52]	Chlamydia, gonorrhea	Self-sampling	Urine, oral, rectal	O: Online D: Pick-up R: In-person	Written	Online Phone	Partly	7-14 days	Yes
	Knight et al. [63]	Chlamydia, gonorrhea	Self-sampling	Urine, oral, rectal	O: Online D: Pick-up R: In-person	Written	Online Phone	Partly	7-14 days	Yes
	Dulai et al. [49]	Chlamydia, gonorrhea	Self-sampling	Urine, oral, rectal	O: Online D: Pick-up R: In-person	Written	Online Phone	Partly	7-14 days	Yes

Table Continued

		Testing					Result			
Service name	**Studya**	**Disease(s)**	**Type of home-based test**	**Type specimenb**	**Order, deliver, and return methodc**	**Instruction method**	**Method of notifi-cation**	**Independent HCP**	**Average delivery time in days**	**Linked to care or follow -up testingd**
Let's talk about it NHS	Nadarzynski et al. [40]	Chlamydia, gonorrhea, HIV, syphilis, hepatitis B and C	Self-sampling	Vaginal (C&G), blood (S, H, HepB/C)	O: Online, phone D: Postal service R: Post service	Written, online video	SMS Phone	Partly	7 days	Yes
Checking In	Ricca et al. [42]	HIV	Self-sampling	Blood	O: Online D: Postal service R: Post service	..	Phone	Partly	7 days	Yes
eSTI	Spielberg et al. [46]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Vaginal	O: Online D: Postal service R: Post service	..	Online	Yes	..	Yes
SH:24	Barnard et al. [51]	Chlamydia, gonorrhea, HIV, syphilis	Self-sampling	Blood (S&H), vaginal (C&G in F), urine (C&G in M), and oral, rectal, and urine (C&G in MSM)	O: Online D: Postal service R: Post service	Written, online video	SMS Phone	Partly	7 days	Yes

	Wilson et al. [59]	Chlamydia, gonorrhea, HIV, syphilis	Self-sampling	Blood (S&H), vaginal (C&G in F), urine (C&G in M), and oral, rectal, and urine (C&G in MSM)	O: Online D: Postal service R: Post service	Written, online video	SMS Phone	Partly	7 days	Yes
	Wilson et al. [60]	Chlamydia, gonorrhea, HIV, syphilis	Self-sampling	Blood (S&H), vaginal (C&G in F), urine (C&G in M), and oral, rectal, and urine (C&G in MSM)	O: Online D: Postal service R: Post service	Written, online video	SMS Phone	Partly	7 days	Yes
Freetesting.hiv	Brown et al. [56]	HIV	Self-sampling	Blood	O: Online D: Postal service R: Post service	Written, online video	SMS Phone	Partly	7 days	Yes
Chlamyweb	Kersaudy-Rahib et al. [57]	Chlamydia	Self-sampling	Vaginal (F), urine (M)	O: Online D: Postal service R: Post service	..	Email Post	Partly	..	Yes
I Want The Kit[f]	Chai et al. [26]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Penile, urine	O: Online D: Postal service R: Post service	Written	Phone	No	..	Yes

Table Continued

		Testing					Result			
Service name	**Studya**	**Disease(s)**	**Type of home-based test**	**Type specimenb**	**Order, deliver, and return methodc**	**Instruction method**	**Method of notification**	**Independent HCP**	**Average delivery time in days**	**Linked to care or follow-up testingd**
	Gaydos et al. [31]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Vaginal	O: Online, phone D: Postal service, pick-up R: Postal service	Written	..	..	..	..
	Gaydos et al. [32]	Chlamydia	Self-sampling	Vaginal	O: Online, phone D: Postal service, pick-up R: Postal service	Written	..	..	..	..
	Gaydos et al. [33]	Chlamydia	Self-sampling	Vaginal	O: Online, phone D: Postal service, pick-up R: Postal service	Written	Phone	No	14 days	Yes
	Gaydos et al. [29]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Urogenital, rectal	O: Online D: Postal service R: Postal service	Written	..	..	..	..
	Gaydos et al. [30]	Trichomonas	Self-testing	Vaginal	O: Online D: Postal service R: Postal service[g]	Written	..	..	..	Unclear

	Kuder et al. [53]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Urogenital, rectal	O: Online, phone D: Postal service R: Postal service	Written	Online	Yes	··	Yes
	Ladd et al. [37]	Chlamydia, gonorrhea, trichomonas	Self-sampling	Rectal, vaginal	O: Online, phone D: Postal service R: Postal service	Written	SMS Email Phone Letter	Unclear	··	··

Note. HCP= health care professional. HIV = human immunodeficiency virus. SMS = short message service. MSM = men having sex with men. C&G = Chlamydia and Gonorrhea. S&H= Syphilis and human immunodeficiency virus. LGV = Lymphogranuloma venereum. ··= missing info

[a] Identifies the first author and publication year of the study examining the respective service.
[b] If the required type of specimen differed between sexes, an F behind the specimen indicated that it was for women and an M indicated it was for males. When a provider offered testing for different diseases, the required specimen per disease was specified.
[c] Identifies the method used for ordering (O), delivering (D) and receiving (R) the test kit.
[d] Identifies whether the individual is directly linked to care or to follow-up testing.
[e] If participants returned the test results to the laboratory, participants were refunded the money for the test.
[f] The service was listed as triage, testing and result service; however, the communication of test results was not independent from a health care professional in each of the studies that examined the service or it was unclear whether the communication of test results was independent from a health care professional.
[g] Returning the test kit was optional.

Appendix 4

Overview of the reported outcomes for the triage, testing, and result services

Outcome	Study	Servicea	Results
Triage service			
Usage	Polilli et al. [12]	Tr	About 6000 users visited the website, a little over 5000 users also completed the risk assessment, and nearly 3500 made an appointment for clinic-based testing.
Linkage to testing or treatment	Polilli et al. [12]	Tr	A total 3500 users scheduled a clinic-based test and 87% was present for testing. In total, 28 individuals (<1%) were tested positive for HIV, and 93% were linked to care.
Predictive value of risk assessment	Gaydos et al. [29]	Tr, Te, Re	In females, a higher risk assessment score predicted the risk for having a STI, independent of age and race. In males, the risk score did not significantly predict STI after controlling for race.
Testing service			
Acceptability/ usability	Ahmed-Little et al. [61]	Tr, Te	Among 2563 respondents, 97% (strongly) agreed that it was acceptable to order a HIV test kit online, 80% felt that this method of testing was easily accessible, 94% found the test instructions easy to understand.
	Chai et al. [26]	Tr, Te, Re	Among the 476 respondents, 75% preferred a self-test versus a clinic-based test, 85% believed it was safe, 88% found it (very) easy to use, and 89% would use internet-screening again.
	De Boni et al. [27]	Tr, Te	Among the 362 respondents, 91% found the website (very) easy to use, 72% had no difficulties navigating the website, 6% could not find the pages they were searching for, and 94% found the instructions for testing clear.
	Gaydos et al. [30]	Tr, Te, Re	Among the 102 respondents, 84% found it easy to follow the instructions for the STI test kit, 95% found it easy collect the specimen, 90% found it easy to interpret the results, and 97% (somewhat) trusted the results. Moreover, 62% preferred self-testing, 77% would recommend the test to a friend, and 80% would get the test if it were available of the counter.
	Gaydos et al. [32]	Tr, Te, Re	Of the 1171 respondents, 92% would use this program for STI tests kits again, 91% preferred self-collection specimens over the clinic, and 97% reported that it was (very) easy to use the kit.

	Gaydos et al. [33]	Tr, Te, Re	Of the 400 respondents, 89% preferred to collect a self-administered test sample, 88% believed it was safe, 90% thought it was (very) easy to use, 86% would use this method of online ordering and home testing again, and 73% preferred at-home delivery of the test kit compared to a pharmacy pickup.
	Knight et al. [63]	Tr, Te, Re	A total of 37 users of an online diagnostic service participated in qualitative interviews. Most users had a preference for this platform instead of clinic-based testing, because of convenience, privacy, and control over specimen collection. Users preferred receiving their results online via the platform compared to phone or email by a clinic staff.
	Kwan et al. [36]	Tr, Te	Among the 55 respondents, 96% reported that the Chlamydia testing program was easy to use and 98% would recommend it to a friend.
	Reagan et al. [58]	Te	Among the 129 respondents, 95% found it easy to follow the instructions for the STI test kit.
	Rosengren et al. [43]	Te	Among the 56 respondents, 93% found the HIV test kit (very) easy to use and 74% (somewhat) preferred the test kit over clinical testing.
	Spielberg et al.[46]	Tr, Te, Re	Among the 106 respondents, 95% prefer the online over clinical testing, 80% would rather test online than go to the clinic for future testing, and 98% would recommend the study to a friend.
	Wilson et al. [60]	Tr, Te, Re	Of the 84 respondents of the group that did online STI testing, 75% found the process of online ordering a STI test, at-home sampling and receiving results online acceptable.
	Wilson et al. [59]	Tr, Te, Re	Among 294 respondents of the group that did online STI testing, 71% found the process of online ordering a STI test, at-home sampling, and receiving the result via a SMS acceptable.
	Witzel et al. [14]	Te	Among the 375 respondents, 98% found the instructions of the HIV test kit easy to understand, 97% found the test kit simple to use and 97% reported an overall good experience.
	Dulai et al. [49]	Tr, Te, Re	Among the 1255 respondents who filled in the survey at this question, 33.1% reported that they found it easier to go to the clinic. Among those who used the service, 44 respondents of 1268, 90% would use the service again.
	Grandahl et al. [48]	Te, Re	Among the 1785 respondents, more than 90% found the service good or very good.

Table Continued

Outcome	Study	Servicea	Results
	Grandahl et al. [64]	Te, Re	A total of 20 users of an online diagnostic service participated in qualitative interviews. Most users highly appreciated the service and found the service easy to use, convenient and confidential. Some barriers they mentioned were language, uncertainty about the procedure, unreliable postal service and insecure handling of data. They would use the service again in the future, even if it was against some costs.
Cost-effectiveness	Ahmed-Little et al. [61]	Tr, Te	Overall costs for testing, per person, were £31-£32 (€26.47-€27.32), which is in line with testing costs in national HIV testing pilots.
	Kersaudy-Rahib et al. [57]	Tr, Te, Re	Home-based self-sampling for chlamydia was €32 per kit compared to €73 for clinical testing. The costs per positive tests were three times higher in the STI clinics than for home tests (€1123 versus €375).
Usage	Ahmed-Little et al. [61]	Te	In total 5179 HIV test kits that were send out and 59% were returned.
	Andersen et al. [25]	Te	The website was visited by 651 people of whom 9% ($n = 60$) ordered a chlamydia test kit online. Another 309 ordered a kit through an answering machine. In the end, 342 were sent a kit and 68% submitted a sample for analysis.
	Barnard et al. [51]	Tr, Te, Re	A STI kit was ordered by 3515 people whom 73% returned a sufficient sample.
	Brown et al. [56]	Tr, Te, Re	Of the 8999 who ordered a HIV self-sampling kit, 54% returned their kit. Kit return was highest in the group that received a primer text message prior to the kit's arrival and additional behavioral insight reminders (56% of $n = 2267$).
	Chai et al. [26]	Tr, Te, Re	In total 1644 STI home tests were ordered online, and 31% of the ordered tests were returned of which 98% as analyzed.
	De Boni et al. [27]	Tr, Te	The website had 17.786 unique visitors, 3885 HIV self-test kits were ordered of which 65% received the test. 21% of the users returned the self-test result online.
	Elliot et al. [28]	Tr, Te, Re	In total 17361 people completed the online risk assessment for a HIV self-sampling kit, 59% ordered a kit ($n = 10.323$). 55% returned the sample for analyses.
	Gaydos et al. [31]	Tr, Te, Re	In total, 3774 people ordered a chlamydia self-sampling test and 32% also returned the sample.
	Gilbert et al. [13]	Tr, Te, Re	In total 868 users created an account at the testing service, of whom 318 users submitted specimens (37%).
	Kersaudy-Rahib et al. [57]	Tr, Te, Re	In the group ($n = 5531$) offered a chlamydia self-sampling test, 2616 users received the test of whom 1616 returned the sample (62%). Test rates were higher in the group that received a self-sampling kit compared to the group that was invited to be screened in primary care (29 vs 9%).

	Kuder et al. [53]	Tr, Te, Re	The kit return rate was 62% (691/1116) before an automated test-result service was implemented and was 66% (858/1303) after implementation. The experimental group (n=1303), after web design changes to order a STI test kit, 62% used the test. The control group (n=1116), before website design changes, 66% used the test.
	Kwan et al. [36]	Tr, Te	In total, 675 users completed an online risk assessment and requested a chlamydia self-sampling test. A total of 377 tests were performed (56%).
	Ladd et al. [37]	Tr, Te, Re	In total, 406 people ordered a test kit for rectal STIs of whom 51% returned specimen.
	Martin et al. [38]	Te	413 chlamydia test kits were ordered (48% via email, 49% during outreach events, 2% via phone). 195 samples (43%) were returned.
	Reagan et al. [58]	Te	STI kit return rate was higher in the group that received the self-sampling kit at home compared to those who received it at a clinic (resp. 72 vs 48%).
	Ricca et al. [42]	Tr, Te, Re	In total 896 users received a HIV self-sampling test kit, 82% returned the specimen for analysis.
	Rosengren et al. [43]	Te	The website received 4389 unique visitors and resulted in 333 request for a HIV test kit. In the group who completed the follow-up survey (n = 56), everyone used the kit.
	Rotblatt et al. [44]	Tr, Te	In total 2927 STI self-sampling kits were ordered online or via phone, of which 55% returned their specimen for analyses. The majority (95%) of the specimen were usable for analyses.
	Rüütel et al. [45]	Tr, Te	24% of those who ordered a self-sampling STI test, provided the specimen (65/265).
	Spielberg et al. [46]	Tr, Te, Re	In total 213 people ordered a STI self-sampling test kit, 67% returned the specimen.
	Wilson et al. [60]	Tr, Te, Re	People who were willing to do an STI test were randomized to receive a text message with referring them to a website with either an online test service or a list with the locations of clinics. In the group referred to online testing, the test rate was significantly higher (45 vs 24%) and there was a reduced time to test (29 vs 36 days).

Table Continued

Outcome	Study	Servicea	Results
	Wilson et al. [59]	Tr, Te, Re	In the group(n = 921) who received home tests and the results online, 50% did the STI test in comparison with 27% in the group(n = 818) who were offered a test and results at the clinic. This was a significant difference. The time from randomization in to the groups to completion of the STI test was shorter in the group who did home testing(28.8 days versus 36.5 days). This was a significant difference. The median time from diagnosis to treatment was for the group who did home testing group 2 days and for the control group 4 days
	Witzel et al. [14]	Te	In total 631 users were sent a HIV test kit. In the two-week follow-up survey, completed by n = 405, 95% indicated having received the kit and 83% had used it. People had not used it, if they planned to use it later (97%) or had tested elsewhere (3%).
	Zhong et al. [47]	Te	198 HIV self-test kits were ordered online, and 192 provided feedback. Of these, 178 (93%) had used the test.
	Grandahl et al. [48]	Te, Re	Among the 1785 users, 85% returned their sample. Reasons for not returning the kit were lack of time(22.5%) or they were no longer worried (12.1%).
Other outcomes	Martin et al. [38]	Te	Among the 195 respondents, a common reason for requesting a chlamydia test kit was that it was for free (49%) and easy to get (39%).
	Witzel et al. [14]	Te	Motivations of users to do HIV self-testing: (a) reduced HIV testing barriers (opportunity barriers such as convenience and ease of use and motivational barriers like confidentiality and stigma), (b) desire to use new technology, and (c) altruistic motivation.
	Zhong et al. [47]	Te	Among the 198 respondents, the two main reasons for doing a HIV self-test were convenience and to save time (46%), and privacy (40%). Facilitators to use the purchased HIV self-test were anonymity (56%), ease of use (49%), and ability to test alone (41%). Barriers were accuracy (43%), potential costs (40%), and concern about having to interpret the results (36%). Besides, 67% of the respondents reported that they would use the test kits in the future if it was free.
	Dulai et al. [49]	Tr,Te,Re	Among the 1247 respondents who filled in this question at the survey, 20 percent was worried the *privacy* of his online information and 5% had low trust in this service.
	Witzel et al. [62]	Te	Reasons for using HIV self-testing by trans men and women were inaccessible and inappropriate clinical services.

Result service			
Usage	Gilbert et al. [52]	Tr, Te, Re	Users of the online platform had significant shorter waiting time for the test results than clinic clients (respectively 1% versus 12% was still waiting on the test results at the time of the survey)
	Koekenbier et al. [35]	Re	Of all the 93 users, 97% obtained their results from the website
	Ling et al. [54]	Re	Test result retrieval was assessed in three periods. In period 1 (n=3624) results were communicated over the phone. In period 2 (*n* = 3931), online results were optional and 41% opted to receive their results online. In period 3 (*n* = 1501), online results was the standard. In period 2 and 3, significantly more users received their results in the group that opted for online results compared to the group that opted to receive their results over the phone. 74% of those in period 2 and 3 who opted or accepted online results also accessed their results. Yet the overall proportion of users who received their results was not significantly different before or after the online result option became available. The number of users who called for results did decrease significantly from period 1 (67%) to period 3 (36%).
	Morris et al. [39]	Re	Among the 3070 users, 69% obtained their results either by the Internet or via an automated voicemail service. Of this group, 65% used the Internet to look up their result.
	Platteau et al. [41]	Tr, Te	In total 1071 tests were done, 99% of results (1057/1071) were delivered through the website. Significantly more users collected their test results when the test was ordered online compared to tests performed during outreach activities (98% vs 87%).
	Rotblatt et al. [44]	Tr, Te	In total 1619 tests were done, 88% of the users retrieved their results on the website.
	Spielberg et al. [46]	Tr, Te, Re	In total 143 tests were done, of those 92% viewed their results online, with 88% who viewed their results the same day they were posted.
Comprehension	Babirye et al.[15]	Re	In total 123 respondents were reached via text message, 93% comprehended the text message with test result.
	Mák et al. [55]	Re	Among the 1852 respondents, 75% who had online access to their test results was confident that they fully understood the results. Among the 1119 respondents who had no online access to their results, the comprehension was significantly higher, namely 85%.

Table Continued

	Robinson et al. [65]	Re	Among the 21 respondents the comprehension of the results differed from difficulty with understanding of the results to no difficulty. However, users who mentioned that they had difficulties with understanding the result described that the reference range of their result was very helpful and this made it easier to use.
	Nadarzynski et al. [40]	Tr, Te, Re	Among the 100 respondents, 13% who received a text message with their results indicated that they did not understand its content, 92% of the respondents understood that no further action is required when a text message states that the STI test is "negative (clear)".
Acceptability	Ling et al.[54]	Re	In total 429 respondents filled in the questionnaire. Two main reason for opting for online results was (a) that test results could be accessed any time of the day (75%) and (b) because respondents believed that they would receive their results faster (37%). Two main reasons for declining online results was (a) that respondents preferred to call the clinic (43%) and (b) because of limited access to the internet (32%).
	Morris et al. [39]	Re	Among the 235 respondents, 87% was (very) comfortable with receiving their results online.
	Platteau et al. [41]	Tr Te	Among the 388 respondents, 96% were very satisfied with the process of ordering a test kit online and receiving the results online, 4% reported mixed feelings.
	Spielberg et al. [46]		Among the 106 respondents, 98% thought the website – that offered triage, testing and result service - was (very) easy to use.
Other outcomes	Babirye et al. [15]	Re	In Uganda, 233 users were eligible to receive an SMS with their tuberculosis test result. 152 of these users (correctly) entered their phone number (65%), with 145 messages being transmitted by the local SMS service provider to the phone network (95%). A total of 123 users were contacted of whom 93% confirmed having received the result.
	Mák et al. [55]	Re	Group 1 (n = 1856) received test results online, 84% of those received their results within a few days. Group 2 (n = 1087) had not online access to their results, 38% of those received their results in a few days. This difference in wait time was significant. Of 2990 questionnaire respondents, 86% reported no/low anxiety after results. This level differed not between users with online access versus those who had not.

	Nadarzynski et al. [40]	Tr, Te, Re	Of the 115 questionnaire respondents, 86% preferred text messages that included the names of the tested STI and that included the results of all STIs tested (in one message).
	Robinson et al. [65]	Re	Users felt feel more comfort and engaged with their health care when they see the results themselves. This service is not limited to a specific disease. Besides they reported that it had no negative effects on themselves, seeing the results. Besides, they thought that it would lead to better communication with the HCP. Reasons for the users to use this online result portal were this better communication, convenience and being a steward of own health care.
	Talboom-Kamp et al. [50]	Re	The questionnaire was completed by 354 of 13907 patients who viewed their results of their laboratory test online (not limited to a specific disease). In this questionnaire the Information and Presentation score was measured and scored a 67.70 (SD 13.12) and the mean Motivation and Confidence to Act score was 63.59 (SD 16.22). Those are two subscales of the eHIQ. These results showed that users found online viewing results easy to use, trustworthy and appropriate. The self-efficacy of users was also relatively high according to this score, but below the cutoff score for a positive attitude.
Test and result services			
Follow up testing and treatment[b]	Ahmed-Little et al. [61]	Tr, Te	3062 tests were done, seven infections were detected, and 100% did confirmatory testing.
	Chai et al. [26]	Tr, Te, Re	501 tests were done, 21% was tested positive, and 99% of those tested positive were treated.
	De Boni et al. [27]	Tr, Te	Among the 542 tests, 34 (6%) were positive or invalid. In total 37 users did a confirmatory tests: 30 were positive.
	Elliot et al. [28]	Tr, Te, Re	Among the 5249 unique tests, 2% tested positive for HIV. Of those, 67% were confirmed as new HIV diagnosis and received treatment, 11% were false reactive, 11% already diagnosed with HIV, and for 10% treatment was unconfirmed.
	Gaydos et al. [32]	Tr, Te, Re	Among the 1171 users, four (0.3%) had a positive test and all were treated.
	Gaydos et al. [31]	Tr, Te, Re	Among the 1203 tests, 9.1% was tested positive for chlamydia of which 96.5% was treated. Among the 496 tests for gonorrhea or trichomonas, everyone with a positive test for gonorrhea (3%) or trichomonas (7%) were treated.
	Jin et al. [34]	Te	Of the 879 people who were eligible for HIV self-testing and received the test kit. Among the 683 returned a photograph of the test result, 98(14%) had a positive test result and of those 72% received treatment.

Table Continued

Outcome	Study	Servicea	Results
	Kersaudy-Rahib et al. [57]	Tr, Te, Re	In the group (*n* = 5531) who received their chlamydia test kit at home 110 (7%) was tested positive and 91% visited a doctor. In the group who were invited to test in primary care setting, 30(6%) tested positive and 87% had seen a doctor.
	Koekenbier et al. [35]	Re	Among the 93 tests, 15% tested positive and, of those, 71% did confirmatory testing.
	Kuder et al. [53]	Tr, Te, Re	In the group that needed to call for their test result (n = 691), 11% tested positive and 58% of the positive tests received treatment. In the group(n= 858), with an website with automated test result service, 10% tested positive and 87% of the positive users received treatment
	Kwan et al. [36]	Tr, Te	Among the 377 tests, 18% of the users tested positive for chlamydia or gonorrhea and 100% of the positive tested users were treated and 94% was treated within 14 days.
	Ling et al. [54]	Re	When results were communicated over the phone (*n* = 193), 81% confirmed treatment within 30 days. When online results were optional (*n* = 240), 82% confirmed treatment and, when online results were the norm (*n* = 110), 71% confirmed treatment. The difference was not significant.
	Platteau et al. [41]	Tr, Te	Among the 1071 tests, 2% were HIV positive and 100% of the positive tested users were linked to care.
	Ricca et al. [42]	Tr, Te, Re	Among the 735 tests, 25 users tested positive for HIV (3%) 14 sought care, three had not and for eight it is unknown.
	Rosengren et al. [43]	Te	56 users reported the results of the HIV self-test (45%), of whom 4% tested positive. All positive tested users did confirmatory testing and had medical care.
	Rotblatt et al. [44]	Tr, Te	Among the 1619 tests, 8% tested positive for a STI. For 88% of the positive users, treatment was confirmed.
	Spielberg et al. [46]	Tr, Te, Re	Among the 143 tests, 6% were tested positive and all received treatment.
	Zhong et al. [47]	Te	Among the 178 tests, six tests were positive for STI and 8 were positive for HIV. All did confirmatory testing, where seven HIV positive results were confirmed and all received treatment.

Note. STI = sexually transmitted infection. HIV = human immunodeficiency virus. SMS = short message service.

[a] The abbreviations highlight the type of service: Tr= Triage service, Te= Test service, Re= Result service.

[b] Data related to follow up testing and treatment is discussed simultaneously testing and result services to avoid overlap because it referred to both outcome measures.

3

Digital Triage Tools for Sexually Transmitted Infection Testing Compared With General Practitioners' Advice: Vignette-Based Qualitative Study With Interviews Among General Practitioners

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Abstract

Background: Digital triage tools for sexually transmitted infection (STI) testing can potentially be used as a substitute for the triage that general practitioners (GPs) perform to lower their work pressure. The studied tool is based on medical guidelines. The same guidelines support GPs' decision-making process. However, research has shown that GPs make decisions from a holistic perspective and, therefore, do not always adhere to those guidelines. To have a high-quality digital triage tool that results in an efficient care process, it is important to learn more about GPs' decision-making process.

Objective: The first objective was to identify whether the advice of the studied digital triage tool aligned with GPs' daily medical practice. The second objective was to learn which factors influence GPs' decisions regarding referral for diagnostic testing. In addition, this study provides insights into GPs' decision-making process.

Methods: A qualitative vignette-based study using semistructured interviews was conducted. In total, 6 vignettes representing patient cases were discussed with the participants (GPs). The participants needed to think aloud whether they would advise an STI test for the patient and why. A thematic analysis was conducted on the transcripts of the interviews. The vignette patient cases were also passed through the digital triage tool, resulting in advice to test or not for an STI. A comparison was made between the advice of the tool and that of the participants.

Results: In total, 10 interviews were conducted. Participants (GPs) had a mean age of 48.30 (SD 11.88) years. For 3 vignettes, the advice of the digital triage tool and of all participants was the same. In those vignettes, the patients' risk factors were sufficiently clear for the participants to advise the same as the digital tool. For 3 vignettes, the advice of the digital tool differed from that of the participants. Patient-related factors that influenced the participants' decision-making process were the patient's anxiety, young age, and willingness to be tested. Participants would test at a lower threshold than the triage tool because of those factors. Sometimes, participants wanted more information than was provided in the vignette or would like to conduct a physical examination. These elements were not part of the digital triage tool.

Conclusions: The advice to conduct a diagnostic STI test differed between a digital triage tool and GPs. The digital triage tool considered only medical guidelines, whereas GPs were open to discussion reasoning from a holistic perspective. The GPs' decision-making process was influenced by patients' anxiety, willingness to be tested, and age. On the basis of these results, we believe that the digital triage tool for STI testing could support GPs and even replace consultations in the future. Further research must substantiate how this can be done safely.

Keywords: eHealth; digital triage tool; sexually transmitted infection; STI; human immunodeficiency virus; general practitioners; GPs decision-making; digital health; diagnostic; sexually transmitted disease; STD; sexually transmitted; sexual transmission; triage; artificial intelligence; HIV; diagnostics; diagnosis; vignette; vignettes; interview; interviews; best practice; best practices; thematic analysis; referral; medical advice

Introduction

Background

The use of eHealth, health services delivered through the internet or related technologies, is increasing, especially since the COVID-19 pandemic [1,2]. The COVID-19 pandemic has shed light on the crucial role of digitization in health care [2]. An important and promising element of digitization in health care are digital triage tools consisting of a questionnaire for patients to identify the risk of a medical problem. These tools use a digital questionnaire typically administered by a health care professional, and an algorithm based on a medical decision tree generates automatic advice for follow-up, for example, a web-based symptom checker. In this paper, we discuss a digital triage tool that advises whether a specific diagnostic test for a specific combination of symptoms is necessary. This specific digital triage tool is based on Dutch medical guidelines.

Such a digital triage tool for different problems and symptoms could be an efficient and accessible method for citizens with medical questions. In addition, this digital triage tool could possibly lower the workload of general practitioners (GPs) as it can replace the triage that health care professionals would do themselves [3]. However, it is important that triage leads to responsible and appropriate care given the situation. Digital triage tools should not result in "over-triage" or "under-triage" [4]. Over-triage is when a patient is advised to undergo a medical treatment or diagnostic test when they do not have an (urgent) medical problem [4]. Under-triage is when a patient is told that they do not have an (urgent) medical problem when they do, with the advice that a diagnostic test or medical treatment is not necessary [4]. It is important to know whether the digital triage tool for diagnostic tests is in line with daily medical practice to maximize its validity.

In daily practice at GPs' offices, medical guidelines are used to support their decision-making. GPs following guidelines has been an important research subject into the decision-making process of GPs in dermatology has shown that GPs do not always adhere to medical guidelines [5]. For example, concerns about the patient or the relationship between the GP and the patient were sometimes part of the decision-making process [5]. Furthermore, a meta-synthesis of qualitative studies identified GPs' attitudes toward and experiences with clinical guidelines [6]. First, this study showed that GPs experience tension between their own experiences and the guidelines they must adhere to as guidelines do not consider personal circumstances. Second, GPs are afraid of missing a patient diagnosis. Third, GPs experience that the guidelines do not always fit with patients' needs, and therefore, GPs act differently from what the guidelines instruct them to do. Earlier reviews have revealed other factors that play a role in the decision-making process of GPs in referrals for diagnostic tests [7-9]. These are, among others, demographic and nonclinical factors such as patient characteristics (eg, age, sex, and social class [8]). In addition, the patient's quality of life and wishes are nonclinical factors that influence the decision-making process of the GP [7]. Not all those

factors are included in medical guidelines and, consequently, in digital triage. All these factors clearly show that the GP makes decisions from a holistic perspective, which makes it even more interesting and important to critically consider decision-making using digital tools from the perspective of the GP. Regarding diagnostic testing, to our knowledge, our study is the first one that compares the advice of GPs with that of a web-based tool. At the same time, this study identifies what factors influence a GP's decision-making process for a diagnostic test.

Objectives

If a digital triage tool is of high quality and the patient is adequately advised, a consultation with the GP could be avoided, resulting in an efficient care process for the patient. The GP can also be supported in the hectic daily workload as the patient uses the tool independently [9]. The first objective of this study was to identify whether the advice of the studied digital triage tool aligned with the daily medical practice of the GP. The second objective was to learn which factors influenced the GP's decision regarding a referral for diagnostic testing. In addition, this research provides insights into the GP's decision-making process and whether factors are possibly missing from a digital triage tool. As a starting point, we investigated these research questions for sexually transmitted infection (STI) triage as the medical guidelines are straightforward (eg, clear risk factors and answer categories). Much research has been conducted on digital applications for STI testing, such as websites in which tests can be ordered, with positive feedback from patients about their usability [10]. Moreover, research has shown that a digital triage tool can potentially lower the threshold for STI testing [10] as this problem can be associated with feelings of shame [11]. To answer the research questions, a vignette-based qualitative study was conducted based on different STI-related patient cases [12].

Methods

Study Design and Participants

A qualitative vignette study was conducted using semistructured interviews with GPs as participants. Data saturation was expected after 10 interviews [13]. There were no specific exclusion criteria. GPs in training, practicing, or retired (for ≤5 y) could participate. In the interviews, the participants were presented with different patient vignettes (see the Materials section for details). After each vignette, the participants were asked about their clinical decision regarding STI diagnostic testing and to describe their thinking and decision-making process. This approach is called the "Think Aloud" method, which allows for a description of how information is structured during a problem-solving task [14]. In addition, it provides rich data for analysis [15].

Ethical Considerations

This study was declared not to fall within the scope of the Dutch Medical Research Involving Human Subjects Act by the departmental ethics committee of the Leiden University Medical Center (reference 22-3002).

Materials

A vignette is a short hypothetical description of a patient representing a standardized combination of specific characteristics [16]. Vignettes made it possible to present patients with the same characteristics to every participant (eg, complaints, relationship status, and age) and, in this way, minimize variations between patients, which is not possible in real life. In this study, the vignettes were based on different aspects of the Dutch medical guidelines for STI testing [17]. In the medical guidelines, different aspects are taken into account to calculate the risk of an STI, such as endemic areas, unsafe sex, and different complaints. The following factors were incorporated into the vignettes: age, gender, sexuality, relationship status, employment (eg, fulltime job or student), history of unsafe sex and how long ago it took place, number of sexual partners, frequency of unsafe sex, frequent GP visits, symptoms, and ethnicity. Some of these factors are not in the guidelines but were included to research whether they influenced the decision-making process of the GP (eg, situation and if the GP was visited often by that patient). In addition, the vignettes were designed in such a way that they would lead to advice from participants to undergo a diagnostic test for STIs or not. In total, 6 different vignettes were created and used (Multimedia Appendix 1). In Textbox 1, a short description of the vignettes is provided. The Dutch vignettes were designed with a GP and checked by another GP. An example of a translated vignette can be found in Textbox 2.

Procedure

Participants were recruited via a LinkedIn post that included the email address of the researcher. Interested participants were instructed to send an email if they wanted to take part. In addition, participants were emailed from the network of the researchers, and the GPs could reply to the email if they wanted to participate. Interested participants were sent information and the informed consent form. In addition, different data and time points were included in the interviews, which could be face-to-face or digital (based on the preference of the participant). Participants had the right to withdraw at any time.

An interview protocol guided the semistructured interviews (Multimedia Appendix 2). All interviews were audio recorded. Each interview started with a short explanation of the study. The first vignette was then read out loud to the participant. They were asked whether they would advise undergoing diagnostic tests for STIs. Next, they were asked to share their reasoning process. These 2 steps were repeated for each vignette (ie, 6 in total). The first interviews were conducted with both inter-

Vignette 1
Woman, aged 20 years, from Spain, student, had unsafe sex multiple times >3 weeks ago, itching of the vagina, does not visit her general practitioner (GP) often

Vignette 2
Man, aged 26 years, plumber, steady relationship, has irritation at the urethra and sensitivity when urinating, visits GP often

Vignette 3
Woman, aged 17 years, high school student, had unsafe sex <3 weeks ago with no complaints, the first time she comes to the practice

Vignette 4
Man, aged 24 years, has a relationship with a man, his partner has sexual contact with other men, has difficulty urinating

Vignette 5
Woman, aged 45 years, has a steady relationship but thinks her partner cheated 6 months ago, has contact bleeding, visits the GP often

Vignette 6
Woman, aged 35 years, has a steady relationship, comes from Surinam, has a burning sensation when urinating, visits her GP often

Textbox 1. Short description of the vignettes.

Mrs A is aged 20 years and studies in the Netherlands but comes from Spain originally. She has not visited you at the practice often. She is not in a committed relationship and has had unprotected sex several times in the past 6 months for more than 3 weeks. She experiences vaginal discharge and itching and irritation in her vagina. She wonders whether she might have a sexually transmitted infection.

Textbox 2. Vignette 1 translated from Dutch to English.

viewers present (KS and Fleur Rekveld), and KS was the lead. The other interviews were conducted by KS, Fleur Rekveld, or both.

Service: Digital Triage Tool

The digital triage tool was developed by a Dutch diagnostic center [18] based on a decision tree with Dutch medical guidelines [17]. The digital triage tool was developed in co-creation with GPs and clinical chemists. A Dutch academic knowledge center assessed the digital triage [19]. During triage, users first go through a series of questions. Their answers determine what question they have to answer next and, in the end, what advice is given. For example, the first question is "Did you have unsafe sex?" If the answer is "no," the advice is not to be tested. If the answer is "yes," a follow-up question appears: what is your gender? Gender is asked about as differences in gender result in different advice (eg, for women users who are advised to undergo a chlamydia test,

it means that the service could advise doing a vaginal swab). Ultimately, the digital triage tool advises whether a diagnostic test for STIs is necessary and, if yes, which one (eg, chlamydia, gonorrhea, or HIV). The digital triage tool is now used in 2 digital services of the diagnostic company where patients can order diagnostic tests themselves with or without a health care professional. These diagnostic services are Directlab, where users can order web-based diagnostic test packages independent of a health care professional, and Homelab, where patients in the digital environment of their GP can order diagnostic test packages. In regular daily practice in the Netherlands, the patient needs to ask for a consultation with the GP (on the phone or in person) and ask for a diagnostic test for STIs. In this situation, the GP performs triage to identify whether it is necessary to conduct an STI test.

Data Analysis

To determine the diagnostic test advice of the digital triage tool, the characteristics of each vignette were entered into it. The ensuing advice was compared with the test advice of the GPs per vignette. To learn which factors influenced the GPs' decision-making process, the combination of the think-aloud process, vignettes, and semistructured interviews was used as a triangulation method to obtain a complete range of data to result in a strong conclusion [12,20]. All interviews were transcribed (intelligent) verbatim. When the transcripts were completed and uploaded to ATLAS.ti (version 22; ATLAS.ti Scientific Software Development GmbH), the audio recordings were deleted. In total, 2 authors (Fleur Rekveld and KS) conducted the qualitative data analysis according to the principles of thematic analysis. Fleur Rekveld and KS developed a preliminary coding scheme based on the coded data from the first 8 participants. The final coding scheme emerged after all the coding was performed by the 2 authors independently. The codes were grouped into themes and subthemes.

Results

Characteristics of the study population

Data saturation was reached after 10 interviews. The characteristics of the participants are presented in Table 1. Their ages ranged from 32 to 70 years, with a mean of 48.30 (SD 11.88) years. The number of men and women was almost equal (6/10, 60% and 4/10, 40%, respectively). Of the 10 GPs, 1 (10%) was retired, 3 (30%) were working part time as GPs, and 6 (60%) were working full time.

Testing advice of online triage versus general practitioners

Table 2 shows, for each vignette, whether the digital tool would advise conducting an STI test and what each participant would advise to do. For 50% (3/6) of the vignettes (ie, numbers 1, 4, and 5), the digital triage tool's advice aligned with all participants'

Table 1. Characteristics of the participants.

Participant	Age (y)	Gender	Employment status
1	32	Woman	Parttime
2	55	Man	Fulltime
3	38	Man	Parttime
4	59	Man	Fulltime
5	70	Man	Retired
6	53	Man	Fulltime
7	55	Woman	Fulltime
8	43	Man	Fulltime
9	38	Woman	Parttime
10	40	Woman	Fulltime

Table 2. Advice of the digital tool and the participants to test for a sexually transmitted infection.

	Digital triage tool	P[a]1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Agreement, n(%)[b]
Vignette 1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10 (100)
Vignette 2	No	No	Yes	No	No	Yes	No	No	Yes	No	Yes	6 (60)
Vignette 3	Later	Later	Later	Later	Later	No	Yes	Yes	Later	Later	Later	7 (70)
Vignette 4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10 (100)
Vignette 5	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10 (100)
Vignette 6	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	8 (80)

[a]P: participant.
[b]Percentage of participants who agreed with the advice of the digital triage tool.

advice. For all 3 vignettes, the advice was to conduct a diagnostic test for STIs. For those 3 vignettes, the patients' risk factors were sufficiently clear for the participants to advise to conduct a test.

In vignette 1, the most important decision-making factor was the patient's age; young age combined with women was an important factor influencing the participants' test advice as having an STI could make this woman infertile. Participant 7 answered the following:

I would test her, always with women of her age who are sexually active.

In addition, unsafe sex was an important factor in the decision to test.

For vignette 4, the main factor in advising to test was the "men having sex with men" risk factor. Participant 5 answered the following:

It is male-male contact, and in addition, there are changes in sexual contacts so that he can do an STI test.

For vignette 5, all participants would advise conducting an STI test as well. Furthermore, 80% (8/10) mentioned that they would also conduct cervical cancer diagnostic tests because of the symptom of contact bleeding. Participant 9 mentioned the following:

In the case of contact bleeding, more research than only an STI is needed. It could be Chlamydia, but a smear test is needed to exclude cervical cancer.

For the other 50% (3/6) of the vignettes, not all participants gave the same advice as each other or as the digital triage tool. For vignette 2, a total of 60% (6/10) of the participants agreed with the advice of the digital tool, and for vignettes 3 and 6, the proportions were 70% (7/10) and 80% (8/10), respectively. It is important to mention that the initial answer of the participants is presented in Table 2. It could be the case that participants answered "no" to advising an STI test for the patient initially. However, the participants mentioned that they would advise conducting an STI test after excluding other diseases. In addition, sometimes, the participants wanted more information about the patient's situation before advising to conduct an STI test.

For vignette 2, most participants wanted to know more about the patient's case before giving the advice to test for an STI. In addition, they wanted to conduct a physical examination or other tests, such as a test to exclude urinary infection, as the patient's symptoms seemed not totally compliant with those of an STI. Participant 2 said the following:

I would like to know a little more; why does he think he has an STI? Does he have other contacts next to his current relationship or an open relationship? Has he heard anything from his wife?

Participant 4 answered the following:

I would check his urine.

Participants answered that the symptoms and risk factors were too unclear to advise an STI test. A minority of the participants would test for an STI to exclude it or to satisfy the patient's request. Participant 2 answered the following:

He asked for an STI test so I would do one.

The participants mentioned that, sometimes, a patient does not have an apparent reason for wanting to take an STI test or the patient has no symptoms that fit with those of an STI. However, sometimes patients do not want to discuss this in detail, and participants found it important to allow for testing at a low threshold if patients asked for it themselves. Participant 9 mentioned the following:

Maybe he (or his wife) is cheating, and they do not want to tell you that directly...It is always the question if the patient is honest with you, so I would test at a low threshold after I did a urine infection test, and then I think he would accept that.

For vignette 3, most participants (7/10, 70%) answered that the patient could take an STI diagnostic test but at a later time. At this time, it was too early to detect an STI. A total of 20% (2/10) of the participants also mentioned that they would talk to the patient about her contraception and provide education about safe sex. Participant 2 said the following:

She had unsafe sex, so I would do two things. Maybe check if she uses birth control, and I would tell her that she can do an STI test after two weeks.

Vignette 6 involved a patient from an endemic area. In total, 25% (2/8) of the participants who agreed with the advice of the digital tool mentioned the endemic area as a reason for testing. Participant 10 mentioned the following:

I would ask her some more questions; however, she is from Surinam, a risk area. So I would test her at a low threshold, especially for a serological test.

The other 62% (6/8) of the participants mentioned low-threshold testing because of the patient's symptoms. Most participants (6/10, 60%) mentioned that they would check for a urinary infection, some before conducting an STI test and others in addition to it. Participant 1 mentioned the following:

I would check her urine first to ensure she has no urinary infection.

It is important to note that almost all participants mentioned that, if a patient requested an STI test, they would meet the request. They also mentioned that, in some cases, they would also give patients more information about safe sex or conduct a physical examination. The decision to do so often depended on age or other risk factors such as contact bleeding. Especially in the case of younger patients, GPs educated them about safe sex and birth control. However, this information provision was not part of their decision-making process but rather of their consultation.

Extra factors that influenced the decision of the GP

There were several factors that the participants considered in their decision that were not included in the digital triage tool. The most important additional patient-related factors were anxiety about infection, the wishes of the patient, and age. Among all participants (10/10, 100%), the patient's anxiety was an additional reason for referring them to an STI test. The participants reasoned that a request for an STI test is not made

easily and that there may be an unknown reason behind it. In their opinion, when patients experience fear-related stress, it might harm their health. Participant 10 mentioned the following:

Sometimes you feel that there is more than they want to say, and then you decide to test at a low threshold.

Age played a role in the decision-making process of the GPs. This was especially the case in vignettes 1 and 3. The GPs mentioned that checking for STIs was important at a fertile age, especially for women. In the Dutch medical guidelines, it is noted that, below the age of 25 years, there needs to be a low threshold for STI testing even if patients report no complaints. Participant 6 answered the following in the interview about vignette 3:

Especially in younger patients, you want to know what they know about sex and the transmission of STIs.

In 2 vignettes, the GPs felt the need to ask additional questions or conduct a physical examination. The digital triage tool only provides advice on an STI test. However, the symptoms may also indicate a urinary tract infection or a stage of cervical cancer. These tests are not advised via the digital tool but were advised by the participants in this study for those 2 vignettes.

One GP also considered who had to pay for the test and whether it was affordable. Participant 3 mentioned the role of the payer or possible reimbursement in the decision. He answered the following about vignette 6:

If she wants to pay for a test and she wants to do a test… Then, she can do a test.

In summary, it can be generally said that GPs in this study paid extra attention to patient-related factors such as fear of infection, desire to undergo the test, and young age when deciding whether to request an STI test.

Discussion

Principal Findings

In this study, we tried to identify whether the advice of a digital triage tool based on medical guidelines aligned with GPs' medical practice. The results showed that other factors, which are not part of the guidelines, played a role in the GPs' decision-making process when determining whether to advise an STI test for a patient. The most impor-

tant additional patient-related factors were the patient's anxiety, wishes, and age. The GPs also considered who had to pay for the test and whether it was affordable. Finally, the GPs were willing in some vignettes to ask additional questions or conduct a physical examination. The most notable factors are discussed in this section and compared with the literature.

In line with other research, the GPs' decision to test depends sometimes on the anxiety and wishes of the patient [7]; these factors were not included in the studied digital triage tool. This additional aspect aligns with the research by Hajjaj et al [5,7]. In addition, our results align with those of a study that researched the barriers to following guidelines among GPs [6] that showed that the patient's preferences were considered more important than following guidelines.

The interviews showed that the age of the patients was an important factor that influenced the GPs' advice. Specifically, younger age was an important reason to advise an STI test because of the risk of infertility and the sexual activity in this group. Age was not included as a factor in the digital triage tool. As STIs mainly occur under the age of 30 years, it is not surprising that GPs tend to advise testing more for patients in this age group [21].

From the literature, it was found that the factor "knowing the patient" influences the decision-making process of GPs [22]. Accumulated knowledge about the patient influences the context and interpretation of the conversation between the patient and the health care professional, especially in the case of psychosocial or unspecific problems such as fatigue. However, in this study, knowing the patient was not a factor that was considered in the vignettes. For this reason, the decisions that the GPs made in this study could be different in real life as they might know the patients.

In addition to patient-related factors (eg, the wishes of the patient), GP-related factors also influenced the decision-making process. The extent to which GPs were open to discussion with patients about why they wanted an STI test or to which GPs were willing to address patients' concerns influenced the decision. In addition, based on the findings of this study, it seems that the GPs expressed a preference for obtaining a complete set of information before deciding. For example, some GPs wanted to have more information about the situation of the patients and their partners. In some cases, GPs wanted to conduct a physical examination or other diagnostic tests (eg, urinary infection) to exclude other diseases. The digital triage tool is strictly bound to the guidelines set up without paying attention to, for example, the anxiety of the patient or the need for additional information. Other guidelines have been developed for possible symptoms of urinary tract infection or cervical problems, which have not yet been combined on the internet.

The advice of the digital triage tool is straightforward and always in line with a strict algorithm. In this study, GPs were found to recommend a diagnostic test for STIs more often than the digital tool. In the Netherlands, a study showed that unnecessary diagnostics (overdiagnostics) are a common problem among Dutch GPs; slightly more

than half of the participating GPs indicated that patients could submit a complaint for not requesting an examination that was indicated and that this played a role to some or a significant extent in the request for diagnostic testing [23].

Our study did not investigate whether the digital tool can prevent overdiagnostics, but we assume that it can be a powerful decision support tool for daily general practice, just as tools for pharmacotherapy are already in use. More research is needed to confirm this.

Another possible reason why GPs are more inclined to test seems to be that it could save them time [24]. For example, if a patient has vague symptoms, it would be easy to request some tests first without having a thorough conversation. Another possible reason specifically for low-threshold STI testing could be feelings of embarrassment to ask about sexual behavior [25]. Recently, a Dutch center for sexual health found that talking about sexual behavior is not done as often as it should by health care professionals [26]. This could be seen as an additional justification for supporting GPs with digital tools for STI testing.

This study does not suggest that digital triage is the holy grail to prevent overdiagnostics or that it is the solution to lower the work pressure of GPs. However, this vignette study confirms that GPs have a more holistic approach to their patients compared with a digital triage tool. A digital triage tool primarily relies on specific responses to predefined questions, whereas a GP can consider more factors such as social factors, lifestyle, and personal context. On the one hand, the comprehensive perspective of GPs might result in a higher frequency of diagnostics when compared with a digital triage tool. This is due to the GPs considering additional factors. Given the high workload and time constraints of GPs, the investigated digital tool can play a helpful role in daily decision-making. In contrast, this holistic approach by GPs could potentially lead to fewer diagnostics. Given their deep understanding of the patients' condition, GPs are better positioned to assess the necessity of tests.

This study has several limitations. It could be that social desirability influenced the GPs' answers on the vignettes and interviews. Potentially, the advice of the GPs was more in line with the guidelines compared with that in their daily practice as they were aware of the fact that they were part of research on this topic [12]. It is also worth mentioning that there could be a disparity between what people think they would do in a particular situation and their actual behavior [27]. In addition, this study is not generalizable to the entire field of diagnostics at general practices because of its focus on STI testing. As a starting point, this study identified factors that influenced the decision-making process of GPs for STI testing. In future research, we recommend investigating digital tools and the decision-making process of GPs for other common diagnostic tests.

A strength of this study is the combination of the vignette method, the think-aloud process, and the semistructured interviews, which aimed to obtain a complete range of data on the topic (triangulation). Although no actual patients were included in this

study, we aimed to make the vignettes as valid as possible by developing and testing them with GPs. In addition, providing the same vignettes to different GPs made it easier to compare patients within different general practices instead of comparing real-life patients with different complaints and characteristics. Currently, we are working on a real-life study in which patients in the waiting room of a GP's office complete digital triage for STI testing (the result of the digital triage tool is not shown to the patient), after which they go on to have their planned consultation with the GP. At this consultation, the GP will also advise whether to test for an STI; the advice of the digital tool and of the GP will be compared. We expect more detailed and practical information to further refine this working method using a digital tool.

A qualitative study in which GPs were interviewed about their general attitude toward the use of digital tools by patients in their practice showed that GPs' attitudes toward digital STI diagnostic services were positive, and they acknowledged that the use of eHealth in their practice could result in a more efficient workflow [28].

It will be interesting to further investigate whether GPs are also willing to use digital triage tools as a standard gateway for their practice for some diagnostic tests. When a digital triage tool is implemented and integrated into the care pathway, it is important to investigate what users think of this integration and whether they are satisfied with this change in their way of working. For future research, it could be beneficial to make a comparison of the experiences of patients with a digital triage tool, triage at the GP's office, and a mix. Notably, recent studies on digital chatbots for medical questions have shown that patients perceived the chatbot's responses to be superior to those provided by GPs [29]. For future applications, it is essential to consider patients' eHealth literacy before using a digital triage tool as the primary tool in daily general practice [30,31]; hybrid care might be a solution to address all types of patients. Finally, it is important to realize that the tool in the care pathway needs to stay up-to-date and needs to be changed when the medical guidelines are updated [32]. This study showed that (holistic) factors that are not part of the digital triage tool affect GPs' decision-making. This is an interesting topic for future research as digital tools and artificial intelligence are increasingly being used in health care. Nowadays, GPs use digital medication prescription tools to support their decision-making, which could help with handwriting errors but also with poor treatment decisions [33]. Another example is an artificial intelligence system that could help GPs decide on the early detection of skin cancer [34,35]. Digital technologies such as these should be researched carefully to see what the impact and consequences are for both GPs and patients.

Conclusions

This study shows that, in some cases, patients receive different advice to undergo an STI test from a digital tool and from a GP. Other factors that are not part of medical

guidelines play a role in the GPs' decision-making process when deciding whether to request an STI test. The most important additional patient-related factors were the patient's anxiety, wishes, and age. One GP also considered who had to pay for the test and whether it was affordable. Finally, some GPs expressed a desire to ask additional questions or conduct a physical examination in certain vignettes. In comparison, the digital triage tool adhered more closely to the medical guidelines, with GPs being more inclined than the digital tool to recommend an STI test for the same patient case. Alignment between the digital tool and GP advice only occurred when the risk factors for STI testing were unequivocally evident. This confirms that GPs decide from a holistic perspective. On the basis of these initial findings, we cautiously posit that a digital triage tool for STI testing can potentially support GPs and may even serve as a substitute for in-person consultations in the future. However, it is imperative to conduct further research to establish safe and effective methods for implementing such a transition.

These conclusions should be approached carefully, recognizing that this study represents an initial exploration and that additional research is required to substantiate and refine these findings.

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Conflicts of Interest

None declared.

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Abbreviations

GP = general practitioner
STI = sexually transmitted infection

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Appendix 1

Translated vignettes from Dutch to English

Vignette 1:
Mrs A is 20 years old, and studies here in the Netherlands but comes from Spain originally. She has not often visited you at the practice. She is not in a committed relationship and has had unprotected sex several times in the past 6 months for more than 3 weeks. She suffers a lot from itching, other discharge and irritation of her vagina. She wonders if she might have an STI.

Vignette 2:
Mr B is 26 years old, is a plumber and has been in a steady relationship with a woman for a few years. He has complaints such as irritation at the urethra and sensitivity when urinating. He wonders what this could be. Could it be an STI? You know Mr B well because he often comes to you with such questions.

Vignette 3:
Mrs C is 17 years old and is coming to your general practice for the first time. She is in her senior secondary school year. Last week she had unprotected sex with a boy. She has no complaints yet, but would still like to do an STI test.

Vignette 4:
Mr D is 24 years old, and a high school teacher. He is in a steady relationship with a man. His husband also has sexual contact with other men. Mr D wants to have a test done to be sure because he sometimes has a difficult time urinating. Furthermore, he does not often visit you at the practice for other matters.

Vignette 5:
Mrs E, aged 45, regularly visits you. She has been in a steady relationship with a man for 2 years now. She has no children and lives alone. She found out that her husband cheated six months ago. She suffers from contact bleeding and therefore wants to have a test done.

Vignette 6:
Mrs F is 35 years old and has a steady relationship with a man. She is from Surinam. She has two children who still live at home. She often visits you at the practice. Occasionally she has a burning sensation when urinating and so she wants to have a test done just to be sure.

Appendix 2

Semistructured interview protocol

1. **Introduction, explantion, informed consent**
   a) Welcome, introduction of facilitator
   b) Introduction to the topic
   c) Explanation of what we are going to do
   d) Informed Consent form
   e) Practical questions?
   f) Demographic questions for the general practitioner
      a. What is your birth year?
      b. Are you still a fulltime general practitioner (and how long)?

questions per vignette

2. **Questions**
   a) You need to make a decision regarding the care for this patient. What would you do for this patient? (If no clear answer: What you do a diagnostic test for sexual transmitted infections?)
   b) Why would you do this?
      a. What factors do you take into consideration?
      b. What is the role of patient characteristics and how they present in your decision?
      * Provide examples of characteristics if necessary, like age or how often they see the patient*
      c. What are your thoughts about the patient?
      d. What do you pay attention to in such patient?
   c) Are there any specific things that we did not have discussed yet, but are for you crucial in the decision-making process for the patient?

4

Direct Access to Diagnostic Testing and Advice Service: a Qualitative Study with Potential Users into Facilitators and Barriers for the Use of Digital a Self-Management Service

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Abstract

Background: Health care lags in digital transformation, while technology can contribute to individuals' well-being. The COVID-19 pandemic has accelerated the uptake of technology in health care and increased the willingness of individuals to perform self-management using technology. A web-based service, Directlab Online, provides consumers with direct online access to diagnostic test packages, which can support self-management of health digitally.

Objective: The aim is to identify the facilitators, barriers an needs of Directlab Online, a self-management service for online access to diagnostic testing.

Methods: A qualitative method was used from a potential users' perspective. The (future) needs, facilitators and barriers for the use of Directlab Online were evaluated. Semistructured focus group meetings were performed in 2022. Two focus groups were focused on sexual transmitted infection test packages and two were focused on prevention test packages. The data analysis was performed according to the principles of the Framework Method. The Consolidated Framework for Implementation Research was used to categorize the facilitators and barriers.

Results: In total 19 participants participated in the focus groups. They had a mean age of 34.32 (SD = 14.70). Important barriers were lacking information of privacy, too much and difficult information and a commercial look and feel. Important facilitators were the right amount of information, the right kind of tests and involving a health care professional. The needs for a service like Directlab Online were ensuring that the service was there for users' health and how they could maintain healthy.

Conclusion: According to the participants, facilitators and barriers were comprehension of the information, the goal of the website and the total look and feel. Although the service is developed in co-creation with health care professionals and users, the needs did not align. For users, the information needed not to be concise and understandable. In addition, users would like to have other kinds of tests available on the service. For future research, it would be beneficial to focus on co-creation between involved medical professionals and users to develop, improve and implement a service like Directlab Online.

Keywords: eHealth; usability; self-management; diagnostic test service; diagnostic; testing; test service; perspective; focus group; user need; user testing; implementation; qualitative; test result; lab test; lab result

Introduction

Society is changing, and the world is becoming increasingly digital [1]. Health care lags in digital transformation, while technology can contribute to individuals' well-being [1, 2]. The COVID-19 pandemic accelerated the development and use of technology in health care, also referred to as eHealth, with more online consultations and increased use of home monitoring [3, 4]. Also, the pandemic, among others, has increased the need and willingness of individuals to perform self-management [5-7]. In chronic disease patients, self-management strategies are often used to support patients in dealing with treatment and lifestyle changes [8]. In addition, self-management strategies can be used to support individuals with home diagnostic tests [9]. The concept of self-management aligns with the positive health definition: "health as the ability to adapt and self-manage in the face of social, physical, and emotional challenges" [10, 11].

eHealth can be used in the three stages of laboratory diagnostic testing. Triage and advice on diagnostic testing is the first stage, the second stage is the testing itself (at home or a facility), and the third stage is the communication of the test results to the user. A systematic review showed that online diagnostic testing services were positively evaluated and preferred over clinic-based testing [9]. However, most of the evaluated services only offered tests to detect sexually transmitted infections (STIs) [9].

eHealth services can support self-management, for example with online services that support behavior lifestyle changes (eg, LIVA healthcare) [12], and with websites where individuals can obtain health information (eg, Thuisarts.nl) [13]. In addition, there are multiple apps to support patients with chronic conditions like hypertension, diabetes or lower backpain [14-16].

In the Netherlands, a web-based service called Directlab Online offers individuals direct access to laboratory diagnostic tests independent of a health care provider [17]. It is a so-called direct-to-consumer platform. Directlab Online gives individuals direct online access to diagnostic testing based on a triage that aligns with medical guidelines. Unlike the services identified in the systematic review [9], Directlab Online offers a variety of diagnostic tests, for example, diagnostic tests for STIs, COVID-19, vitamins, and testing for health questions concerning fatigue and the prevention of heart disease. The results and the information on the website can give individuals insight into their health, which could support and motivate them to adopt healthier behaviors [12]. In addition, it supports users to be better informed about their health without the interference of a health care professional, which can lead to more efficient and accessible care [18]. Packages to test the health of individuals fit with the patient-centered care approach, which can lead to a better quality of care [19]. Patient-centered care aims to empower patients to take charge of their health and actively participate in their health care [20]. Another term used is person-centered care, which is similar, only not disease-related, and fits better with the positive health definition [21].

To maximize the potential and impact of Directlab Online, it is important that the service is of high quality and user-friendly. For that reason, it is essential to know what barriers and facilitators there are for individuals to use the service. For example, known factors in dermatology that could influence the uptake of a digital service are, among others, financial aspects and accessibility for a digital service [22]. In another research, facilitators and barriers for digital services for older adults in primary care are researched. Non-familiarities with online environments appeared to be a barrier and efficiency is seen as an important facilitator for the use of a digital service in primary care [23]. In the earlier mentioned review about STI testing complicated language and insecurity about data handling, were also discovered for ordering online an STI test [9]. To our knowledge, no research has been performed into facilitators, barriers, and needs of a direct-to-consumer platform that offers direct access to multiple diagnostic tests and (online) results. Identifying the needs, facilitators and barriers will help determine what is necessary to optimize the use and improve the implementation of those services. This can give insight into the potential future directions for developing such services.

Objectives

The current study aims to identify the facilitators and barriers to using a service like Directlab Online and identify the needs regarding direct online access to diagnostic testing. To do so, focus groups were held. Half of the focus groups focused on STI testing and the other half on prevention test packages. STI tests and prevention test packages are the most ordered test packages on Directlab Online. The focus is on potential users, thus those who have not used Directlab Online before, because we are interested in people's first impression of the service.

Methods

The service: Directlab Online

Directlab Online is a Dutch web-based service available for everyone, where diagnostic tests can be ordered online [17]. The service was developed by a multi-disciplinary innovation team of a diagnostic company (Saltro, part of Unilabs) and was launched in 2016 [24, 25]. The process is presented in Figure 1. First, individuals go through an online triage, based on medical guidelines, to determine whether diagnostic tests are relevant and, if yes, which one. Second, individuals can order and buy associated tests. Depending on the ordered diagnostic tests, a self-sampling kit is sent to the individual's home address or an appointment is made at a blood collection center or a laboratory for a blood sample. Once the laboratory receives the collected specimen, high-quality analyses are conducted. The results of the tests are communicated through an online secure patient portal. Deviating results are also communicated to the patient's general

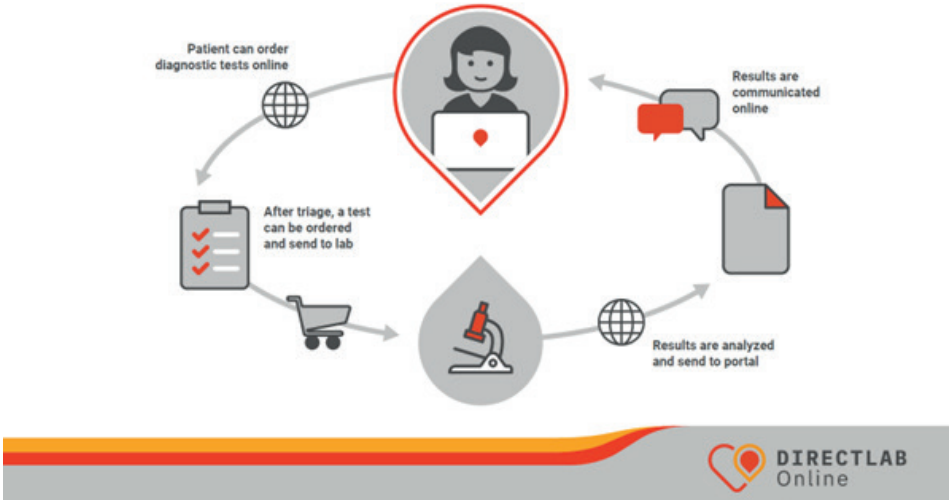

Figure 1. Stages of Directlab Online.

practitioner; however, only if the patient has authorized this. The triage is based on medical guidelines, and the diagnostic test packages were developed in co-creation with and tested by general practitioners and laboratory specialists referred to as medical doctors. Diagnostic test packages consist of different parameters for diagnostic testing. For example, a test package for cholesterol measures the following parameters: low-density lipoproteins, high-density lipoproteins, triglycerides, and total cholesterol. Appendix 1 provides a complete overview of the test packages that could be ordered on Directlab Online during the focus groups. Table 1 provides an overview of the prevention and STI test packages that were part of the discussions with the focus groups.

Study design and participants

Focus group meetings were performed with potential users of the service. As the Directlab Online service offers a wide variety of test packages, we focused on two specific categories (ie, prevention and STI test packages). These test packages were ordered most frequently. Half of the focus groups thus focused on STI test packages, and the other half focused on the prevention test packages. The general inclusion criteria for the focus groups were: speaking Dutch and not having used Directlab Online before. In addition, there were specific inclusion criteria to ensure that the socio-demographic characteristics of the participants in the focus groups were in line with the characteristics of the target population of the test packages. Namely, a specific inclusion criterion for the focus group about STI testing was that participants were between 18 and 30 years old. The specific inclusion criterion for the focus groups about prevention test packages was that the participants were between 18 and 65 years old. It is important to note that there were no specific health or disease requirements to participate.

Table 1. Test packages that are available on Directlab Online.

Category	Parameters
Prevention tests	
Health check-up	Check total cholesterol[a], low density lipoproteins (LDL)[a], high density lipoproteins (HDL)[a], triglycerides[a], Hba1C[a], albumin/creatinine ratio[b].
Health check-up at home*	Measuring parameters via self-sampling of blood: total cholesterol[c], LDL[c], HDL[c], triglycerides[c], Hba1C[c], albumin/creatinine ratio[b]
Cholesterol	Check total cholesterol[a], LDL[a], HDL[a], triglycerides[a]
Cholesterol at home*	Measuring parameters via self-sampling of blood: Total cholesterol[c], LDL[c], HDL[c], triglycerides[c]
Anemia	Check hemoglobin[a], mean corpuscular volume[a], ferritin[a] and C-reactive protein[a]
Diabetes	Check glucose[a] and Hba1C[a]
Healthy bones*	Check calcium[a] and vitamin D[a]
Healthy kidneys*	Check creatinine[a], glomerular filtration rate[a], albumin/creatinine ratio[b]
Thyroid check	Check thyroid function via thyroid stimulating hormone[a] and freeT4[a]
Sexual transmitted infection tests	
Chlamydia	Check for chlamydia[d] (eg oral, anal, vaginal, urine sample)
Gonorrhea	Check for gonorrhea[d] (eg, oral, anal, vaginal, urine sample)
Human Immunodeficiency Virus (HIV)	Check for HIV[a]
Syphilis	Check for syphilis[a]
Hepatitis B	Check for Hepatitis B[a]

[a]Blood sample needed for diagnostics, [b]Urine sample needed for diagnostics, [c]blood sample by self-sampling needed for diagnostics, [d]Oral, anal, vaginal or urine sample needed for diagnostic tests
*those tests are not available any more on Directlab Online after the service update

The study was declared to not fall within the scope of the Dutch Medical Research Involving Human Subjects Act by the Medical Ethics Committee (MEC) of the Leiden University Medical Center (N21.101). Focus group meetings were held until data saturation was reached.

Procedure and data collection

The recruitment period started on the 25th of October 2021 and lasted until the 20th of February 2022. Participants were recruited via different online channels (eg, LinkedIn and Facebook). Individuals were invited to contact the researcher (KS) via email when interested. Then the researcher sent them more information. In addition, questions were asked about their birth year and if they could understand Dutch. A few date options for online meetings were sent if the individual met the inclusion criteria. When individuals could participate, they received an email with the date and time, a link

to the Zoom platform where the meeting would take place (online), and a link to an online informed consent form which they were asked to sign before participation. All participants had the right to withdraw at any moment. The focus group meetings took place between the 10th of January and the 2nd of March 2022, with researchers MH and KS present [26]. KS led the focus groups, and MH managed the time and assisted with technical issues. The focus group meetings were semistructured, following a pre-defined topic list with open-ended questions to leave space for discussion (see Appendix 2). First, general questions were asked about using eHealth to see how familiar participants were with eHealth. Second, participants had ten minutes to look at the website of Directlab Online and navigate through the website on computer or phone; no further instructions were given. When the time was up, questions were asked about the website in general (eg, the first impression, whether they needed help when using it, and if they found the website attractive). While navigating the website, they had the option to write down notes or vocalize their impressions, expressing their observations, preferences and feelings about the site [27]. Third, participants were instructed to go through Directlab Online, do some triages, and look at their test advice. Namely, we allowed participants to navigate through the process as normal users would. Therefore they needed to read information, could do a triage with medical questions about their symptoms and they could receive a test advice. After that, questions were asked about the triage service, facilitators and barriers to using Directlab Online, and their needs for such a service. At the end of the focus groups, they received an online gift card of €25,-.

Data analysis

All focus groups were audio recorded for the subsequent analyses and were transcribed (intelligent) verbatim. When the transcripts were completed, the audio records were deleted. Two reviewers, MH and KS, conducted the qualitative data analysis according to the principles of the Framework Method [28]. The Framework Method is a systematic and flexible approach commonly used for the thematic analysis of health research semistructured interview data [29]. The method combines deductive and inductive techniques, which fit with the aim of the research to identify specific issues regarding the use of Directlab Online and leaves space to identify needs and opportunities that have not been formulated a-priori. First, open coding was performed independently by the two reviewers KS and MH. The interview data were coded using the software Atlas.ti 22. Second, the codes were compared between the two reviewers, and deductive coding was performed. Third, codes were grouped into categories, resulting in the analytical framework. Fourth, final themes were achieved via discussion and consensus between researchers KS and MH. Fifth, for identifying the facilitators and barriers, the Consolidated Framework for Implementation Research (CFIR) was used [30]. The framework is widely used for the content analysis of qualitative data about factors influencing implementation success [30]. The framework is also comprehensive and

makes it able to systematically study a wide array of facilitators and barriers [31]. In addition, using this framework made it possible to compare findings and transfer findings to other implementation studies [32]. The CFIR is a theory-driven model and comprises five domains: (1) the innovation domain, (2) the outer setting domain, (3) the inner setting domain, (4) the individuals' domain, and (5) the implementation process [30, 33]. Identified facilitators and barriers were placed within the CFIR domains.

Results

Participant characteristics

Data saturation was reached after four focus groups with 19 participants. The characteristics of the participants are shown in Table 2. The age ranged from 20 to 61, with a mean of 34.32 (SD=14.70). The number of males and females was almost equal (9 and 10). The focus groups lasted around 90 minutes per group.

Age differed over the two different focus groups, as fitted with the target population of the diagnostic test packages. Overall, the experiences and choices of the focus groups regarding the website were the same. In most cases, the focus group results were therefore discussed together. When the result(s) differed between the two groups, this was specified. Different themes around usability, facilitators, barriers, and needs emerged from the data and are elaborated on below.

Facilitators and barriers for the uptake of innovation

The identified barriers and facilitators were categorized into the domains of the CFIR, specifically into the following three domains: innovation domain, outer setting domain and individuals domain. The other two domains of the CFIR framework (ie, inner setting and implementation process) did not align with the facilitators and barriers mentioned by the participants and were therefore not discussed. Table 3 gives insight into the most essential and changeable facilitators and barriers identified. Therefore, it is not an exhaustive list of all potential barriers and facilitators that influenced the service uptake. It is important to realize that certain factors can be considered as a facilitator and barrier. For example, financial costs are frequently mentioned as a factor affecting the willingness to use digital health services [33]. When there are high user costs, it is a barrier; however, low costs can be considered a facilitator. Below the table, the identified facilitators and barriers are explained in more detail and explained per domain.

Facilitators and barriers in the innovation domain

A) Innovation source

Participants mentioned different factors that were related to the innovation source of the innovation domain. Those factors mainly influenced the credibility and trustworthiness in a positive (facilitator) or negative (barrier) way. First of all, the website's com-

Table 2. Characteristics of the participants.

Participant	Gender	Age	Focus group[a]
1	Female	27	1
2	Female	25	1
3	Male	24	1
4	Male	30	1
5	Female	20	1
6	Female	25	2
7	Female	46	2
8	Female	59	2
9	Male	24	2
10	Male	20	2
11	Female	25	3
12	Male	25	3
13	Female	30	3
14	Male	24	3
15	Male	39	4
16	Female	58	4
17	Female	59	4
18	Male	30	4
19	Male	62	4

[a]Groups 1 and 3 focused on STI packages, and groups 2 and 4 focused on prevention packages

mercial look and feel were the most frequently mentioned barriers that influenced its reliability. Participants mentioned, for example, that the option to buy a gift card for a diagnostic test package was not fitting for a website that is designed for your health. In addition, they mentioned the high prices for diagnostic test packages and the website's general look and feel. The following was said about this:

The website said: buy this. But I want to know why this test? (p4)

I found it a very commercial website; this lowers my enthusiasm. (p8)

Participants did not notice that health care professionals were involved in the service and partly developed the service.

Second, the availability of reviews was frequently mentioned as a facilitator for reliability and credibility but, in some cases, as a barrier. Good reviews could be experienced as a facilitator, and bad reviews as a barrier to experiencing the website as reliable and trustworthy. The following was said about this:

Yes, ... I found it important if I go to a new website to sell or buy something to see that others used the site and what they bought. (p13)

Table 3. Facilitators and barriers derived from the focus groups embedded in the conceptual framework for implementation research (CFIR).

Domain of CFIR	Domain description	Results
Innovation domain		
A.Innovation Source	The group that developed and/or visibly sponsored the use of the innovation is reputable, credible, and/or trustable.	The general practitioner group that developed and/or visibly sponsored the service was reputable, credible, and trustable, which resulted in a reliable service Information about privacy and presenting good reviews improved reliability and credibility Commercial look and feel influenced the credibility. Also stock pictures influenced this
C.Innovation relative advantage	The innovation is better than other available innovations or current practices.	The service was easy to use, which made the service accessible It was easy to use the service without going to the general practitioner
F.Innovation complexity	The innovation is complicated, which may be reflected by its scope and/or the nature and number of connections and steps.	Too many testing possibilities and too much information made the website less user-friendly The search bar and filters on the website increased the user friendliness of the website Using a lot of medical words made the service difficult to comprehend
Outer setting domain		
D. Partnerships and connections	The Inner Setting is networked with external entities, including referral networks, academic affiliations, and professional organization networks.	The service was linked with academic institutions and other medical professionals, which increased the reliability of the service for users
G.1. Societal pressure	Mass media campaigns, advocacy groups, or social movements or protests drive the implementation and/or delivery of the innovation.	Media campaigns, reviews and blogs could helped stimulate participants to use the service
Individuals domain: subdomain patient characteristics		
B. Capability	The individual(s) has interpersonal competence, knowledge, and skills to fulfill Role (different characteristics of individuals)	If participants had experience with a similar service, they felt more confident in using the service. Otherwise, feelings of anxiety or tension could have influenced their competence, knowledge, and skills

Third, seven participants mentioned the facilitator's "privacy". For the participants, it was important to know where the data was stored and for how long. This information was, however, difficult to find on the website. The following was said about this:

And then it is the question of how long data is stored and how that is important to know. (p8)

I want to know, what happens to the data and how long is it stored? (p16)

Participant 7 pointed out that a clear and transparent privacy statement could be a unique selling point of the service.

Lastly, the most mentioned barrier in the innovation source was the presence of stock pictures on Directlab Online. Participant 3 said:

... those stock pictures on the website; they gave an image of unreliability.

As a facilitator, participants mentioned that real people in pictures or even famous people that used the tests could positively influence the reliability and use of the service. Also, they mentioned that a short video with education and instructions about diagnostic test packages could improve the triage's clarity and the diagnostic packages' content.

C) Innovation relative advantage

Participants mentioned several factors why they would use this innovative service. Those factors were mostly related to accessibility of the service compared to other services or to normal practice. For example, the easiness of ordering a test online without going to the general practitioner was a relative advantage of the service. A participant mentioned:

Yes, I would rather order online because going to the general practitioner… it takes time. (p7)

Also another participant mentioned the benefit of ordering a test online without going to the general practitioner:

Hmm yes, I thought of a few things when I first saw the website.. of the vitamin tests, STI tests, and COVID tests... I thought yes, you do not want to go to the general practitioner for that. Especially for STI testing, the threshold is high. In this way, you still test and see if you are healthy. (p1)

However, the relative advantage was negatively influenced by the high costs of the tests. One participant stated:

The costs will stop people from buying anything. (p17)

F) Innovation complexity

Several facilitators and barriers that influenced the complexity of the service were mentioned by the participants. First of all, the amount of test packages and parameters available were confusing. It became clear from the focus groups that offering the 'right' number of diagnostic tests was important; participants were not enthusiastic about a test package with many separate parameters. Participants mentioned that they were optimistic about the possibility of ordering STI testing, COVID-19 testing, and some prevention tests. However, participants mentioned that after the triage, they received advice to test a lot of different test packages. Recommending many diagnostic test packages to the participants was a barrier because they were confused about which test package was important for them. Also the high amount of information provision about those testpackages was experienced as difficult by around half of the participants. Participant 13 mentioned:

When I open the website, a lot of information is present. Too many tests are available. Of course, this website wants to sell tests, but... I do not know. I found the home page too complicated, too unclear.

Second, the language used on the website was a factor that influenced the use of the service. The language on the homepage was experienced as straightforward and was therefore a facilitator. However, when completing the triage and choosing the diagnostic package, the information was more challenging to understand. Namely, medical and incomprehensible terms were used. Participant 8 mentioned:

I think you have a very broad target group of people who would like to use this, and I think it is written for the somewhat well-educated, reasonably well-informed citizen, shall we say. … Offer more comfort to people by using less difficult vocabulary.

Third, participants mentioned elements of the website itself, which influenced the user-friendliness. Participants were happy with the filters in the search bar to look for a particular test, the search function and the website's colours. Participant 14 mentioned:

Personally, I found the website easy to use, and what I experienced as very positive were the filters….

However, about a third of the participants found the website unclear (among others, due to too much text) and complicated (eg, where to find what they were looking for), and they found the homepage too busy.

Facilitators and barriers in the outer setting domain

D) Partnerships and connections

The service was linked to academic institutions, which increased its reliability. Mentioning partners would increase the uptake according to the participants: Participant 13 mentioned*:*

Yes, mentioning partners would be nice.. And famous names always attract attention.

G.1) Societal pressure

Participants mentioned that reviews and blogs could help in increase the use of the service and its reliability. Participant 5 mentioned:

You want to read reviews and experiences of others.

Facilitators and barriers in the individuals domain

B) Capability

The individual's skills and knowledge regarding services like Directlab Online influenced their willingness to use the service and their perception of potentially using it. The younger participants (20-30 years old) mentioned that they had experience with this kind of website, which reassured them to use this service. However, some older participants (39 years and older) had less experience with digital services in general and mentioned some anxiety and tension when they needed to order a test. Some of them would prefer to go to the general practitioner for diagnostic tests. However, all age groups mentioned the benefit of ordering STI tests online without going to the general practitioner.

Future needs

Different needs were identified regarding the services like Directlab Online. First, the service's purpose must be more explicit for the participants. For them, it was unclear that the service could help them self-manage their health. Participant 19 indicated:

And this is what I miss on the website; what is in it for me and my health as a patient or consumer?

Second, there was a need to understand what the advantages were of ordering diagnostic tests online (eg, more accessible compared to going to the general practitioner for tests). Participants wanted this information to be more evident on the website.

Third, participants also explained that they would like to have more information about how they could remain healthy or what they could do to become healthier after getting their test results back. It could help, according to the participants, to let them know more specifically that general practitioners make the diagnostic test packages designed for the service. All participants saw the benefit of ordering STI diagnostic test packages online and receiving them at home. The current offer of diagnostic test packages does not meet the wishes of all participants. There was a need for additional tests, such as tests for food allergies, testosterone, fertility or urinary infections. A participant mentioned:

I want a urine tract infection test; those are relatively cheap, I think…(p1)

Discussion

Principal findings

The current qualitative study aimed to evaluate the facilitators and barriers of an online direct access to diagnostic test service from the perspective of potential users. In addition, the study tried to identify the needs, to use such services. The study showed that a tailored amount of information could benefit the service. Participants needs to use a service like Directlab Online were to be ensured that the website was there for their health. It was important that the participants saw the benefit of a diagnostic test package. Identified barriers and facilitators were categorized using the Consolidated Framework into Implementation Research. The study showed that privacy, too much information and a commercial look and feel were important barriers. Facilitators were the right amount of information on the service and involving a health care professional in the service. In addition, the study showed that a tailored amount of information could benefit the use of the service. In short, we noticed that a lot of facilitators and barriers were influencing the reliability or accessibility of the service. For example, the commercial look and feel and lack of privacy information contributed to a less reliable service for the potential users and ordering a test online without a health care professional was influencing the accessibility.

Directlab Online is a service for users to support them in self-managing their health. An important quality-enhancing element for Directlab Online was that medical doctors had been actively involved in developing the service. Medical doctors have significantly influenced the content and information shown on the website. The focus groups with potential users, however, identified needs and wishes that did not completely align with the ideas of the general practitioner. To illustrate, medical doctors wanted other types of diagnostic test packages online than the participants wanted to use. Furthermore, the general practitioners wanted detailed information on the website, whereas this information overload was not always working well for the participants.

A study about an online results portal also discussed the complex balance between the medical necessities and participants' needs for the right amount of understandable information [34]. Presenting information requires a balance between too much medical information and the information users need to understand test packages and results. A potential way to solve overwhelming participants with information is to not present all the information directly in one view to the participant but by offering clickable links or short videos [34].

The current study used the CFIR to identify and categorize the facilitators and barriers. In another study, researchers performed an inventory to determine which obstacles must be overcome and how to optimize eHealth in primary care using this framework [33]. They found similar results to our study; costs and privacy issues were identified as important barriers. In addition, in line with other studies, the following facilitators were identified as "experience with eHealth" and "easiness to use" [33, 35]. In comparison with other studies utilizing the CFIR to classify facilitators and barriers, similar factors were predominantly identified. A notable factor highlighted in a study involving cancer patients utilizing a digital self-monitoring system was the necessity to elucidate the service's added value, alongside concerns regarding privacy issues. [36]. However, other factors were also mentioned, such as the connection with health care professionals, which were not identified in our study. The target population (cancer patients) could be an important explanation for this difference. The comparison with other literature revealed that irrespective of the type of digital service or the user population, the facilitators and barriers remained quite consistent. The current study's inventory could help determine what obstacles need to be overcome and how we might optimize an application like Directlab Online.

Depending on the participants, mainly influenced by age, some would use an online website to organize their health. In contrast, other participants, mainly older participants, were more at ease with going to the general practitioner and organizing their health directly via the general practitioner [37]. The older participants would rather go to the general practitioner in this research, which could lead to the cautious conclusion that online direct access to diagnostic services is not attractive for everyone [37]. In addition, this study showed that the use of a service like Directlab Online is not only age-related but also the user's health-related problem and the type of test package was important. Participants' needs were to feel the relevance of ordering a diagnostic test package online instead of going to the general practitioner. The relevance was clear for the STI test packages but unclear for other diagnostic test packages. The study results showed that it remains important to involve all end-users in the service to ensure that the service supports the needs of the target population [38]. Directlab Online was developed with general practitioners and elements that they found important were integrated in the service. Whilst this current study gave insight in the facilitators and barriers of potential users and it appeared that those things were not the same. It is important for a reliable and proper service, that both perspectives of

all stakeholders should be included in (further)development of such services. Finally, the facilitators and barriers to using a service like Directlab Online that were found could be used to optimize the service and comparable services.

Strengths and limitations

There is a lot of direct access to diagnostic testing services available, mainly when it entails STI diagnostic test packages. However, not many of them have a scientific basis or are developed by medical professionals. This is the first study that looked into the facilitators and barriers of a service that provides more diagnostic test packages than only STI tests and which is developed in co-creation with medical doctors. Another strength of the study was that the CFIR framework was used to analyze the facilitators and barriers mentioned in the focus groups. Embedding the facilitators and barriers in this framework made the comparison with other research easier. In addition, the domains identified by the CFIR framework can help to find the right implementation strategy [33, 39].

The current study focused on potential users because we were interested in their first impression of the service. The rationale was that - in the real world - such a service could be visited by many new users [40]. Previous experiences have not biased the impression of potential users. However, this could also be a limitation because participants who did use Directlab Online before could have another opinion about the service. This made the results less generalizable. Another limitation is that the mean age of participants was relatively low, making it more difficult to generalize the results to the general Dutch population. However, all participants, independent of age, mentioned the benefit of ordering STI tests online. The service showed benefits for participants who are ashamed to visit a general practitioner for a diagnostic package; and for participants who wish to order tests in an accessible, non-binding way.

Future research

Directlab Online is a service developed for a wide range of users. However, the current study showed that it is important to include end-users to ensure that the service fits the population's needs. Co-creation with end-users and medical professionals could be a solution to solve disbalances in wishes and needs between them and to improve an eHealth application [38]. For future research, organizing co-creation sessions and analyzing their results could be beneficial to improve the service. Finally, in future research, information about the influence of the diagnostic test's result on the user's lifestyle could be analyzed. Namely, this could possibly result in a preventive role for a service like Directlab Online to improve the health of a population.

Conclusions

According to participants, information provision, comprehension, and the total look and feel of the website were the most important elements that influenced the use and uptake of a direct-to-consumer website for diagnostic test packages. Barriers, like the commercial look and feel and lack of privacy information, negatively influenced reliability and accessibility. The study showed that it is important to include relevant stakeholders in creating an eHealth intervention because there was a disbalance between users' needs and what involved general practitioners consider necessary. Future research could take a quantitative approach to further identify the needs regarding test packages and to identify the demographics of users and the influence of test results on the behavior of users. Directlab Online offers opportunities for more online self-management of health.

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Conflicts of Interest

During the research, KS and ETK were employees at Unilabs.

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Abbreviations

CFIR = Consolidated Framework for Implementation Research
STI = Sexually Transmitted Infection

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Appendix 1

Overview of test packages on Directlab Online

Table 1. The other test packages on the website Complete of Directlab Online.

Category	Parameters
Vitamin tests	
Vitamins check	Gain insight in blood levels of vitamins B6, B11, B12, and D
Vitamins plus check	Gain insight in blood levels of vitamins B6, B11, B12, D, ferritin and hemoglobin
Vegetarian	Gain insight in blood levels of vitamins B12, D, hemoglobin, mean corpuscular volume, and ferritin.
Vegan	Gain insight in blood levels of vitamins B12, D, hemoglobin, mean corpuscular volume and ferritin.
Vitamin D	Gain insight in vitamin D blood level
Vitamin B12	Gain insight in vitamin B12 blood level
Test for common complaints	
Fatigue	Check for causes of fatigue in blood levels: glucose, thyroid stimulating hormone, C-reactive protein, freeT4, hemoglobin, mean corpuscular volume, ferritin, B11, B12 and glomerular filtration rate
Hair loss	Check for causes of hair loss in blood levels: hemoglobin, mean corpuscular volume, ferritin, thyroid stimulating hormone)
Burn out*	Check for causes of burn out in blood levels: glucose (non-fasting), HbA1c, C-reactive protein, thyroid stimulating hormone, freeT4, hemoglobin, mean corpuscular volume, ferritin, Vitamin B11 and B12
Why do I not lose weight?*	Check for thyroid stimulating hormone and glucose (non-fasting)
Drugs test	
Amphetamine/XTC	Check if there are traces in urine of Amphetamine/XTC
Benzodiazepines	Check if there are traces in urine of Benzodiazepines
Cocaine	Check if there are traces in urine of Cocaine
Cannabis	Check if there are traces in urine of Cannabis
Opiates	Check if there are traces in urine of Opiates
Total drugs tests	Check if there are traces in urine of benzodiazepines, amphetamine/XTC, cannabis, cocaine, Gamma Hydroxy Butyrate and opiates.
COVID-19 tests	
Antibody test	To check if a consumer has antibodies against COVID-19 in their blood
Post-COVID test	If a consumer has still complaints after a COVID-19 infection he/she can check if something is wrong. Gain insight in blood levels: glucose (non-fasting), total cholesterol, low density lipoproteins, high density lipoproteins, triglycerides, C-reactive protein, thyroid stimulating hormone, freeT4, hemoglobin, mean corpuscular volume, ferritin and vitamins B11, B12 and D
Vitamins test	Gain insight in blood levels of vitamins B6, B11, B12, and D after COVID-19 infection

*those tests are not available any more on Directlab Online after the service update

Table 2. The test packages focused on in the focus groups.

Category	Parameters
Prevention tests	
Health check-up	Check total cholesterol[a], low density lipoproteins (LDL) [a], high density lipoproteins (HDL)[a], triglycerides[a], Hba1C[a], albumin/creatinine ratio[b].
Health check-up at home*	Measuring parameters via self-sampling of blood: total cholesterol[c], LDL[c], HDL[c], triglycerides[c], Hba1C[c], albumin/ creatinine ratio[b]
Cholesterol	Check total cholesterol[a], LDL[a], HDL[a], triglycerides[a]
Cholesterol at home*	Measuring parameters via self-sampling of blood: Total cholesterol[c], LDL[c], HDL[c], triglycerides[c]
Anemia	Check hemoglobin[a], mean corpuscular volume[a], ferritin[a] and C-reactive protein[a]
Diabetes	Check glucose[a] and Hba1C[a]
Healthy bones*	Check calcium[a] and vitamin D[a]
Healthy kidneys*	Check creatinine[a], glomerular filtration rate[a], albumin/creatinine ratio[b]
Thyroid check	Check thyroid function via thyroid stimulating hormone[a] and freeT4[a]
Sexual transmitted infections tests	
Chlamydia	Check for chlamydia[d] (eg oral, anal, vaginal, urine sample)
Gonorrhea	Check for gonorrhea[d] (eg, oral, anal, vaginal, urine sample)
Human Immunodeficiency Virus (HIV)	Check for HIV[a]
Syphilis	Check for syphilis[a]
Hepatitis B	Check for Hepatitis B[a]

[a]Blood sample needed for diagnostics, [b]Urine sample needed for diagnostics, [c]blood sample by self-sampling needed for diagnostics, [d]Oral, anal, vaginal or urine sample needed for diagnostic tests
*those tests are not available any more on Directlab Online after the service update

Appendix 2

Semistructured interview guide

1. Introduction, explanation, informed consent
    a. Welcome. Introduction moderator and note taker
    b. Introduction subject
    c. Focus group rules
    d. Scheduling
    e. Consent Form
    f. Practical questions?

2. Proposal round
    a. Each participant briefly introduces himself.

3. Opening Questions
    a. Explanation about digital care in general, Explanation of 'Directlab Online'
    b. What were your experiences with digital health care before this study started?

Explanation of what we are going to do
Let the participants go through the website for about 10 minutes.

4. Overall website
    a. How did you find the Directlab website?
    b. What is your first reaction to the website?
    c. What expectations do you have now? / Is it clear what service is offered on the website?
        i. What do you think of the service?
    d. How did you experience the website?
        i. To what extent did you find the website easy to use?
        ii. Do you think you can handle the website quickly?
        iii. Were you able to easily find what you were looking for?
        iv. To what extent did you find the website attractive?
        v. Do you need help using the website?
        vi. Does the Directlab website form an unambiguous whole for you?

5. Elements of the website
    a. Did you find the general information provided on the website clear?
        i. Do you think information is missing?
        ii. Do you think other elements are missing on the website (e.g., Chatbot or similar)
    b. Have you seen the blogs on the website? If so, will you read or use it?
    c. Have you noticed that there are two different types of packages?
        i. Yes? Do you understand the difference between the two types of packages? Is a distinction between lifestyle and medical packages of added value for you?
        ii. No? Explanation about the two different packages and why it was decided to make this distinction: reliable] How do you view this?

Show the triage questions yourself, different per focus group

6. Triage plus test advice
    a. How did you experience the questions on the website that led to testing advice?
    b. To what extent did you understand these questions?
        i. Are there any words you had to look up?
    c. To what extent were the questions easy to answer?
    d. Did you understand why you had to answer these questions?

7. Facilitators, barriers, improvements: points and potential contributing and counteracting factors of the website and online testing method for the future
    a. In principle, this service is intended for everyone. What factors do you think may hinder/encourage the service?
        i. Which points do you see as barriers to using Directlab?
        ii. The service is currently paid for. Would you pay for it? [Disadvantage, if something is reimbursed, you have to provide more personal information]
        iii. Compensation, costs, personal characteristics?
        iv. What do you need to assess Directlab (even) more positively?
    b. Do you have ideas on how to improve Directlab?
        i. If so, what could these improvements look like?
    c. Does this way of ordering tests give you a sense of control?
    d. To what extent does Directlab feel to you as a reliable service? [probing – why is that]

e. If you were not using Directlab to request diagnostics, would you have gone to the GP?
    i. How do you feel about being able to request a diagnostic test without a counselor?
f. How do you experience privacy [complete online questionnaires, order tests, enter personal data, and pay]?
    i. How do you think Directlab handles this?

8. Needs: Request utility of online diagnostic test
    a. To what extent does this method of ordering online tests meet your needs?
    b. Would you use Directlab yourself in the future?
        i. What tests would you use Directlab for [tell more about other types of tests]
        ii. Would you like to see other types of tests that are not currently available?
        iii. Developments are underway about self-drawing blood for a test. How do you feel about this?
    c. Would you skip a doctor's appointment using Directlab?
    d. How do you feel about being able to request a diagnostic test without a counselor?

9. Closure
    a. Of all the things we discussed today, what did you find most important?
    b. To what extent would you recommend Directlab to others?
    c. Are there any points that we have not discussed?
    d. Do you have any additional comments/questions?
    e. End of the focus group. Would you like to be kept informed of the results of the research?

5

Usability of Homelab, an Online Service at the General Practitioner for Diagnostic Tests: A Pilot Study With a Questionnaire

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Abstract

Background: eHealth potentially can make health care more accessible, efficient, and can help to reduce the workload in primary care. Homelab is an eHealth tool implemented in the environment of the general practitioner. It offers relative simple laboratory diagnostics without getting a referral of the general practitioner. After logging in patients select and order a diagnostic test based on their symptoms. The test results are presented online to the general practitioner and patient.

Objective: This study aims to evaluate the use, usability and user characteristics of Homelab. Furthermore, it aims to evaluate whether Homelab replaces an appointment at the general practitioner.

Methods: Homelab has been implemented since May 2021 as a pilot in a Dutch general practice. The number of requests and the ordered diagnostic packages are monitored. After using Homelab, patients are invited to complete a short questionnaire. The questionnaire contains demographic questions and assesses usability using the System Usability Scale (10 items). In addition, questions about requesting an appointment with the general practitioner without Homelab are included. All data were anonymous.

Results: The questionnaire was filled by 74 individual patients. The mean age of the patients was 40.33 (SD 12.11) years, and half of them were females (39/74, 53%). The majority of the patients were highly educated (56/74, 76%) and employed (53/74, 72%). Approximately 81% (60/74) of the patients reported that they would use Homelab again in the future and 66% (49/74) reported that they would have gone to the general practitioner if they had not used Homelab. The usability of Homelab was perceived higher by the younger age group (mean 73.96, SD 14.74) than by the older age group (mean 61.59, SD 14.37). In total, 106 test packages were ordered over 1 year, and the most requested diagnostic package was "Am I still healthy? I want to do my annual health checkup." Homelab was used the most during the months of the COVID-19 lockdown.

Conclusions: The use of Homelab, a digital self-service for ordering diagnostic tests, was monitored in this study, and its usability was perceived as above average. Our findings showed that patients are willing to use Homelab in the future and they would use it most of the time as a replacement for regular consultations. Homelab offers opportunities for more accessible and efficient health care for both the patient and the general practitioner.

Keywords: eHealth; diagnostic testing; general practitioner; general practice; GP; referral; online testing; diagnostic; laboratory test; usability; digital health; health care service; service delivery

Introduction

The number of patients with chronic diseases is high and is increasing worldwide [1,2], thereby leading to a high workload for health care professionals, especially in primary care, as many patients require complex care [3]. General practitioners (GPs) have a positive attitude toward innovations like eHealth [4-6]. eHealth can be defined as "health services and information delivered or enhanced through the internet and related technologies" [7]. eHealth can potentially lower the workload of GPs [4,5]. For example, in the Netherlands, a noncommercial website was developed by GPs for citizens to obtain reliable health information [8], and a significant decrease in the consultations was noted after the website's launch compared to the total consultations before the launch [8,9]. Apps that support lifestyle change or the self-management of chronic diseases (eg, promoting physical activity, healthy diet, weight management) can also benefit GPs, as these apps can take over part of the GPs' coaching [10-12]. Consequently, GPs may have more time for other health care activities.

The COVID-19 pandemic accelerated the development and use of technology in health care with more web-based consultations and home monitoring [13,14]. One study showed that using technology in health care increased accessibility because it was easy for patients to use web-based consultations [13]. eHealth gives patients more control of their health, and it has the potential to increase self-management [15]. A way to use eHealth effectively is to integrate eHealth into regular care—the so-called hybrid care or blended care; in this way, eHealth can be used more frequently, which may positively impact health care outcomes [16].

One area where eHealth can be used is laboratory diagnostic testing with direct access to diagnostic tests and result services. With such services, patients can order a diagnostic test online, for example, for COVID-19, perform the test at home or a facility, and view the result online. A recent review [17] showed that most of the included web-based diagnostic services (which were operated independently by health care professionals) were positively evaluated and found very acceptable by patients, but most of the services focused on sexually transmitted infections, and direct access to diagnostic services for other diseases was rare.

Our study describes a new diagnostic-related eHealth initiative called Homelab, which is a direct web-based access service implemented in the environment of the general practice. Patients can use Homelab to order diagnostic tests online without going to the GP for a diagnostic test referral. After ordering a test on Homelab, the patient's GP needs to authorize the ordered test; this way, GPs can monitor what is being ordered. Authorizing the ordered tests ensures that the tests are reimbursed health care. A consultation is scheduled when a diagnostic test result is abnormal or a disease or a condition is present. Both the patient and the GP can view the test result online.

To our knowledge, this is the first web-based diagnostic service completely integrated into the web-based environment of the GP, and no research has been performed into the type of users and the frequency of use of Homelab. Although services are available where patients can order diagnostic tests themselves without a GP [17], a service where this is integrated in the GP environment is new. Homelab has several advantages for the patient. First, patients do not need a GP consultation for a diagnostic test referral, and the patient can thus quickly order a diagnostic test online. Second, Homelab can help a patient prepare for the GP consultation, as the diagnostic test result can be viewed online beforehand. This way, Homelab may help to empower the patient and increase consultation efficiency. Further, it may save time for the GP because the GP does not have to perform consultations for relatively simple diagnostic test referrals; consequently, GPs may have more time for more complex cases. Another critical aspect of the Homelab service is reimbursed health care. In a previous review [17], web-based diagnostic services were not part of reimbursed health care, and the patient had to pay the costs. Costs, however, were a barrier to using such services [17].

Objectives

Homelab was implemented as a 1-year pilot in 2021 in a general practice in the Netherlands, making it possible to research a direct access diagnostic service in the environment of the GP. This pilot study aims to identify who uses Homelab, how and how often Homelab is used, and how patients perceive its usability. Furthermore, the aim of this study was to identify whether using Homelab potentially replaces an appointment with the GP.

Methods

Study design and population

A quantitative pilot study was conducted between April 21, 2021 and April 4, 2022. User characteristics and user experiences were collected through questionnaires, and data on how often Homelab was used (eg, what and how many tests were ordered) were extracted from Homelab. The data were not linked to each other due to privacy legislation. Homelab was implemented as a pilot at the Westerdokters General Practice in Amsterdam; this practice is known for its innovation and digitization. The study population consisted of registered patients at the Westerdokters General Practice who chose to use Homelab. There were no exclusion criteria for participation. All the patients of the Westerdokters General Practice could use Homelab.

The service: Homelab

Homelab is a Dutch digital self-service that offers patients direct access to diagnostic tests. This service is accessible from the website of the general practice. The test

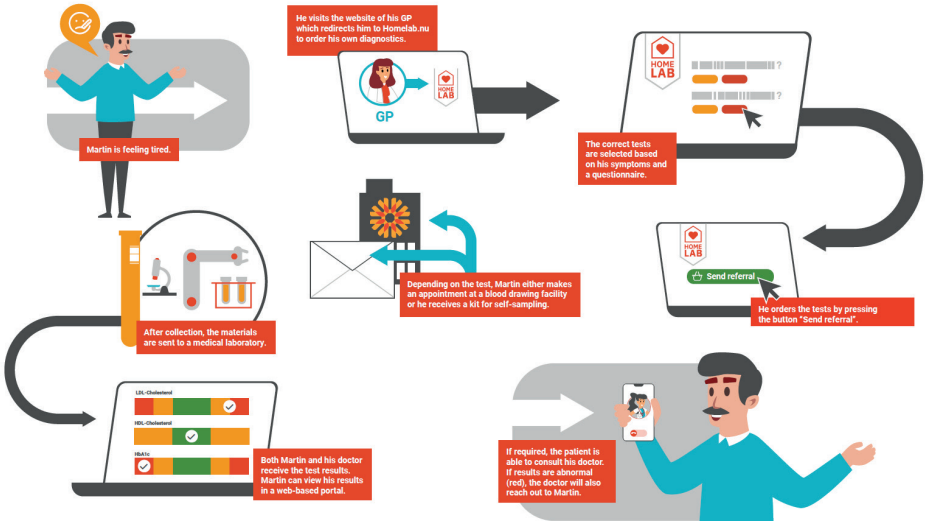

Figure 1. Patient journey of Homelab. GP: general practitioner; $HbA1_c$: hemoglobin $A1_c$; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

- I feel tired; what is wrong?
- Am I still healthy? I want to do my annual health checkup.
- Am I allergic?
- What is my blood type?
- Why do I often have pain in my stomach?
- Why can I not lose weight?
- Do I have anemia?
- Do I have an elevated prostate-specific antigen? (only available for men)
- Why do I have hair loss?
- Is my body system free of any traces of drugs?

Textbox 1. The list of health problems that can be selected on Homelab (translated from Dutch to English).

packages ordered on Homelab are frequently requested and are standard diagnostic tests, for example, diagnostic tests for anemia or fatigue. Unilabs developed Homelab in co-creation with Dutch GPs. In Figure 1, the patient journey is presented. Unilabs is an international diagnostic provider, which offers laboratory, imaging, and pathology specialties in 16 countries [18].

First, patients visit the GP's website and log in via a 2-factor authentication. Second, patients can select a health problem (see Textbox 1; eg, I feel tired; what is wrong?). Third, patients complete follow-up questions related to the selected health problem (eg, Have you been tired for several weeks or months, and is this affecting your life?). The questions are based on medical guidelines (triage). Fourth, after the digital triage, a combination of specific diagnostic tests, further referred to as test package(s), is suggested to the patient. It could also be that an explanation is given without a

diagnostic test referral. Fifth, the patient can order the recommended test package(s), and the GP can authorize or cancel the requested test package(s). Depending on what kind of materials (eg, feces, urine, blood) are required for testing, the patient can make an appointment for blood sampling at the general practice or hand in their urine sample or feces at the general practice. After the analysis of the materials (eg, feces, urine, blood) in a professional medical laboratory, results are presented in a secure tailor-made web-based portal and available for both the patient and GP [19,20]. An electronic consultation can be initiated by the patient or the GP when the results are concerning or if the patient has questions.

Outcome measures

Questionnaire data: demographic and clinical characteristics

The following demographic characteristics of Homelab users were assessed: year of birth, gender, education level, and employment status. Low education was defined as primary school or prevocational secondary education; intermediate education included upper secondary education and vocational education; and high education was defined as graduated from universities of Applied Sciences, research universities, and doctoral degree programs. For employment status, there were different categories: student, which was defined as a pupil (secondary school and student); employed (defined as having a fulltime or parttime job, or being an entrepreneur); voluntary work, retired, or unemployed, which was defined as being unemployed or unable to work (eg, due to sickness or incapacity for work); or other. Finally, patients were asked whether they had a chronic disease. Answer options were "yes, asthma/chronic obstructive pulmonary disease;" "yes, cardiovascular disease;" "yes, diabetes;" or "no, none of the above."

Questionnaire data: Homelab use

To gain insight into how Homelab was used, 3 questions were asked. The first question was on using Homelab as a replacement for consultation. To investigate whether patients would have gone to the GP if they did not have access to Homelab for a diagnostic test, we asked the following question: If you did not order a diagnostic test via Homelab, would you have gone to the GP? The answer options were yes, no, and I don't know.

The second question determined whether patients would like to have the possibility of ordering diagnostic tests independent of the GP in the future. The following question was asked: Would you like to have the possibility of ordering diagnostic tests online independent of a GP in the future? Answer options were yes, no, and I don't know.

The third question was on the costs of using Homelab. In this pilot study, Homelab could be used for free by patients. Generally, in the Netherlands, the costs of diagnostic tests ordered at the general practice are covered by the health care insurance or

by the patient when the patient's medical costs in that year are below €385 (US $418) (ie, the standard amount of obligatory, deductible excess in 2021). To identify whether patients would order the test if they had to pay for it themselves, the following question was asked: I would also order this test when it would come at the expense of the deductible of my health insurance. The answer items were rated on a 5-point Likert scale ranging from strongly disagree to strongly agree.

Questionnaire data: System Usability Scale (SUS) - 10 items

The System Usability Scale-10 items (SUS-10) is a valid and robust questionnaire to determine whether a system is user-friendly and can be used for an app or website [21]. The questionnaire consisted of 10 items (eg, I think that I would like to use this app frequently). Each item was rated on a 5-point Likert scale ranging from strongly disagree to strongly agree. The negatively formulated items were reversed scored. The sum score of all the items was multiplied by 2.5 to obtain the total SUS score. The SUS total score ranges from 0 to 100, where a higher score means that the app is more user-friendly [21]. A score above 68 is considered usability above average [22].

Ordered test packages

Data on the number of ordered test packages and the type of ordered test packages were collected. This information was downloaded via a content management system function of Homelab. This anonymized data were not linked to the questionnaire data. Therefore, data were not traceable to an individual participant, and the data were anonymous.

Procedure

On the Westerdokters Practice website, a link to Homelab was provided. Homelab was explained to patients in the general newsletter of Westerdokters twice. After the patients ordered a diagnostic test, they had the possibility of completing the questionnaire. At the start of the questionnaire, there was a short introduction about the study aim, expectations from participants, and why the study was performed. Patients were not obliged to fill in the questionnaire. From the beginning of the pilot study until January 2022, Homelab users could complete the questionnaire multiple times (ie, every time they ordered diagnostic test package(s) on Homelab). In January 2022, this was corrected, and patients could only complete the questionnaire once. All data were downloaded via a content management system of Homelab.

Ethical approval

Approval by an ethics committee was not needed for this study because no intervention or trial has occurred in the sense that the research participants were subjected to actions or had modes of behavior imposed on them. Obtaining informed consent and ethical approval was unnecessary because the questionnaire data were anonymously collected. The data on the frequency of Homelab use were anonymous.

Statistical analyses

Descriptive statistics (eg, mean [SD], total sample, percentages, frequencies) were used to summarize all the demographic and clinical characteristics, number and type of orders of test package(s), and data on SUS-10. Moreover, the data were split for age (≤40 years and >40 years) and gender, and descriptive statistics were used to give insight into these different groups. The analyses were performed using SPSS version 25 (IBM Corp) [23].

As described above, there was a fault in the programming, and patients could complete the questionnaire multiple times. If patients ordered multiple packages on Homelab (at the same time), the patient would be presented with the questionnaire after every ordered test package. In the final data set, however, we wanted patients to be only represented once. Therefore, we looked at the demographic characteristics of successively incoming data points. When the demographic data of the next row(s) were identical, we looked at the SUS data of these rows. If there was variation in the SUS data in the first row but not in the consecutive row(s) (ie, all items scored with a 3), we assumed that the consecutive row(s) were of the same patient and were therefore removed from the final data set.

Results

Descriptive statistics

In total, 79 questionnaires were completed. Data from 5 questionnaires were removed because these data were from individuals (n=3) who completed the questionnaire multiple times, resulting in a total of 74 patients with valid questionnaires. Table 1 presents the demographic and clinical characteristics of the patients and their use of Homelab data. The mean age of the patients was 40.33 (SD 12.11; range 23-73) years; half of them were females (39/74, 53%), and the majority were employed (53/74, 72%) and highly educated (56/74, 76%). Furthermore, most did not have asthma, chronic obstructive pulmonary disease, diabetes, or cardiovascular diseases (69/74, 93%).

Use of Homelab

Of the total patient population, 66% (49/74) reported that they would have gone to the GP if they had not used Homelab, while 22% (16/74) reported that they did not know if they would have gone. The percentage of patients in the younger age group (24/41, 59%) who would have gone to the GP was lower than that of patients in the older age group (25/33, 76%). Moreover, the percentage of male patients (24/34, 71%) who would have gone to the GP was higher than that of female patients (25/39, 64%). Of the total patient population, 81% (60/74) wanted to use Homelab again in the future without going to the GP, while 8% (13/74) did not know if they wanted to use it again. The percentage of patients in the younger age group (36/41, 88%) who would use

Table 1. Demographics and clinical characteristics of Homelab users (N=74).

Characteristics	Total	Age		Gender	
		≤40	>40	Male	Female
	N(%)/M (SD)	*N(%)/M (SD)*	*N(%)/M (SD)*	*N(%)/M (SD)*	*N(%)/M (SD)*
Age, mean (sd)	40. 33 (12.1)	31.95 (3.8)	50.76 (10.7)	41.44 (12.1)	38.64 (11.3)
Gender, n(%)					
Male	34 (46)	17 (42)	17 (52)	N/A[a]	N/A
Female	39 (53)	24 (59)	15 (46)	N/A	N/A
Unknown	1 (1)	0	1 (3)	N/A	N/A
Education, n(%)					
Low	5 (7)	0	5 (15)	3 (9)	1 (3)
Intermediate	13 (18)	7 (17)	6 (18)	9 (27)	4 (10)
High	56 (76)	22 (67)	22 (67)	22 (65)	34 (87)
Employment status, n(%)					
Student	5 (7)	2 (5)	3 (9)	5 (15)	0
Employed	53 (72)	34 (83)	19 (58)	25 (74)	28 (72)
Unemployed	6 (8)	3 (7)	3 (9)	1 (3)	5 (13)
Voluntary work	0	0	0	0	0
Retired	7 (10)	0	7 (21)	3 (9)	3 (8)
Other	3 (4)	2 (5)	1 (3)	0	3 (8)
Chronic diseases, n(%)					
Asthma/COPD	4 (5)	0	4 (12)	3 (9)	1 (3)
Cardiovascular diseases	1 (1)	1 (2.4)	0	0	1 (3)
Diabetes	0	0	0	0	0
No	69 (93)	40 (98)	29 (88)	31 (91)	37 (95)
Replacement for consultation[b], n(%)					
Yes	49 (66)	24 (59)	25 (76)	24 (71)	25 (64)
No	9 (12)	8 (20)	1 (3)	4 (12)	5 (13)
I don't know	16 (22)	9 (22)	7 (21)	6 (18)	9 (23)
Future use Homelab[c], n(%)					
Yes	60 (81)	36 (88)	24 (73)	26 (77)	34 (87)
No	1 (1)	1 (2)	0	0	1 (3)
I don't know	13 (8)	4 (10)	9 (27)	8 (24)	4 (10)
Willing to use it came at the deductible expense of my health insurance[d], n(%)					
Totally agree	19 (26)	8 (20)	11 (33)	9 (27)	10 (26)
Agree	16 (22)	10 (24)	6 (18)	7 (21)	9 (23)
Neutral	19 (26)	14 (34)	5 (15)	7 (21)	11 (28)
Disagree	14 (18)	6 (15)	8 (24)	8 (24)	6 (15)
Totally disagree	6 (8)	3 (7)	3 (9)	3 (9)	3 (8)
System usability scale (10 items), mean (sd)	68. 45 (15.7)	73.96 (14.7)	61.59 (14.4)	67.94 (15.3)	69.30 (16.3)

[a]N/A: not applicable.
[b]This variable was based on the question, "If you did not order a diagnostic test via Homelab, would you have gone to the general practitioner?"
[c]This variable was based on the question, "Would you like to have the possibility of ordering diagnostic tests online independent of a general practitioner in the future?"
[d]This variable was based on the statement of "I would also order this test when this would come at the expense of the deductible of my health insurance."

Table 2. Overview of the diagnostic packages and frequency of ordering the packages (N=106).

Package name	Number of ordered packages
	Values, *N* (%)
Am I still healthy? I want to do my annual health checkup.	51 (48.1)
I feel tired; what's wrong?	24 (22.6)
Am I allergic?	9 (8.5)
What's my blood type?	7 (6.6)
Do I have anemia?	4 (3.8)
Do I have an elevated prostate-specific-antigen? (only available for men)	4 (3.8)
Why do I often have pain in my stomach?	3 (2.8)
Why can I not lose weight?	2 (1.9)
Why do I have hair loss?	2 (1.9)
Is my body system free of any traces of drugs?	0

Homelab again in the future was higher than that of patients in the older age group (24/33, 73%). In addition, the percentage of female patients (34/39, 87%) who would use Homelab again was higher than that of male patients (26/34, 76%). Almost half of the patients (35/74, 47%) (totally) agreed with the statement, "I would also order this test when this would come at the expense of the deductible of my health insurance," and about a quarter (20/74, 27%) (totally) disagreed with the statement. The percentage of patients in the younger age group (18/41, 44%) who (totally) agreed with this statement was slightly lower than that in the older age group (17/33, 52%). For both females (19/39, 49%) and males (16/34, 47%), the percentage that (totally) agreed was almost equal.

Usability of Homelab

The mean score on the SUS-10 was 68.45 (SD 15.74; range 40-100), which can be considered above average usability. The average SUS score in the younger age group (mean 73.96, SD 14.74) was higher than that in the older age group (mean 61.59, SD 14.37). There did not appear to be gender differences (females, mean 69.30, SD 16.29; males, mean 67.94, SD 15.29).

Ordered test packages

The number of unique users of Homelab was 76. The total number of diagnostic test packages that were ordered was 106. In the beginning, Homelab was not used very often (n=3); in May, a few days after the release, Homelab was not used at all. In June, July, August, September, October, November, and December of 2021, Homelab was used 14, 8, 5, 5, 9, 4, and 6 times, respectively. In January and February of 2022, Homelab was used the most (22 times in both months). Table 2 gives an overview of the types of diagnostic test packages that were ordered and how often they were

ordered. The most ordered test package was "Am I still healthy? I want to do my annual health checkup" (51/106, 48.1%). The second and third most ordered test packages were "I feel tired; what is wrong?" (24/106, 22.6%) and "Am I allergic?" (9/106, 8.5%), respectively. One test package was not ordered (Is my body system free of any traces of drugs?).

Discussion

Our findings

Our study identified the characteristics of Homelab users, how and how often the diagnostic service was used, and its usability. The main users of Homelab were highly educated and employed. The age range of the users was broad, but the mean age of the studied population was comparable to that of the Dutch population in 2022 (40.3 years old vs 42.3 years old, respectively) [24]. Patients used Homelab in two-thirds of the cases instead of going to a GP; 81% (60/74) of the patients were willing to use it in the future and half of the patients would also order diagnostic test packages when it came at the expense of the deductible part of their health insurance. Thus, the usability of Homelab was perceived as above average.

The usability of Homelab was perceived higher by younger patients than by older patients, which is in line with that reported in other research on eHealth services [20,25]. Research shows that younger patients are more digitally competent than older patients and are more used to a web-based world [26], potentially making it easier for them to use an app such as Homelab and thereby explaining the higher usability score among younger patients. Older patients may have scored the usability lower because they may have specific wishes and needs (eg, having face-to-face contact with their GP); older patients may have more physical problems or chronic diseases where a normal consultation with the GP might be more preferred [27]. The wishes and needs of older patients could result in lower scores on the items of the usability questionnaire, such as willing to use Homelab in the future. Indeed, most patients who visit the GP are older; in the Netherlands, two-thirds of the consultations are performed with patients older than 40 years [28,29]. Although the usability of Homelab perceived by older patients was lower than that perceived by younger patients, the usability was still perceived as average. Future research should be performed to investigate how Homelab could be beneficial and seamlessly meet the needs of users of this specific older age group to improve its usability [30,31].

This pilot study was also set up to identify if patients would use Homelab excessively because they could order the diagnostic test packages themselves. However, the number of ordered tests was not very high in the pilot period, and it seemed that there was no excessive use. Although it is too early to draw conclusions, Homelab seems to show potential in replacing consultations with the GP without excessive and

unnecessary use (based on the number of ordered tests found in this pilot in combination with the answers to the question, "If you did not order a diagnostic test via Homelab, would you have gone to the GP?").

This was the first study performed on a web-based service for patients, allowing them to order diagnostic test packages in the digital environment of the GP without needing a consultation. Other studies have evaluated services with direct access to laboratory diagnostic testing and results, but those services were without a health care professional [17]. In Homelab, the GP is involved to ensure that patients receive proper care. Still, for the GP, Homelab requires a minimum of time investment. Our results suggest that patients were willing to use Homelab in the future, and they used this service instead of going to the GP, which suggested that they are willing to replace the physical consultation with Homelab. Publications on other digital apps also showed a decrease in consultations when eHealth was used [8,9].

A previous study [32] that researched the usability of another kind of direct access to a diagnostic service was comparable to that of Homelab. However, it [32] was not performed in the GP environment. That study [32] found that the service to order diagnostic tests for sexual transmitted infections online was easy to use (an element of the SUS), which was in line with the results of this study. Our study is the first to describe a web-based service for diagnostic tests where patients can order diagnostic tests themselves in the general practice environment. However, an important part of this service is a tailor-made results portal where patients can view their results online. The results portal was not investigated in this study, but previous studies have examined the benefits of presenting results online [19,33]. Research shows that more than one-third of the studied population was positive about accessing their diagnostic test results online [33], and the usability of the web-based results portal was rated positively [19]. More research is needed to address the efficiency and usability of Homelab.

Limitations and strengths of this study

Our study has some limitations. First, Homelab was piloted during the COVID-19 pandemic, which means that there were restrictions in daily life, and a large part of primary health care was shifted to web-based care [13,14]. Thus, it could be that patients were more open to using Homelab in the COVID-19 period, as web-based health care was the norm. If patients were more open to eHealth in that period, this could have led to more positive reactions to Homelab. Especially in the lockdown period in the winter of 2021/2022 in the Netherlands, Homelab was used more than that in the other months. However, the shift to web-based health care possibly remains because the benefits of using eHealth are more well-known now, and patients have a more positive attitude toward eHealth now than before the COVID-19 period [34,35]. Second, data were unavailable on whether patients really used the diagnostic test package that they ordered. For more insight into patients' follow-ups, the entire patient journey should be analyzed in future research. Third, the general practice where Homelab was piloted was a

relatively digital practice; they have a website where patients can make appointments online and have remote consultations (eg, phone calls, chats, video calls) [36]. Patients of this general practice were perhaps more used to eHealth than patients at other less digital general practices, which could influence the perceived usability of Homelab.

A strength of our study was that this is the first pilot study in a real-world setting with a new web-based diagnostic service. This usability study can help in making this service user-friendly and help in receiving the best experience for the user. Points of improvement derived from this study can be used to revise the service [37]. Another strength is that Homelab was developed in co-creation with GPs. Co-creation in eHealth interventions is an important precondition for good adoption of eHealth [11]. Homelab was piloted and developed for general practices in the Netherlands. However, a service like Homelab can also be implemented in other European countries with comparable primary health care systems where the GP is the first gatekeeper—in particular, Nordic countries are relatively advanced in adopting eHealth [11].

Conclusions

This pilot study describes Homelab, a digital self-service, wherein patients can order diagnostic tests online in the environment of the GP. This eHealth tool was used by a broad age group but not used excessively. Patients were willing to use Homelab in the future, and they used it most of the time as a replacement for regular consultation. The usability of Homelab was perceived as above average and as better in a younger population. More research should be performed to increase the usability of Homelab, obtain more insights into end user's needs, and examine if Homelab can lead to more efficient and accessible health care for both patients and GPs.

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Data availability

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

KS and ETK are employees of Unilabs, where Homelab has been developed.

Abbreviations

COPD = Chronic Obstructive Pulmonary Disease
GP = General Practitioner
SUS = System Usability Scale

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A Pharmacy-based eHealth Intervention Promoting Correct Use of Medication in Patients with Asthma and COPD: Results from a Non-Randomized Pre-Post Study

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Abstract

Background: Asthma and chronic obstructive pulmonary disease (COPD) affect millions of people worldwide. While medication can control and improve disease symptoms, incorrect use of medication is a common problem. The eHealth intervention SARA (Service Apothecary Respiratory Advice) aims to improve participants' correct use of inhalation medication by providing information and as-needed tailored follow-up support by a pharmacist.

Objective: The primary aim of this study was to investigate the effect of SARA on exacerbation rates in participants with asthma and COPD. Secondary aims were to investigate its effects in terms of adherence to maintenance medication and antimycotic treatment.

Methods: In this nonrandomized pre-post study, medication dispensing data from 382 Dutch community pharmacies were included. Exacerbation rates were assessed with dispensed short-course oral corticosteroids. Medication adherence between new and chronic users was assessed by calculating the proportion of days covered from dispensed inhalation maintenance medication. Antimycotic treatment was investigated from dispensed oral antimycotics in participants who were also dispensed inhaled corticosteroids (ICS). Outcomes were assessed 1 year before and 1 year after implementation of SARA and were compared between SARA participants and control participants. More specifically, for exacerbation rates and medication adherence, a difference score was calculated (ie, 1 year after SARA minus 1 year before SARA) and was subsequently compared between the study groups with independent-samples *t* tests. For antimycotics, the relative number of participants who were dispensed antimycotics was calculated and subsequently analyzed with a mixed-effects logistic regression.

Results: The study population comprised 9452 participants, of whom 2400 (25.39%) were SARA participants. The mean age of the population was 60.8 (15.0) years, and approximately two-thirds (n=5677, 60.06%) were female. The results showed an increase in mean exacerbation rates over time for both study groups (SARA: 0.05; control: 0.15). However, this increase in exacerbation rates was significantly lower for SARA participants (t_{9450}=3.10, 95% CI 0.04-0.16; *P*=.002; Cohen *d*=0.06). Chronic users of inhalation medication in both study groups showed an increase in mean medication adherence over time (SARA: 6.73; control: 4.48); however, this increase was significantly higher for SARA participants (t_{5886}=–2.74, 95% CI –3.86 to –0.84; *P*=.01; Cohen *d*=–0.07). Among new users of inhalation medication, results showed no significant difference in medication adherence between SARA and control participants in the year after implementation of SARA (t_{1434}=–1.85, 95% CI –5.60 to 0.16; *P*=.06; Cohen *d*=–0.10). Among ICS users, no significant differences between the study groups were found over time in

terms of the proportion of participants who were dispensed antimycotics (t_{5654}=0.29, 95% CI –0.40 to 0.54; *P*=.76; Cohen *d*=0).

Conclusions: This study provides preliminary evidence that the SARA eHealth intervention might have the potential to decrease exacerbation rates and improve medication adherence among patients with asthma and COPD.

Keywords: asthma; COPD; medication adherence; exacerbations; pharmacy; eHealth

Introduction

Asthma and chronic obstructive pulmonary disease (COPD) are chronic respiratory diseases that affect millions of people worldwide [1,2]. Asthma and COPD place a significant health burden on patients and an economic burden on society [3-5]. Medication cannot cure these diseases but can reduce disease symptoms and improve control, which, in turn, can positively affect patients' quality of life [6-9]. Unfortunately, nonadherence to maintenance medication is common in patients with asthma and COPD. Indeed, adherence rates have been found to vary from 22% to 78% [7]. Nonadherence can have detrimental effects on clinical outcomes for individuals with asthma and COPD. Notably, it could negatively affect lung function, disease control, exacerbation rate, health-related quality of life, and work productivity [6,7,10]. In addition, nonadherence has been associated with higher health care use and costs [6,7].

Factors related to nonadherence to inhaled medication are multifaceted and can include intentional nonadherence (eg, concerns about side effects and complexity of medication regime) and unintentional nonadherence (eg, experiencing difficulties with how or when to use medication or lacking skills to use inhaler devices) [7,9,11-15]. Regarding incorrect use of the inhalers, Lavorini et al [12] systematically investigated the use of dry powder inhalers by patients with asthma or COPD. The results showed that between 4% and 94% of the patients did not use their inhalers correctly, with exact rates depending on the type of inhaler and the assessment method used. As such, these patients need additional care to support correct medication usage, and effective intervention strategies are required.

A variety of strategies have been investigated that aim to tackle the problem of nonadherence. Training and education on correct inhaler technique are considered crucial in combating nonadherence [9] and in effectively managing one's asthma or COPD [16]. A Cochrane systematic review demonstrated the efficacy of interventions intended to improve adherence to inhaled corticosteroids (ICS) among patients with asthma [17]. Adherence education, electronic trackers or reminders, and simplified regimens were found to improve adherence by 20%, 19%, and 4%, respectively [17]. Recently, a meta-analysis by Jeminiwa et al [18] also showed a positive effect of eHealth strategies on improving adherence to ICS among people with asthma. However, according to the Cochrane systematic review, clinical outcomes are often not improved with those interventions [17].

In the Netherlands, the eHealth intervention SARA (Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies) was developed to promote correct use of inhalation medication for patients with asthma and COPD. The goal of this self-management intervention is to reduce the burden of lung disease and reduce exacerbations by stimulating correct use and adherence of inhaler medication in patients with asthma and COPD. SARA combines several interventions' components, including education, self-management strategies, and as-needed follow-up care by a pharmacist.

Objectives

This study aimed to investigate the effectiveness of SARA in participants with asthma and COPD by comparing pharmacy dispensing data over time, that is, before and after the implementation of SARA, as well as between SARA participants and a control group. The primary aim of this study was to investigate the effect of SARA on exacerbation rates. The secondary aims were to investigate the effect of SARA on medication adherence and antimycotic treatment.

Methods

The SARA eHealth intervention

The SARA eHealth intervention was developed by the Service Pharmacy organization. The Service Pharmacy organization supports independent but affiliated community pharmacies (ie, Service Pharmacies) in their day-to-day business operations to provide high-quality pharmaceutical care and provide offline and online communication. The Service Pharmacy organization developed SARA to support and prepare pharmacies for the second dispensing of inhalation medication. Pilot studies were then conducted with SARA and its corresponding questionnaire. Relevant input on how to improve the intervention was gathered by conducting two focus group interviews with pharmacists as well as patients with asthma and COPD, gaining insight into their needs and preferences. Their input was used to improve the intervention where possible.

SARA aims to improve the correct use of inhalation medication by providing information and supporting knowledge about this type of medication. SARA is an online platform that contains the following: (1) comprehensive information about inhalation medication, its usage, and side effects; (2) inhalation instruction videos; (3) informational videos about asthma and COPD; (4) a pollen forecast; and (5) a questionnaire that is emailed to individuals on the 15th day after starting SARA. A 7-item questionnaire was developed by the Service Pharmacy organization, assessing patients' inhalation medication usage and related experiences, concerns and doubts, difficulties, and side effects (Multimedia Appendix 1). The questionnaire was based on the national Dutch guideline for pharmaceutical patient consultation, specifically regarding the second dispensing of inhalation medication, which was in development at the time [19]. This consultation guideline aims to support the community pharmacist in providing patient-centered care during pharmaceutical consultations provided by the pharmacist to the patient. The seven drafted questions were discussed in a focus group with pharmacists, and the feedback was subsequently used to improve the questionnaire to maximize its reliability. The outcomes of the questionnaires are automatically forwarded to the corresponding pharmacy. Next, the pharmacist can provide as-needed follow-up care in case any important issues are encountered, such as experiencing one or more severe side effects. The type and intensity of follow-up care

can be tailored to the identified patient needs and preferences and the pharmacist's resources. Pharmacists are trained to identify patients' individual needs before delivering additional support, especially because SARA identifies those with extra needs. The follow-up care can entail additional detailed inhalation instructions or training (eg, when a patient experiences difficulties inhaling), providing additional information on how to properly use the medication (eg, when a patient reports not knowing when to take the medication or whether one can use the medication in combination with other medication), or providing additional information on the importance of taking the medication and its effects (eg, when a patient reports not having taken the medication because of doubts about whether it will work). The follow-up care can be offered through extra pharmacy visits, extra house visits, telephone calls, or digital communication tools, such as chats.

Design

This study entailed a nonrandomized pre-post study design. Pharmacy dispensing data were used to compare patient-level medication dispensing data over time (ie, the year before versus after implementation of SARA, hereafter often referred to as "over time") and between groups (ie, SARA versus control participants).

Ethical Considerations

No ethics approval was applied for because this study was declared to not fall within the scope of the Dutch Medical Research Involving Human Subjects Act by the Medical Ethics Committee (MEC) of the Leiden University Medical Center (MEC No. G20.030).

Participant flow

From the beginning of 2017 onward, SARA has been implemented in approximately 400 Service Pharmacies in the Netherlands. Not all Service Pharmacies participated in SARA. Some pharmacies could not participate in SARA because of conflicting software programs, among other reasons. Other pharmacies declined to participate in SARA due to personnel problems, thereby resulting in not having the resources to implement a different and new way of working.

In the participating pharmacies, individuals were offered SARA during a pharmacy visit when collecting inhalation medication for their asthma, COPD, bronchitis, or another indication. More specifically, individuals were offered SARA when they were dispensed medication for obstructive airway disease within the R03 class of drug, according to the use of the Anatomical Therapeutic Chemical (ATC) classification as developed by the World Health Organization (WHO) [20]. The trigger for pharmacists to invite a patient to participate in SARA was dispensing of an R03 class of drug. However, pharmacists could choose not to offer SARA to patients if they considered them ineligible for participation in SARA, for example, those living in a nursing home or those with very limited digital literacy levels. When interested in SARA, participants

were subsequently enrolled in the intervention. Otherwise, they were asked to indicate whether they were not interested in SARA at that specific point in time or would never be interested. Patients' choices were registered by the pharmacists in the pharmacy dispensing database, as well as the date their choices were registered, from here on referred to as the "registration date." If patients wanted to participate, they were enrolled by their pharmacist in the SARA program, after which they were sent a registration confirmation link and were able to start the program accordingly. The process of registering patients' choices in the database was sometimes delayed in daily practice, with pharmacists conducting the formal registration in the pharmacy dispensing database a while after the actual dispensing. Patients who were interested and subsequently agreed to participate in SARA were categorized as SARA participants. Those who were not interested were categorized as control participants. Additionally, patients who collected their inhalation medication and who were never offered SARA were categorized as control participants as well.

The index date was calculated using one of the following two options: (1) if there was an R03-medication dispensing available on the registration date, the registration date was defined as the study index date, or (2) if there was no R03-medication dispensing available on the registration date, the last dispensing date before the registration date was defined as the study index date. Subsequently, the index date was used to calculate the specific period of analysis (ie, the year before as well as the year after implementation of SARA) for each participant. More specifically, the index date was coded as the starting date of the year of analysis after the implementation of SARA. The exact year of analysis before implementation of SARA was coded as the year before the index date, not including the index date itself. Figure 1 presents an example of the index date calculation using option 2, in which case the registration date of the participant was May 31, 2016. As no medication dispensing was available for this date, the last dispensing date before the registration date (ie, May 30, 2016) was taken as the index date. Subsequently, May 30, 2016, was set as the starting date of the year after implementation, whereas the year before implementation of SARA would cover the period up to and including May 29, 2016.

Study population

Medication dispensing data from January 2015 to September 2020, from 382 Service Pharmacies located in different regions of the Netherlands, were obtained by information and communications technology service provider NControl. Patients' data in the NControl database are pseudonymized, meaning that their data cannot be directly connected to the natural person (ie, data subject) to whom they belong without the use of additional information, which is kept separately, according to Article 4(5) of the General Data Protection Regulation [21]. NControl provided a selection of this pseudonymized data to the main researchers of the Leiden University Medical Center, including data on patient demographics (ie, year of birth and gender), disease indi-

cation (ie, asthma, COPD, bronchitis, or other), the name of the Service Pharmacy, and medication dispensing records with detailed information on the type of the dispensed medication, ATC codes, corresponding dispensing date, amount dispensed, estimated covering days, and prescribed daily dosage. These data were not attributable to specific data subjects; these subjects were represented by personal identifier numbers that could not be used to directly identify a natural person (ie, data subject).

The study population consisted of individuals collecting R03 medication at one of the included 382 Service Pharmacies. Eligibility criteria to be included in the analyses were as follows: (1) patients aged 18 years or older at the time of their first available dispensing date record, (2) patients registered as SARA or control participants (ie, no missing data on SARA participation status), and (3) the time between the index date and the most recent R03-medication dispensing was a maximum of 30 days. This third inclusion criterion was chosen because SARA was always offered during a participant's pharmacy visit for collecting one's R03 medication, and if the time between this dispensing date and the registration date was more than 30 days, we considered it as a potential source of bias. We then presumed that it indicated a significant delay in the pharmacists' registration of SARA participation, which would result in uncertainty about what period to operationalize as "before implementation of SARA" and what period to operationalize as "after implementation of SARA." The fourth eligibility criterion was that patients had to have a disease indication from the pharmacy for asthma or COPD, excluding patients with indications other than asthma or COPD. The fifth and final eligibility criterion was that patients had to have at least one medication dispensing record before starting the 2-year analysis period and at least one record after, in order to ensure complete and up-to-date dispensing data during the analysis period. Besides the five eligibility criteria mentioned above, additional outcome-specific eligibility criteria were in place for the secondary outcomes of medication adherence and antimycotic treatment (see the respective subsections in the Outcome Measures section).

Outcome measures

Exacerbation rates

The primary outcome measure was the difference in exacerbation rates over time (ie, before versus after implementation of SARA) between SARA and control participants. The medication dispensing data of short-course prednisone and prednisolone, hereafter referred to as prednisone, were used to estimate exacerbation rates, as prednisone is prescribed to inhibit the inflammation of exacerbations. Prescriptions with ATC codes H02AB06 (prednisolone) and H02AB07 (prednisone) were used to estimate exacerbation rates. The medication dispensing records were categorized as exacerbations based on the Dutch College of General Practitioners' guidelines for asthma

and COPD [22,23], that is, in the case of a dispensing record reflecting a daily dosage of 30 or 40 mg of prednisone for a minimum of 5 days and a maximum of 14 days. The mean number of exacerbations in the year before and after implementation of SARA was summed into a mean total score of exacerbations for each of these analysis periods.

Medication adherence

One of the secondary outcomes was the difference in medication adherence over time between SARA and control participants. In addition to the general eligibility criteria as mentioned in the Study Population section, another inclusion criterion was formulated for this outcome measure. Participants needed to have at least three dispensing records of R03 medication during the 2-year analysis period in order to exclude fully nonadherent participants and validate the method of calculating medication adherence. In this way, participants with early cessation were excluded from the calculation, and only patients who were pharmacologically treated were included in the analyses.

The WHO definition of adherence was used to operationalize medication adherence, that is, the extent to which a person's behavior corresponds with the agreed-upon recommendations from a health care provider [15]. Studying medication adherence using medication dispensing records of pharmacies is a common method for assessing adherence [24]. Relevant groups of inhalation medication according to the WHO ATC classification included R03 medication, that is, medication for obstructive airway diseases [25]. All medication dispensings of the maintenance R03 medications represented by the following codes were included in the database: R03BA01, R03BA02, R03BA05, R03BA08, R03AK06, R03AK07, R03AK08, R03AK10, R03AK11, R03AL03, R03AL04, R03AL05, R03AL08, R03AL09, R03AC18, R03AC13, R03AC12, R03BB04, R03BB05, R03BB06, and R03BB07. These included ICS, long-acting beta agonists, long-acting muscarinic antagonists, and fixed-dose combinations. Nebulizers were excluded from the analyses.

Medication adherence was operationalized as the proportion of days covered (PDC). The PDC is the preferred method for calculating adherence at a population level and has been operationalized by the Pharmacy Quality Alliance [26]. In this study, the PDC was defined as the ratio of the number of days that a patient had medication available for at least one type of R03 medication during exactly 1 analysis year (ie, before and after the implementation of SARA, respectively) to the total number of days that the patient was dispensed the medication during that same period (ie, estimated covering days of the medication). Hence, the PDC reflected the proportion of days that the individual had at least one type of R03 medication available during the corresponding year of analysis.

More specifically, the "at least one" method was applied, which is a standardized method for measuring concurrent adherence to multiple related medications, in this case, the broad class of R03 medications. When the estimated coverage period of

dispensed R03 medication did not precisely cover all 365 days of the 1-year analysis period, the data from the first available R03-medication dispensing record before or after the analysis period, respectively (ie, depending on whether it concerned the analysis period before or after implementation of SARA), was used to determine the coverage of days belonging to the analysis period. Two assumptions were made in this process: (1) participants would only come to collect R03 inhalation medication once they finished their previously collected medication; in this way, the stock was not taken into account, and (2) participants would fully adhere to the prescribed dosage from the dispensing date onward until the end of the prescribed covering days. The above-mentioned methods and flow of this calculation of the PDC is presented in Figure 1.

Looking at Figure 1, a patient's analysis period before implementation of SARA started on May 30, 2015, but no medication dispensing was available for this date. The last dispensing before the start of this analysis period was on May 20, 2015, with an estimated coverage of 15 days, that is, the period of May 20 to June 3, 2015. The period from June 4, 2015, onward to the day before the next medication dispensing on June 18, 2015 (ie, the period from June 4 up to and including June 17, 2015), would be coded as "not covered." Similarly, looking at Figure 2, for example, a patient's analysis period after implementation of SARA ended on May 30, 2017, and the last available dispensing record concerned a dispensing of R03 medication on April 15, 2017, with an estimated coverage of 15 days. This last dispensing thus covered the period from April 15 to 29, 2017. No records of dispensing data were available for the period from April 30 to May 30, 2017; hence, this period was coded as "not covered." Medication adherence scores could range from 0 to 100, where 100 would reflect all 365 days of the analysis year being covered.

As it is commonly a cutoff point for good adherence, the PDC of 0.8 was used [26,27]. If it could not be determined whether or not a patient was covered by medication for a specific day of the year, a PDC could not be calculated; this would be considered a missing value.

The analyses were performed separately for *new users* and *chronic users* of R03 medication because different behaviors were expected for these two groups [28]. New users refer to participants starting with inhalation medication, operationalized as zero R03 dispensing records in the year before the index date. Chronic users refer to those already using R03 medication, operationalized as having at least one R03 dispensing record in the year before the index date.

Antimycotic treatment

Antimycotic treatment was operationalized as the difference over time in dispensed antimycotics between the SARA and control participants. The prevalence of oral candidiasis, potentially associated with ICS use, was estimated based on dispensing data of antimycotics in the subpopulation of participants who were dispensed ICS during the analysis period. Therefore, an additional inclusion criterion was formulated: partic-

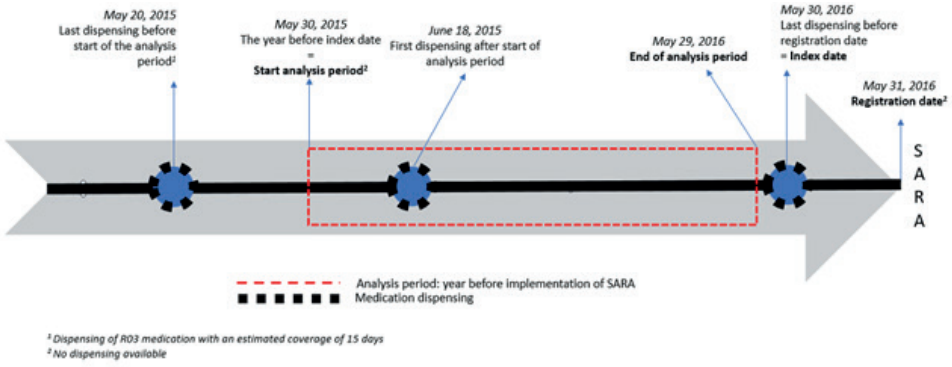

Figure 1. Operationalized analysis period for the year before the implementation of SARA. Step 1: the index date (ie, May 30, 2016) was used to calculate the specific period of analysis (ie, the day before the index date = the end of the analysis period before the implementation of SARA). Step 2: medication adherence scores were calculated based on the proportion of days covered with the "at least one" method. SARA: Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies.

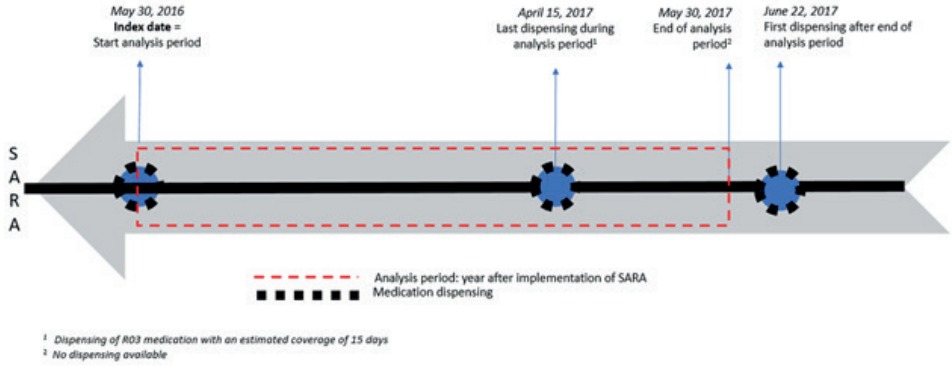

Figure 2. Operationalized analysis period for the year after the implementation of SARA. Step 1: the index date (ie, May 30, 2016) was used to calculate the specific period of analysis (ie, index date = the start of the analysis period after the implementation of SARA). Step 2: medication adherence scores were calculated based on the proportion of days covered with the "at least one" method. SARA: Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies.

ipants needed to have at least one medication dispensing record of ICS (ie, ATC code R03BA01, R03BA02, R03BA05, or R03BA08) during the analysis period. If a participant was dispensed antimycotics (ie, ATC code J02AC01 [fluconazole], J02AC02 [itraconazole], A07AA02 [nystatin], A07AA07 [amphotericin B], or A07AC01 [miconazole]) during the analysis period, the outcome was coded as 1 ("yes"); if not, the outcome was coded as 0 ("no"). Next, the percentage of participants with an antimycotic dispensing was calculated per study condition and subsequently compared before and after the implementation of SARA.

Statistical analyses

The study population characteristics, per outcome measure, were summarized by descriptive statistics: means and SDs for continuous variables, and counts and percentages for dichotomous and categorical variables. Potential differences between SARA and control participants were analyzed using *t* tests for normally distributed continuous variables and chi-square tests for categorical variables.

Differences in the outcome measures of exacerbation rates and medication adherence were analyzed using independent *t* tests to examine potential differences between the two study groups over time. More specifically, difference scores were calculated per patient by subtracting the outcome scores (ie, exacerbation rates and PDC sores for the subpopulation of chronic users of inhalation medication) of the year before implementation of SARA and the scores in the year after. Additionally, for the subpopulation of new users of inhalation medication, an independent-samples *t* test was conducted to investigate differences in medication adherence in the year after implementation of SARA between SARA and control participants. The potential effects of covariates (ie, age and gender) were tested by means of analysis of covariance. The results of these analyses were only presented in the case of significant effects of covariates.

A mixed-effects logistic regression was conducted to analyze the change over time between the two study groups regarding the relative number of patients who were dispensed antimycotics. In this analysis, an interaction term of time (ie, before and after the index date) and the study condition (ie, SARA vs control) was included to analyze the change over time across groups. The potential effects of covariates (ie, age and gender) were tested by adding those as interaction terms to the model. The results of these analyses were only presented in the case of significant effects of covariates.

All analyses were conducted in the total population consisting of both patients with asthma and those with COPD. For exploratory purposes, separate analyses for the subpopulations of patients with asthma and those with COPD were conducted. For all the analyses, a significance level of $P \leq .05$ was used, and a Cohen *d* was calculated to measure effect sizes. All analyses were conducted in SPSS Statistics for Windows (version 25.0; IBM Corp).

Results

Study population

The flow of included patients is presented in Figure 3. The total study population comprised of 9452 individuals with either asthma or COPD. Of those, 25.39% (n=2400) were enrolled in SARA, 25.73% (n=2432) indicated that they were not interested in using SARA, and 48.88% (n=4620) were not invited to participate or indicated that they did

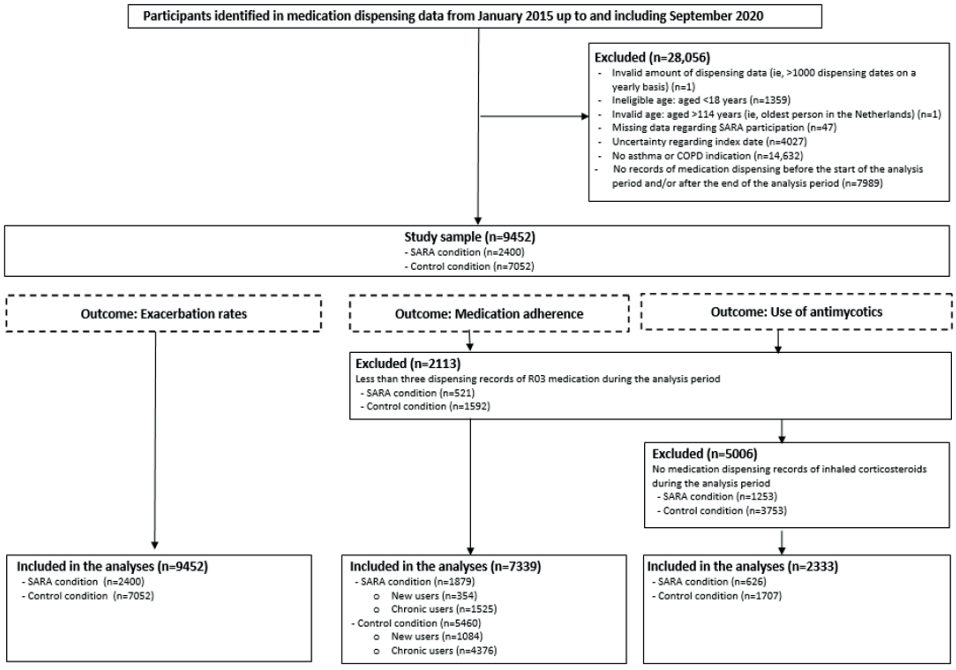

Figure 3. Flow of participants for the different outcome measures and corresponding analyses. SARA: Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies.

not want to start using SARA at that particular moment in time. As the inclusion criteria differed per outcome measure, the demographic characteristics are presented separately for each outcome measure (Table 1). Overall, the mean age of the study population was 60.8 (SD 15.0) years, and almost two-thirds of the study population were female. In all the different subpopulations, the mean age of patients using SARA was significantly lower than that of patients in the control group. In general, there was a significantly larger proportion of men in the control group as compared to the SARA group. Table S1 in Multimedia Appendix 2 shows the characteristics of the study samples separately per disease indication for asthma and COPD.

Exacerbation rates

In the year before the implementation of SARA, 63.00% (5955/9452) of the total study population had 0 exacerbations (range 0-12). In the year after the implementation of SARA, 56.00% (5293/9452) of the study population had 0 exacerbations (range 0-14). In both study groups, the mean rate of exacerbations was higher in the year after the implementation of SARA (SARA: mean 0.73; control: mean 0.82) than in the year before (SARA: mean 0.68; control: mean 0.67). Yet, as shown in Table 2, there was a significant difference between the SARA and control participants regarding the exacerbation rate over time, showing that the increase in exacerbations was significantly less in the

Table 1. Demographic characteristics of the study populations analyzed for the different outcome measures.

		Study group		Total population	
		SARA[a]	Control		P value[b]
Outcome measure: Exacerbation rate					
Total population		n = 2400	n = 7052	n = 9452	
Gender, n(%)	Male	882 (36.75)	2851 (40.43)	3733 (39.49)	0.002
	Female	1504 (62.67)	4173 (59.17)	5677 (60.06)	
	Unknown	14 (0.58)	28 (0.40)	42 (0.44)	
Age(years), mean(sd)		57.7 (13.8)	61.9 (15.3)	60.8 (15.0)	<.001
Outcome measure: Medication adherence					
Total population		n = 1879	n = 5460	n = 7339	
Gender, n(%)	Male	693 (36.88)	2200 (40.29)	2893 (39.42)	0.01
	Female	1175 (62.53)	3239 (59.32)	4414 (60.14)	
	Unknown	11 (0.58%)	21 (0.38)	32 (0.44)	
Age (years), mean (sd)		60.9 (13.4)	65.1 (14.5)	64.0 (14.4)	<.001
- Subpopulation: New users[c]		n = 354	n = 1084	n = 1438	
Gender, n(%)	Male	128 (36.16)	420 (38.74)	548 (38.11)	0.38
	Female	225 (63.56)	658 (60.70)	883 (61.40)	
	Unknown	1 (0.28)	6 (0.55)	7 (0.49)	
Age (years), mean (sd)		59.4 (14.2)	62.7 (16.5)	61.9 (16.0)	0.002
- Subpopulation: Chronic users[d]		n = 1525	n = 4376	n = 5901	
Gender, n(%)	Male	565 (37.05)	1780 (40.68)	2345 (39.74)	0.02
	Female	950 (62.29)	2581 (58.59)	3531 (59.84)	
	Unknown	10 (0.66)	15 (0.34)	25 (0.42)	
Age (years), mean (sd)		61.3 (13.1)	65.7 (14.0)	64.6 (13.9)	0.04
Outcome measure: Antimycotic treatment					
Total population		n = 626	n = 1707	n = 2333	
Gender, n(%)	Male	196 (31.31)	612 (35.85)	808 (34.63)	0.04
	Female	428 (68.37)	1090 (63.85)	1518 (65.07)	
	Unknown	2 (0.32)	5 (0.29)	7 (0.30)	
Age (years), mean (sd)		55.1 (14.2)	59.0 (16.2)	58.0 (15.8)	<.001

[a]SARA: Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies.
[b]P values represent comparisons between the SARA group and the control group; for characteristics with multiple subcategories (ie, gender), values for the group are reported in the top row of the group.
[c]New users are participants with zero R03 dispensing records in the year before the index date.
[d]Chronic users are participants with at least one R03 dispensing record in the year before the index date.

SARA group (*P*=.002). The results of the exploratory analyses are presented in Table S2 in Multimedia Appendix 2. In both participants with asthma and those with COPD, the mean exacerbation rate increased over time in both the SARA group (asthma: mean increase 0.07; COPD: mean increase 0.03) and the control group (asthma: mean increase 0.17; COPD: mean increase 0.12). As presented in Table S2 in Multimedia Appendix 2, among the asthma participants, the difference in exacerbation rates differed significantly between study groups (*P*=.003), indicating that SARA participants had a signif-

Table 2. Outcome results in terms of exacerbation rates.

Descriptives				Statistics			
Study group and periods[a]	**Exacerbation rate, mean (sd)**	**Difference score[b]**	**Participants (N=9452), n (%)**	***T-test(df[c])***	***P* value[c]**	**95% CI[c]**	**Cohen *d*[c]**
Control				3.10(9450)	.002	0.037 – 0.163	0.06
1 year before	0.67 (1.2)		7052(74.61)				
1 year after	0.82 (1.3)	0.15	7052(74.61)				
SARA							
1 year before	0.68 (1.2)		2400(25.39)				
1 year after	0.73 (1.2)	0.05	2400(25.39)				

[a]The study periods were 1 year before and 1 year after the implementation of SARA (Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies).
[b]The difference score was calculated as the exacerbation rate the year after SARA minus the rate the year before SARA; values are only reported in the "1 year after" rows.
[c]Statistics comparing study groups are reported only in the top row of values.

icantly lower increase in exacerbation rates over time in comparison to the control participants. No significant difference between the SARA and control participants was found in the COPD population regarding the change in exacerbation rate over time (Table S2 in Multimedia Appendix 2).

Medication adherence

In both study groups, the mean PDC in the subpopulation of chronic users was higher in the year after compared to the year before implementation of SARA for both SARA participants (after: mean 77.26; before: mean 70.53) and control participants (after: mean 77.77; before: mean 73.29). However, there was a significant difference in change over time between the SARA and the control groups, showing that the increase in medication adherence was significantly higher in the SARA group (Table 3).

The exploratory results, repeating the analyses for the chronic user subgroup of participants with asthma and participants with COPD, are presented in Table S3 in Multimedia Appendix 2.

For patients with asthma who were chronic users, there was an increase in medication adherence with no significant difference between the SARA and control participants. Gender was found to be a significant covariate for the patients with COPD who were chronic users. Splitting the analyses for men and women within this subpopulation showed that the increase in medication adherence for men was significantly higher for SARA participants than for control participants. For women, there was no significant difference between SARA and control participants over time in terms of medication adherence.

When comparing medication adherence in the year after implementation of SARA between the study groups for new users with COPD, this population showed significantly higher medication adherence in the SARA group as compared to the control group (Table S4 in Multimedia Appendix 2). No significant difference between the study groups was found in the subpopulation of new users with asthma.

Table 3. Outcome results in terms of medication adherence among the chronic user subpopulation.

	Descriptives				Statistics			
Study group and periods[a]	**PDC[b], mean (sd) *(SD)***	**Days covered mean, (sd)**	**Difference Score[c]**	***Participants (n=5888), n (%)***	***T-test (df)*[d]**	**P value[d]**	**95% CI[d]**	**Cohen *d*[d]**
					-2.74 (5886)	.01	-3.856 – -0.839	-0.07
Control								
1 year before	73.29 (28.3)	267.50 (103.4)		4368(74.28)				
1 year after	77.77 (25.2)	283.86 (91.8)	4.48	4368(74.18)				
SARA								
1 year before	70.53 (29.8)	257.45 (108.6)		1520(25.82)				
1 year after	77.26 (25.0)	282.01 (91.1)	6.73	1520(25.82)				

[a]The study periods were 1 year before and 1 year after the implementation of SARA (Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies).
[b]PDC: proportion of days covered.
[c]The difference score was calculated as the PDC 1 year after SARA minus 1 year before SARA; values are only reported in the "1 year after" rows.
[d]Statistics comparing study groups are reported only in the top row of values.

Table 4. Results of the mixed-effects logistic regression regarding dispensed antimycotics among participants who were dispensed ICS.

	Descriptives		Statistics			
Study group and periods[a]	**Dispensed Antimycotics, n(%)**	**Dispensed ICS, n(%)**	***T-test (df)*[c]**	***P* value[c]**	**95% CI[c]**	**Cohen *d*[c]**
Control n=1707)			0.23(4662)	0.82	-0.461-0.584	0
1 year before	80 (4.69)	1707 (73.17)				
1 year after	104 (6.09)	1707 (73.17)				
SARA (n=626)						
1 year before	34 (5.43)	626 (26.83)				
1 year after	40 (6.39)	626 (26.83)				

[a]The study periods were 1 year before and 1 year after the implementation of SARA (Service Apothecary Respiratory Advice; in Dutch, Service Apotheek Raad en Advies).
[b]ICS: inhaled corticosteroids; percentages are based on total participants in both groups (n=2333).
[c]Statistics comparing study groups are reported only in the top row of values.

Antimycotic treatment

As shown in Table 4, the relative mean number of participants who had been dispensed antimycotics was higher after the implementation of SARA as compared to the year before for both SARA participants (6.4% vs 5.4%) and control participants (6.1% vs 4.7%). Results showed no significant differences in the relative number of participants who had been dispensed both ICS and antimycotics between the SARA and control

groups (*P*=.82). Additionally, in the exploratory results, no significant differences were found with respect to antimycotic treatment over time between SARA and the control participants in the subgroups of participants with asthma and COPD (Table S5 in Multimedia Appendix 2).

Discussion

Principal findings

This study investigated the effectiveness of the pharmacy-based eHealth intervention SARA by comparing pharmacy dispensing data between SARA and control participants over time before and after the implementation of SARA. The results showed a smaller increase in exacerbation rates over time for SARA participants as compared to control participants. Furthermore, in the SARA group, chronic users of inhalation medication had a significantly larger increase in medication adherence over time as compared to control participants. Finally, no significant differences between the study groups were found with respect to antimycotic treatment over time.

Although the observational data do not entirely allow for causal conclusions, the significantly smaller increase in exacerbation rates over time among SARA participants may suggest a beneficial effect of SARA. Earlier clinical intervention studies comprising a behavioral intervention and integrated disease management program have also found positive effects on exacerbation rates among asthma participants [29,30]. Yet, SARA has the potential to help control exacerbations in a less invasive and less time-consuming way; this is potentially apparent in reduced material and immaterial costs, such as less time spent conducting follow-ups by pharmacists.

The results regarding medication adherence showed that chronic users of inhalation medication in the SARA group had a significantly higher increase in medication adherence as compared to control participants. This finding aligns with a previous meta-analysis examining eHealth strategies to improve medication adherence in ICS users [18]. However, it is essential to note that the mean medication adherence was lower for SARA participants than control participants, both before and after the implementation of SARA. A potential explanation is selection bias. Patients with more severe symptoms may have been more likely to be invited to participate in the SARA intervention by the pharmacists because they may visit the pharmacy more often, and patients with more severe symptoms typically show lower medication adherence [10]. On the other hand, patients with more severe symptoms may simply have been more interested in participating in the SARA intervention considering their higher disease burden, which may have, in turn, biased the results. The finding that new users of inhalation medication generally had lower medication adherence scores than chronic users emphasizes the importance of analyzing those two patient groups separately, as they appear to have different adherence patterns.

An interesting difference between men and women was found in the analysis of patients with COPD who were chronic users of inhalation medication. The results suggested that men within this subpopulation benefitted more from SARA (ie, increased medication adherence in comparison to controls) than women (ie, no differences between SARA and control participants). Little research is available on gender-associated differences in response to self-management interventions. A narrative review did discuss some evidence that women have more trouble with using inhalation medication correctly [31]. Furthermore, a systematic review discussed mixed results regarding gender-associated differences in response to pulmonary rehabilitation [32]. Thus, there appears to be some evidence of gender-associated differences that could explain our finding; however, more research is needed to investigate individual differences of patients regarding adherence based on their characteristics, beliefs, and attitudes to adherence.

With respect to antimycotic treatment for oral candidiasis in a subpopulation of ICS users, no difference was found between the study groups over time. These results should be interpreted carefully because the included sample was small, possibly limiting the power to detect statistical significance. To our knowledge, this was the first study that analyzed the effect of an eHealth intervention for patients with asthma and COPD on antimycotic treatment. The exploratory analyses showed a more favorable course of exacerbation rates over time for SARA versus control participants in the subpopulation of patients with asthma. This effect was not found in the subpopulation of patients with COPD. Our results are in line with previous research investigating a clinic-based intervention aiming to improve inhaler techniques, which only showed a positive effect in patients with asthma but not in patients with COPD [33]. It might be that patients with asthma benefit more from the educational intervention elements than patients with COPD. Alternatively, it might be due to more difficulties in managing COPD symptoms as the disease progresses, or the fact that COPD often results from smoking and that smoking cessation is quite challenging.

Furthermore, exploratory results showed that new users of inhalation medication had higher medication adherence in the year after SARA implementation among SARA participants as compared to control participants, but only in the subpopulation of patients with COPD and not in patients with asthma. In addition, patients with COPD generally had higher medication adherence than patients with asthma. This is in line with literature showing that patients with COPD generally have better adherence rates than patients with asthma, and there are multiple explanations for this [34]. First, it can be related to the different disease courses; in patients with asthma, the use of medication can, for example, be more dependent on the season than in patients with COPD [34]. Second, patients with COPD generally experience more consistent and severe disease symptoms [34]. Third, older age is associated with being more adherent, and patients with COPD are generally older than patients with asthma [35].

The findings of this study should be interpreted in light of several strengths and limitations. A major strength of this study pertains to the large amount of pharmacy dispensing data stemming from thousands of patients from hundreds of pharmacies geographically located throughout different areas in the Netherlands. This is likely to benefit the generalizability of the study results. In addition, these kinds of trials can contribute to external validity more than a randomized controlled trial [36]. Furthermore, the data set allowed for longitudinal research comparing data before and after the implementation of SARA with continuous enrollment of patients instead of during a specific period of time. For that reason, the impact of seasonal effects or national guidelines are expected to have been limited. Regarding the study limitations, the study results were based on retrospective pharmacy dispensing data. This design has several limitations, such as data that were not originally designed to answer specific research questions. Indeed, pharmacy dispensing data were limited in terms of not providing information about actual usage of the medication, more specifically if, when, and how often dispensed medication was used. Still, dispensing data are commonly used as a proxy for medication adherence [37,38]. Future studies could consider including other measures of medication adherence, for example, self-reports of medication use, smart inhaler devices, or measurements of metabolite levels [37,39-41]. Another study limitation is related to the commonly used "at least one" method to calculate the PDC as an indicator of medication adherence. This methodology does not take into account potential overuse of medication. Besides, the PDC can slightly differ when using the highest stock records of medication [42,43]. In addition, our assumption when interpreting the results was that better medication adherence was a consequence of better self-management skills. However, it could be the case that lower medication adherence is a sign of good self-management, as the patients may only take their medication when actually needed. This is an interesting topic for future research. In addition, future research could combine multiple methods to calculate medication adherence to provide a more comprehensive picture of this outcome measure. A recent publication by Menditto et al [43] proposes measuring persistence as a pragmatic and informative measure of medication adherence behaviors, which would allow for benchmarking of adherence strategies. Such strategies would thus facilitate cross-study comparisons and might help to identify a gold standard for calculating medication adherence [37,38,44]. This pragmatic trial only allowed for adherence measures based on pharmacy dispensing data. More specifically, the PDC is a preferred method of assessing medication adherence in case of treatment with multiple types of medications. An alternative metric such as the medication possession ratio (MPR) would be unable to cover multiple medication treatments since its numeration is the sum of days supplied in the period. In case of multiple medications, the MPR has to be averaged for each individual medication, leading to skewed results with possibilities of invalid ratios over 100%. So there are biases, such as not taking into account overuse and stockpiling, but using the PDC was a well-considered choice.

Another study limitation was that it was unknown what kind or intensity of support was offered by pharmacists. Hence, different pharmacists may have provided different types of support to patients. Even though this is inherent to tailored interventions, it would be worthwhile to investigate *what* type of support has the most beneficial effect. This also includes identifying *when*, *how*, and *how much* support should be offered. Addressing these questions can help to develop and strengthen evidence-based interventions [45]. A final study limitation that needs to be mentioned was the difference in demographic characteristics between the SARA and control participants. More specifically, SARA participants were generally younger and more often female. Even though such differences are not unusual in nonrandomized studies, they may have created selection bias [46]. However, SARA was, in principle, offered to all kinds of participants with varying degrees of symptoms. Therefore, the possibly biased selection of participants in the SARA group is likely to be representative of the group of potential future users of eHealth interventions for these groups. An important aspect to also take into account is that the questionnaire for the SARA intervention might increase patients' awareness for medication adherence, but it is unlikely that this strongly affected adherence behavior directly. In future research, this could be something to take into account. More research is needed to draw firm conclusions on the effectiveness of SARA. A randomized controlled trial is needed to allow causal conclusions, which can then be used for a cost-effectiveness analysis as well, where, next to pharmacy dispensing data, other data can be collected, such as the following: (1) other sources that measure medication adherence, (2) objective data regarding exacerbation rates, (3) the actual and correct use of inhalation medication, and (4) health system characteristics that may impact adherence (eg, patient-provider interaction quality and procedural elements) [46]. In addition, qualitative research would allow for more insight into user experiences and could subsequently be used to optimize the intervention. In parallel, it would be interesting to investigate patients' acceptability and effectiveness of the different components of the SARA intervention (eg, education materials and online support by a pharmacist). Also, it would be worthwhile to get a better understanding of the pharmacist perspective, for instance, what is their attitude toward eHealth in general and SARA specifically, what is the usability of SARA, and how is SARA used in the pharmacy (ie, does it add to the efficiency of care processes?)? Another recommendation for future research is to analyze the long-term effectiveness of SARA.

This research shows that SARA has the potential to help patients in decreasing exacerbation rates and improving medication adherence. Before large-scale implementation, it would be valuable to investigate both the patient and pharmacist perspective more thoroughly, both quantitatively and qualitatively. In this way, the full potential of the intervention can be maximized, making sure the intervention fits the needs and preferences of both of these stakeholders. Implementation barriers and facilitators can be investigated and taken into account when considering implementa-

tion strategies, such as integration of SARA into the workflow of pharmacists as well as the capacities of pharmacists to offer tailored follow-up care [47,48].

Conclusions

This was the first study that assessed the effectiveness of a multi-component eHealth intervention stimulating correct use of medication. The results suggest that such an intervention has the potential to decrease exacerbation rates and improve medication adherence. This could subsequently have important clinical implications and lead to better patient outcomes and potentially reduced health care costs.

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Conflicts of interests

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List of abbreviations

ATC = Anatomical Therapeutic Chemical
COPD = Chronic Obstructive Pulmonary Disease
ICS = Inhaled Corticosteroids
PDC = Proportion of Days Covered
SARA = Service Apothecary Respiratory Advice, in Dutch '*Service Apotheek Raad en Advies*'
WHO = World Health Organization

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Multimedia Appendix 1

Translated 7-item questionnaire of SARA

Question 1.

Did you already start with [name medication]?

Yes — 1.1: Are you using [name medication] according to the prescribed dose?
- Yes
- No, I use less
- No, I use more

No — 1.2: Why did you not start with [name medication]?
- My complaints are gone or have been reduced
- I do not want to use this medication
- I am afraid of the side effects
- It is too expensive
- Other [free space to fill in]

No, not yet picked up at the pharmacy — 1.3: are you planning on using [name medication]?

Question 2. (Asked if answer to question 1 is Yes)

Do you like [name medication]?

- I am (very) satisfied about [name medication]
- I am pretty satisfied about [name medication]
- I am dissatisfied about [name medication]
- I stopped
  - *2.1Why did you stop with [name medication] (multiple answers possible)*
    - My complains are gone or reduced
    - The medication did not work
    - I experienced side effects
    - I had problems with the use/intake of [name medication]
    - I forgot
    - Other [free space to fill in]

Question 3. (Asked if answer to question 2 is **not** I stopped)

What do you expect about the effect of [name medication] (multiple answers possible)?

- Effectivity
- Quality of life
- Prognosis, healing, morbidity, mortality
- I do not know what I can expect
- Other [free space to fill in]

Question 4. *Did you experience problems when using [name medication] in the first weeks (multiple answers possible)?*

No

Yes [list of problems]

I experience side effects [space to fill in 5 side effects

I forget to take [name medication]

I am struggling with the time I need to take [name medication]

I have trouble opening the package

I find it hard to swallow [name medication]

I find it hard to inhale [name medication]

Other, [free space to fill in]

Question 5. *Are you worried about the use on the long term, and if so, what are you worries (multiple answers possible)?*

I am not worried

I am worried if [name medication] is effective enough

I am worried if [name medication] damages my body

I am worried about the side effects

I am wondering if I can take [name medication] with other medications

I am worried I do not use [name medication] the way it is meant to

Other [free space to fill in]

Question 6. *Do you have questions about the use, mechanisms or other things?*

No

Yes → fill in on which questions you would like an answer (multiple answers possible)

How does it work?

What are the side effects?

How long do I have to use this medication?

What is the best time to take [name medication]?

Can I take this medication with other medications?

Will it influence my driving behavior/ Can I drive with [name medication]?

Is it reimbursed by my health insurer?

Question 7. *Do you want an appointment to discuss your questions/worries?*

Yes

No

Multimedia Appendix 2

Results of exploratory analyses

Table S1. Demographic characteristics of the study population(s) analyzed for the different outcome measures. Data are provided as means (*SD*) or as counts (percentages).

			Study group		Total population
			SARA	Control	
Outcome measure: Exacerbation rate					
Asthma			*n* = 1459	*n* = 3921	*n* = 5380
	Gender*	Male	463 (31.7%)	1485 (37.9%)	1948 (36.2%)
		Female	987 (67.6%)	2416 (61.6%)	3403 (63.3%)
		Unknown	9 (0.6%)	20 (0.5%)	29 (0.5%)
	Age*		54.1 (14.7)	58.0 (16.4)	56.9 (16.0)
COPD			*n* = 941	*n* = 3131	*n* = 4072
	Gender	Male	419 (44.5%)	1366 (43.6%)	1785 (43.8%)
		Female	517 (4.9%)	1757 (56.1%)	2274 (55.8%)
		Unknown	5 (0.5%)	8 (0.3%)	13 (0.3%)
	Age*		63.3 (10.0)	66.8 (12.1)	66.0 (11.7)
Outcome measure: Medication adherence					
Subpopulation: New users[a]					
Asthma			*n* = 233	*n* = 649	*n* = 882
	Gender	Male	81 (34.8%)	230 (35.4%)	311 (35.3%)
		Female	152 (65.2%)	415 (63.9%)	567 (64.3%)
		Unknown	0	4 (0.6%)	4 (0.5%)
	Age*		56.2 (15.0)	58.6 (17.3)	58.0 (16.8)
COPD			*n* = 121	*n* = 435	*n* = 556
	Gender	Male	47 (38.8%)	190 (43.7%)	237 (42.6%)
		Female	73 (60.3%)	243 (55.9%)	316 (56.8%)
		Unknown	1 (0.8%)	2 (0.5%)	3 (0.5%)
	Age*		65.6 (9.9)	68.7 (12.9)	68.0 (12.4)
Subpopulation:Chronic users[b]					
Asthma			*n* = 849	*n* = 2266	*n* = 3115
	Gender*	Male	263 (31.0%)	876 (38.7%)	1139 (36.6)
		Female	579 (68.2%)	1378 (60.8%)	1957 (62.8)
		Unknown	7 (0.8%)	12 (0.5%)	19 (0.6%)
	Age*		57.6 (14.1)	69.4 (11.4)	61.0 (15.0)
COPD			*n* = 676	*n* = 2110	*n* = 2786
	Gender	Male	302 (44.7%)	904 (42.8%)	1206 (43.4%)
		Female	371 (54.9%)	1203 (57.0%)	1574 (56.5%)
		Unknown	3 (0.4%)	3 (0.1%)	6 (0.2%)
	Age*		65.9 (10.1)	62.3 (15.2)	68.6 (11.2)

Table S1. Continued.

			Study group		Total population
			SARA	Control	
Outcome measure: Antimycotic treatment					
Asthma			*n* = 440	*n* = 1046	*n* = 1486
	Gender*	Male	118 (26.8%)	366 (35.0%)	484 (32.6%)
		Female	320 (72.7%)	675 (64.5%)	995 (67%)
		Unknown	2 (0.5%)	5 (0.5%)	7 (0.5)
	Age*		52.3 (14.8)	55.4 (16.9)	54.47 (16.4)
COPD			*n* = 186	*n* = 661	*n* = 847
	Gender	Male	78 (41.9%)	246 (37.2%)	324 (38.3%)
		Female	108 (58.1%)	415 (62.8%)	523 (61.7%)
		Unknown	0	0	0
	Age*		61.6 (10.1)	64.8 (13.0)	64.14 (12.5)

Note: COPD = Chronic Obstructive Pulmonary Disease; SARA = eHealth intervention Service Pharmacy Advice (in Dutch 'Service Apotheek Raad en Advies')

[a] Participants with zero R03-dispensing records in the year before the index date

[b] Participants having ≥ 1 R03-dispensing records in the year before the index date

*Significant difference between the SARA and the control condition ($p<0.05$)

Table S2. Data of the outcome measure exacerbation rates displayed per disease indication.

Descriptives						**Statistics**			
Study subpopulation	**Period[a]**	**Study group**	**Exacerbation rates *M (SD)***	**Difference score[b]**	***N***	**t(df)**	***P*-value**	**95% CI**	**Cohen *d***
Asthma						2.97(2820)	.003	0.036 – 0.177	0.11
	Year before	Control	0.55 (1.0)		3921				
	Year after	Control	0.72 (1.1)	0.17	3921				
	Year before	SARA	0.54 (1.0)		1459				
	Year after	SARA	0.61 (1.0)	0.07	1459				
COPD						1.67 (4070)	.09	-0.016 – 0.207	0.05
	Year before	Control	0.82 (1.3)		3131				
	Year after	Control	0.94 (1.5)	0.12	3131				
	Year before	SARA	0.88 (1.4)		941				
	Year after	SARA	0.91 (1.4)	0.03	941				

Note: CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; M = Mean SARA= Intervention 'Service Pharmacy Advice' (in Dutch '*Service Apotheek Raad en Advies'*); SD = Standard Deviation

[a] One year before or one year after the implementation of SARA

[b] Difference score of the year after SARA minus the year before SARA

Table S3. Data of the outcome measure medication adherence displayed per disease indication and subpopulation.

Descriptives						Statistics			
Period[a]	Study group	PDC *M (SD)*	Days covered *M (SD)*	Difference score[b]	*N*	*t(df)*	*P*-value	95% CI	Cohen *d*
Study subpopulation									
Chronic users and asthma						-1.86 (1500)	.06	-4.148 – 0.114	-0.10
Year before	Control	70.94 (28.6)	258.93 (104.3)		2261				
Year after	Control	76.76 (24.6)	280.18 (89.8)	5.82	2261				
Year before	SARA	66.92 (30.5)	244.24 (111.5)		845				
Year after	SARA	74.76 (25.5)	272.86 (93.1)	7.84	845				
Male: Chronic users and COPD						-2.80 (1201)	.005	-9.391 - -1.654	-0.16
Year before	Control	76.32 (27.8)	278.58 (101.4)		901				
Year after	Control	77.96 (27.2)	284.58 (99.3)	1.64	901				
Year before	SARA	74.82 (29.2)	273.11 (106.4)		302				
Year after	SARA	82.98 (22.8)	299.25 (83.2)	8.16	302				
Female: Chronic users and COPD						0.13(1571)	0.9	-2.957 – 3.394	0.01
Year before	Control	75.49 (27.9)	275.52 (101.7)		1203				
Year after	Control	79.59 (24.5)	290.50 (89.5)	4.10	1203				
Year before	SARA	75.16 (27.4)	274.35 (100.1)		370				
Year before	SARA	79.05 (24.8)	288.52 (90.5)	3.89	370				

Note: CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; SARA= Intervention 'Service Pharmacy Advice' (in Dutch '*Service Apotheek Raad en Advies'*); PDC = proportion of days covered; df= degrees of freedom; M = Mean; SD = Standard Deviation;

[a] One year before or one year after the implementation of SARA

[b] Difference score of the year after SARA minus the year before SARA

Table S4. Exploratory results of the type of user effect in terms of medication adherence rates one year after the implementation of SARA.

Descriptives						**Statistics**			
Study sub-population	**Period[a]**	**Study group**	**PDC** ***M (SD)***	**Days covered** ***M (SD)***	***N***	***t(df)***	***P*-value**	**95% CI**	**Cohen *d***
New users total						-1.85 (1434)	.06	-5.604 – 0.160	-0.10
	Year after	SARA	66.17 (23.1)	241.52 (84.3)	353				
	Year after	Control	63.45 (24.2)	231.48 (88.5)	1083				
New users asthma						-0.90 (878)	.37	-5.302 – 1.971	-0.06
	Year after	SARA	63.70 (23.4)	232.52 (85.4)	232				
	Year after	Control	62.04 (24.5)	226.44 (89.4)	648				
New users COPD						-2.34 (206)	.02	-9.860 - -0.839	-0.33
	Year after	SARA	70.89 (21.8)	258.76 (79.7)	121				
	Year after	Control	65.54 (23.7)	239.23 (86.7)	435				

Note: CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; SARA= eHealth intervention Service Pharmacy Advice (in Dutch '*Service Apotheek Raad en Advies'*); PDC = proportion of days covered; df= degrees of freedom; M = Mean; SD = Standard Deviation;

[a] one year after the implementation of SARA

Table S5. Data of the outcome measure use of antimycotics displayed per disease indication.

Descriptives					Statistics			
Study subpopulation	**Period[a]**	**Study group**	**Prescribed antimycotics (%)**	***N***	***t(df)***	***P*-value**	**95% CI**	**Cohen *d***
Asthma					0.35(2968)	0.73	-0.519 – 0.743	0.01
	Year before	Control	4.9	1046				
	Year after	Control	5.7	1046				
	Year before	SARA	6.1	440				
	Year after	SARA	6.1	440				
COPD					0.49(1690)	0.79	-1.084 – 0.831	0.02
	Year before	Control	4.4	661				
	Year after	Control	6.7	661				
	Year before	SARA	3.8	186				
	Year after	SARA	7.0	186				

Note: CI = Confidence Interval; COPD = Chronic Obstructive Pulmonary Disease; SARA= Intervention 'Service Pharmacy Advice' (in Dutch '*Service Apotheek Raad en Advies'*); df= degrees of freedom; M = Mean; SD = Standard Deviation;
[a] One year before or one year after the implementation of S

7

General discussion

The health care landscape, especially in primary care, demands a transformation in response to several factors, such as the increasing complexity of medical needs and a growing aging population. This transformation is essential for upholding the delivery of high-quality health care that remains accessible to all. eHealth presents opportunities for improving the accessibility of health care services by empowering individuals to manage their health through self-management. The overarching goal of this thesis was to examine whether different online services that provide direct access to care are usable and effective for patients and citizens. Different online services were investigated in different settings and with different users, with or without the involvement of health care professionals. Chapters 2 through 5 investigated the use and usability of direct access to different diagnostic test services. Chapter 2 presented a scientific overview of available online direct access to test and result services. Chapter 3 compared an online triage service with the decision-making process of general practitioners (GPs). Chapters 4 and 5 examined two different kinds of direct access to diagnostic tests and result services to investigate the use and usability of those online services. Lastly, Chapter 6 evaluated the effectiveness of an online self-management service, which was implemented in the daily practice of a pharmacy. With medication dispensing data, the effectiveness of medication adherence as well as exacerbation rates were evaluated.

Main findings

The services explored in this thesis were found to demonstrate positive outcomes for direct access to care services in different settings. Overall, usage rates were high, and the patients or citizens who utilized the services were satisfied. However, it remains crucial to ensure that online services align with the needs of the target population for their effective utilization [1]. For most studies in this thesis, a preference was found among younger populations for using online services, rather than among older populations. The following paragraphs summarize the main findings for each chapter.

Chapter 2 systematically assessed the availability and usage of direct online access to diagnostic tests and result services. Specifically, the study focused on direct access for patients to (a) web-based triage that leads to diagnostic testing, (b) self-sampling or testing options, and/or (c) test results. The results indicated that the online services were highly used and that follow-up rates were high, indicating that users who ordered diagnostic tests online and tested positive were adequately linked to treatment. In total, 31 different services were discussed in 45 research studies. Most of the services offered direct access to sexually transmitted infections (STIs) testing and were used by a younger population. The acceptability and usability of the diagnostic test services were high, and there was a preference for home-based testing instead of clinic-based testing. More research is required in the field of diagnostic testing services for diseases other than STIs.

The first part of direct access to diagnostic tests and result services is often triage. Chapter 3 compared an online triage tool for STI testing and GPs' decision-making process through a qualitative vignette study. The online triage tool had a higher adherence to guidelines, while GPs considered patient preferences. It could be stated that GPs had a more holistic view of their patient, while the online triage tool adhered strictly to guidelines. Further research on this topic could provide a deeper understanding of the validity of online triage tools. When an online triage tool works for a diagnostic test, it could probably be used to reduce GPs' work pressure, thereby increasing access to care [2]. To explain, online triage could efficiently sort patients based on the severity of their symptoms. Patients with less urgent issues could be directed to appropriate self-care or self-testing resources, while patients with more serious concerns could be prioritized for immediate attention. This could help GPs to focus their time and expertise on patients who need it the most.

Next, Chapter 4 evaluated the usability of an online platform through which citizens can order diagnostic tests independently of a health care professional. The online triage tool from Chapter 3 was part of this service. Citizens participated in focus groups where information about the usability of the service was gathered. The amount of information provided as well as the comprehension (inclusion of medical terms) and user friendliness of the online service were identified as key elements that influence the usability of the eHealth service. The study also examined the needs of citizens for such a service to assist us in understanding why individuals would choose or prefer the website over visiting a GP. Mainly the younger population would use a website like Directlab Online for ordering diagnostic tests, while the older participants would rather visit their GP to address their health-related questions.

Then, Chapter 5 introduced Homelab, an eHealth service that allows patients from affiliated GP practices to independently order diagnostic tests under the online guidance of their own GP. The service's use and usability were evaluated through a quantitative questionnaire, which was implemented after patients used the service. The service's usability was perceived as above average by patients of all age groups, but particularly among younger patients. The average usability score was higher in the younger age group than in the older age group. Gender differences did not appear to exist in the perceived usability of Homelab. Furthermore, Homelab was used the most during the COVID-19 lockdown. Additionally, patients expressed a desire to use Homelab again in the future and as a substitute for regular consultations. This indicates that a service like Homelab can contribute to more accessible and efficient health care by reducing consultations.

Lastly, Chapter 6 investigated the effect of a pharmacy-based eHealth service designed for asthma and COPD patients, namely SARA. Medication dispensing data were used in a pre–post study to obtain insights into the effects of the service. Outcomes were assessed one year before and one year after the use of SARA and compared between users and non-users. The study revealed that the online service

SARA had the potential to assist in the self-management of asthma and COPD patients, resulting in decreased exacerbation rates and improved inhaled medication adherence. Especially in chronic users of inhaled medication, an increase in medication adherence was visible compared with controls. SARA users were, in general, younger than the non-users; however, their mean age was approximately 60 years.

Lessons learned

Based on the studies presented in this thesis and conversations with patients and health care professionals, some lessons were learned about the implementation of online services. They are described in the following paragraphs.

First, the (perceived) reliability of the online service is important. This lesson is derived from Chapter 4, which delved into Directlab Online and highlighted that the launch and implementation of an online service do not guarantee its usage or appreciation. For citizens to embrace an online service, it must be perceived as reliable and user-friendly as well as deliver tangible benefits that users can readily perceive. Furthermore, considering that Directlab Online operates as a website for citizens without direct involvement from health care professionals, it was difficult for citizens to trust the service as a reliable resource. To ensure that a service like Directlab Online works, the service's reliability should be clear to users. Thus, it is beneficial to let users know that health care professionals were involved in the service.

The second lesson is that the needs of users can differ from the wishes of other stakeholders, and it is crucial to discuss those differences. For example, in Chapter 4, GPs wanted to have very detailed medical information on the online service; however, in the focus groups, the users highlighted that most of the information was not particularly helpful and that the amount of difficult information was perceived as a barrier to using the service. According to the users, information about privacy and the benefits of the service compared with visiting a GP was lacking. Thus, it is critical to co-create services with all relevant stakeholders to make the online service usable and effective [3]. Ultimately, a balance between the wishes and needs of all stakeholders must be found [4].

The third lesson is that the service must be as easy as possible for all users – both patients and health care professionals. During conversations with GPs for Chapter 5, I encountered a barrier related to the navigation of a novel digital environment, a finding that aligns with previous research regarding GPs' attitudes and experiences with online services [5]. Consequently, GPs would rather not use Homelab. Future endeavors should consider accommodating diverse login procedures and assuring GPs that the online services will seamlessly integrate with their existing suite of applications and workflows [6]. In addition, these future endeavors should consider laws and regulations to ensure privacy and security. Moreover, training for GPs in how to use the online service could help to make it as easy as possible for them to use [6]. The usability of the service is also critical for enabling patients and citizens to use it, as derived

from Chapters 4 and 5. The service must be as easy as possible for patients to use. For example, as found in Chapter 4, many elements of the service could be improved to increase its usability, such as information provision and the use of difficult terms. Those factors influenced the use and usability of the service negatively and should be considered when developing an online service. Crucial aspects to consider are language, the amount of information, colors, and the general look and feel of the website. As discussed in the previous paragraph, co-creation could help to optimize the usability of the service during development.

Lastly, a good implementation of an online service takes time, as seen in the Homelab study in Chapter 5. In the first months of Homelab's implementation, the service was barely used. It took time for patients to find the service and use it. For developers, project managers, and health care professionals, it remains important to be patient and to let patients get used to the service. It could be beneficial to help patients navigate through the service or provide leaflets with information about it.

Implications

In general, as highlighted in the introduction and discussion chapters of this thesis, a need exists for increased accessibility to health care. The online services examined in this thesis could contribute to more efficient work processes, and they also increased the role of the patient through self-management, which demonstrates their potential. The online services exhibited the potential to improve the management of relatively uncomplicated cases, such as STI testing, through using online triage, ordering tests online, and receiving results online. This innovative approach can optimize the allocation of GPs' time resources, allowing them to dedicate a greater proportion of their efforts to the provision of care for more complex medical conditions and patients. However, it is imperative to acknowledge that while this perspective presents a promising vision for the future of health care delivery, the efficacy and safety of such services necessitate rigorous validation through comprehensive research endeavors. Further investigation is warranted to ascertain the feasibility, reliability, and overall impact of these online services on patient outcomes and health care utilization.

The online triage tool (Chapter 3), used in two of the services examined in this thesis, presented advice based on input from the patient, and the service was then able to present medical advice based on medical guidelines. It would be interesting to also consider the patient's medical history in the online triage tool (eg, medication use). Thus, the online tool could be more personalized for every patient and provide better advice on what kind of care is necessary for a specific patient. In addition, for every online service discussed in this thesis, it could be beneficial to make them more personalized. For example, for SARA, it would be a valuable enhancement if the intervention had input about the user's medication usage and any other relevant medication conditions. If this additional medical information was input into the service, SARA could offer more comprehensive information and guidance to the patient and health care professional concerning their medication regimen and overall health situation.

An interesting finding derived from Chapter 4 is that participants expressed a preference for the involvement of a health care professional in the process of ordering diagnostic tests, as this heightened the perceived level of reliability in the service. Noteworthily, the health care professional does not necessarily have to be their own GP, as citizens highlighted during the focus groups. In the Netherlands, every citizen currently has a specific GP, and sometimes their GP is unable to accommodate them due to a lack of available appointment slots. From the focus groups, the observation that a patient does not necessarily want to visit his or her own GP suggests that patients could be redistributed among various GPs, potentially alleviating the workload in specific geographic areas. The ability to distribute care is desirable because some regions of the Netherlands do not have enough health care professionals [7]. Moreover, the finding of patients' preference to not necessarily want to consult their own GP underscores a receptiveness among citizens to transformative shifts within health care. Specifically, it implies a readiness for potential changes in the role of the GP in the coming years.

In the study in Chapter 5, dialogues were conducted with GPs concerning Homelab. They revealed that the GPs exhibited a profound sense of responsibility for all online interactions with their patients. They underscored the enduring nature of their responsibility for their patients' well-being. Consequently, Homelab could offer significant advantages if GPs were granted the capability to review the outcomes of online triage and not only the advice of the triage (response of the patient for each question), thereby enabling them to assess patients' responses to specific questions. This potential feature could potentially enhance GPs' sense of control over patient care and facilitate a more nuanced understanding of patients' specific health complaints.

Here, I wish to emphasize that eHealth is not the solution for all health care challenges, nor should it be regarded as the holy grail. Nevertheless, enormous potential exists for favorable outcomes if health care professionals embrace online services. Noteworthily, the development and implementation of robust online services require a significant investment of time and resources, as corroborated by the findings in Chapter 5 and by other relevant research on the implementation of eHealth [8]. As delineated in Chapter 5, the initial months following the introduction of Homelab witnessed a limited uptake, with a scarcity of test packages being ordered. However, as Homelab became a more integral component of health care provision over time, its utilization steadily increased. The assimilation of Homelab into routine health care practices provides an opportune avenue for investigating its cost-effectiveness. A similar rationale holds for the online intervention SARA.

The effectiveness of SARA was researched in Chapter 6. SARA appeared to be a potentially effective method for increasing medication adherence in asthma and COPD patients through online self-management. The self-management intervention could be expanded to other chronic diseases to reduce the disease burden by increasing medication adherence. Non-adherence to medication in chronically ill patients is

a common problem, not only in asthma and COPD patients [9]. If a self-management intervention like SARA could assist in increasing adherence, it could reduce the disease burden and possibly also the work pressure in health care.

In this thesis, it appeared that all of the examined online services were used more by younger participants, and the usability was also better perceived by the younger population (Chapters 2, 4, 5, and 6), which is in line with earlier research about eHealth services [10-12]. One could posit that online services are more aligned with the requirements and/or proficiencies of a younger demographic, which suggests that online services may not be universally applicable. However, it is imperative to underscore several key considerations in this context. First, Chapters 2, 4, and 5 involved services where STI testing is mostly used. Since STIs mainly occur in people below the age of 30 years, it is logical that younger patients would appreciate such online services more than a population with higher age [13]. Second, although the online services were more highly appreciated by the younger population, some services were also used by a relatively higher age group. For example, for Homelab, the mean age was approximately 40 years. The usability was scored lower among patients in the higher age group than in the below-40 age group, but both groups reported good usability [14]. Third, the mean age of the population in SARA was approximately 60 years, which was comparatively higher than the mean age in the other studies of this thesis. Nevertheless, the mean age of 60 years aligns well with the COPD population that SARA was made for [15], but it was found to be effective. In line with this finding, similar findings were found for another online service with videos explaining the most essential information from package leaflets for medication [16]. Specifically, two-thirds of the population were aged above 55 years [16]. Here as well, the research demonstrated that the younger population experienced more valuable additions (eg, saw the benefit) to the website than the population with a higher age. However, all users of the website were positive in general [16]. Some studies found that, especially in an older population, the online service had more of an effect than in the youngest population [17]. With the increasing technological competence of the elderly, eHealth could become more suitable for all [18]. In addition, tailored and more personalized online services could improve their accessibility [19]. Research findings have indicated that co-creation can increase effectiveness and contribute positively to implementation [18, 20]. Concretely, this means that there must be even more co-creation with a more diverse group of users to increase the accessibility and use of online services. Only then can online services provide a potential strategy for changing the general accessibility of health care.

Furthermore, while primary health care is lagging in digitization, we still observed a significant reliance on non-digital equipment, including administrative tasks [21]. While some general practices have embraced online operations or established effective means of digital communication through scientifically validated eHealth solutions, these instances remain exceptions rather than the norm. Health care professionals in

primary care are facing multiple related issues, such as a lack of time and resources [22]. Scientifically validating online services could play a crucial role in identifying both benefits and obstacles to the responsible expansion of online services in health care. Identifying benefits and obstacles is essential for ensuring that these services not only work effectively in practice but also integrate seamlessly into the daily routines of health care professionals, addressing any associated barriers [23]. As mentioned earlier, scientific validation is needed to guarantee that these services align with the needs of health care professionals and serve as practical tools for enhancing patient care.

Strengths and limitations

A notable strength of this thesis is that all of the studies pertained to online services that were implemented or subjected to pilot programs in authentic real-world settings, within the realm of daily practice. None of them were in experimental environments or specific populations. Notably, the generalizability of real-world studies is higher than that of randomized controlled trials (RCTs) [24]. In addition, this thesis underscores the importance of consistently considering the requirements, inclinations, and facilitators that enable users to effectively engage with online services. By doing so, these services could benefit both patients and health care professionals, ensuring that the right assistance for the GP is provided in the appropriate manner.

A general limitation of online service research lies in the duration required for research and implementation as well as the pace of innovation. The studies presented in this thesis were conducted between 2020 and 2023. However, the rapid pace of development of Internet-related technologies – and thus of online services – poses a challenge in maintaining pace with the day-to-day tools used by patients [25]. This limitation changed, for example, the relevance of one of our studies; specifically, during the comparison between an online triage tool and the decision-making process of a GP, it became evident that an artificial intelligence chatbot could serve as an effective machine for answering health-related questions [26]. Highlighting the difficulty of aligning scientific research with the constantly evolving technologies used by patients, a significant concern was that the tools under investigation could already have been outdated by the time the research concluded. Especially for online services, it could be beneficial to deviate from the golden standard of RCTs to validate new services and research their effectiveness [27]. RCTs require a significant amount of time and money. As previously stated, time is not always available in the quickly changing digital world [25]. For online services, RCTs do not often fit with the large group of different kinds of users whom one would want to include to use one's service; in other words, the external validity of RCTs does not fit with that for online services [28]. Online services are used in a real-life environment where confounding factors cannot be anticipated [29]. Other methods for scientifically analyzing online services can be recommended depending on the research goal [30]. Differences can be made in different phases

– namely conceptual, design and usability, implementation, effectiveness, and feasibility. Specifically, a feasibility study (used to estimate critical parameters required for the main study) would not evaluate the service, while an interrupted time-series design would evaluate the service over a longer period [30]. For example, the vignette study in this thesis (Chapter 3) was used to provide valuable insights into how health care professionals would respond to a specific situation or scenario where conducting this type of research in a real-life setting was not feasible. By presenting participants with the same scenarios (eg, complaints, sexual history, and age), we attempted to minimize variations between scenarios and ensure that each general practitioner encountered the same patients [30-32].

Another limitation was that most of the research for this thesis was performed during the COVID-19 pandemic. A consequence of the COVID-19 lockdown period was that most interviews and focus groups had to be performed online. However, with good preparation, the right number of participants, and a highly usable platform, online interviews and focus groups can be a strong option [33].

Future research

As discussed in the introduction chapter, online services could end up in the metaphorical Valley of Death. In this thesis, the online services were implemented in real-life settings. Investigating online services in real-life settings could be instrumental for avoiding the Valley of Death phenomenon, since they are not solely studied in controlled research environments [34, 35]. However, other factors (eg, how often services are used and if they are cost-effective) are also crucial for, among others, health insurance companies and policymakers [36, 37]. Understanding costs is vital for health insurers to provide cost-effective coverage to their policyholders and make informed decisions about service inclusion and reimbursement rates. More research is required to investigate whether online services are cost-effective, as cost-effective online services would be less likely to end up in the Valley of Death.

An online triage service plays a significant role in online services such as Directlab Online and Homelab. Ensuring the effectiveness of the triage tool is of paramount importance. While this thesis addressed certain aspects related to the triage tool, it would be intriguing to explore how users perceive its language and understandability. Certain (medical) words or phrases used in the online triage tool may prove difficult or confusing for users [38]. In such cases, users might misinterpret the tool's recommendations, leading to inaccurate or insufficient advice. By delving into the user experience and ensuring the clarity and comprehension of the online triage tool, its accuracy and effectiveness could be enhanced, ultimately benefiting users and improving the overall performance of the online services. Research should investigate whether the holistic view of the GP can be integrated into an online triage tool by adding questions about the patient's background and medical history.

The goal of these services is to increase the self-management of citizens and patients; however, this thesis did not examine whether the services improve self-management. Addressing whether the online services Directlab Online and Homelab could effectively contribute to the self-management of users' health could be crucial. Researching self-management can be achieved by tracking the progress of patients or citizens who have ordered diagnostic tests through these services. The effect on self-management can be researched through self-management questionnaires. In addition, it could be interesting to examine changes in patients or citizens' health and assess the role of the services in facilitating such changes. Furthermore, it is important to consider the potential time-saving benefits of Homelab for GPs. Investigating whether Homelab leads to a reduction in consultations and saves valuable GP time is another direction for future research. Furthermore, users of Directlab Online should be followed over a longer period to answer the following questions: Are they changing their behavior as a result of the diagnostic test that they ordered? Are they ordering more diagnostic tests? Do they feel more in control? In addition, for SARA users, the following question could be examined: Are they feeling more in control, and did it change their quality of life?

Another interesting topic for future research could be pharmacists' perspective on SARA. SARA has been demonstrated to have the potential to be effective in patients with asthma and COPD. However, to ensure its effective functioning, it is equally crucial to gather feedback from pharmacists who use the service in their professional practice. Research about pharmacists' perspective on SARA could be performed qualitatively by interviewing them and quantitatively by measuring how much time they spend on SARA and how much they would normally spend on a patient. SARA can be expanded for use for more chronic diseases, but more research about those perspectives would be necessary. In addition, more research could be performed on patients' quality of life.

Conclusions

We researched different online services designed for citizens, healthy GP patients, and chronic disease patients. The online services could not only help in the self-management of those populations but also lead to more accessible health care. We are able to conclude that the suitability of the researched eHealth services is not yet for all. They tend to be more favorably received and used by younger patients or citizens. Nevertheless, in general, patients and citizens tend to be open and positive regarding the use of online services, frequently finding the usability of the services to be satisfactory. With ongoing collaboration among all stakeholders and an improved understanding of technology and the Internet, eHealth services hold the potential to become more inclusive.

Notably, health care professionals have a critical role in shaping the quality of these online services and increasing their reliability through their involvement. In addition, a health care professional possesses a unique ability to approach patients, reason, and decide holistically – a perspective that is not (yet) fully integrated into online services.

However, patients and citizens exhibit positivity and receptiveness toward direct online access to care across different settings, which can offer considerable value. Yet, for these services to truly enhance self-management and health care's accessibility, it is imperative to maintain ongoing user engagement, including by actively addressing user needs and preferences. This proactive approach will ensure that eHealth services are optimized in terms of their usability, effectiveness, and overall contribution to the realm of self-management and accessible health care.

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Summary

The health care landscape is evolving due to increasing demand, the complexity of care, and a shift toward early prevention, in addition to changes in health care settings. To address these challenges, eHealth (electronical health) is gaining importance, as it offers opportunities to reduce health care professionals' work pressure, enhance patient self-management, and improve health care accessibility. Yet, eHealth services must be validated to ensure that they fulfill their intended purpose. In addition, online services must also be practical and user-friendly. This thesis studied online services that have already been implemented or piloted in the health care landscape. It assessed their usability and effectiveness at helping patients and citizens with self-management and improving the accessibility of health care. In **Chapter 1**, the challenges in health care and the role of eHealth in patient self-management are described in detail. In addition, the thesis objectives are presented. The general objective was to investigate whether different online services that offer direct access to care are usable, effective, and safe for patients and citizens for self-managing their health care with or without the involvement of health care professionals. Next, **Chapters 2 through 5** specifically investigate the use and usability of direct access to various diagnostic test services. Then, **Chapter 6** investigates the effectiveness of an online self-management and support tool for asthma and chronic obstructive pulmonary disease (COPD) patients supported by health care professionals. Lastly, **Chapter 7** presents a discussion of the findings and concludes the thesis.

Chapter 2 evaluates the availability and utilization of direct online access to diagnostic tests and result services. A review was conducted that focused on patients having direct access to online triage, ordering tests online, performing tests at home, and receiving the results digitally. The review encompassed 31 different services, which were predominantly focused on sexually transmitted infections (STIs). Users rated the usability of these services as well as their acceptability positively. Testing for STIs at home had higher user rates compared with clinic-based testing, as it reduces the barriers to getting tested. In addition, performing a diagnostic test at home was demonstrated to be acceptable, safe, and convenient for users. Moreover, after users received positive test results for a sexual infection, follow-up care was available. Direct access to diagnostic test and result services could potentially reduce the barriers to testing, improve efficiency, and reduce the workload of general practitioners (GPs) as patients would be able to assume a more active role in their care.

Chapter 3 compares the advice of an online triage tool for STIs with the advice of GPs. In this qualitative study, 10 GPs were asked to provide advice for six different patient vignettes about whether to perform an STI test. These vignettes were identified as patient cases structured around risk factors associated with STIs. Specifically, different aspects were considered to calculate the risk of an infection, such as unsafe sex and different complaints. Furthermore, factors such as age, gender, and relationship status

were considered, and they differed for each vignette. The advice of the online tool for each vignette was compared with the advice offered by the GPs. In addition, this study sought insights into the decision-making process behind the GPs' advice; specifically, it examined why they advised or did not advise an STI test for a particular patient case (a vignette in this study). The results revealed that in three out of the six vignettes, the advice for testing offered by the online triage tool and all GPs was the same. For the remaining three vignettes, discrepancies were observed between the online tool and the GPs as well as among the GPs themselves. Consistency between the online tool and GPs was more prevalent when risk factors for STI testing were unequivocally evident, such as in cases involving men who have sex with men. The decision-making process of GPs was influenced by patient-related factors, including the anxiety levels of the patient, patient preferences, and age. Additionally, some GPs expressed an inclination to ask further questions or conduct physical examinations before advising patients to be tested. From these findings, it could be concluded that the GPs tended to adopt a comprehensive and holistic perspective, considering various aspects of the patient, while the online tool tended to align more closely with medical guidelines. The online triage tool demonstrated potential as a substitute for in-person consultations in the future. However, this tool needs to provide safety, effectiveness, and user friendliness, and more research is required to ensure this. Furthermore, incorporating more holistic inquiries into the triage tool, developed in collaboration with GPs, could be advantageous.

The online triage tool researched in Chapter 3 is also among the online services researched in Chapters 4 and 5. **Chapter 4** examines an online service's usability, for which focus group sessions were conducted. A total of 19 participants were interviewed to assess the service's usability, identify user needs, and identify factors that either facilitate or impede its utilization. The online service allows citizens to independently order diagnostic tests, such as those for STIs, without the involvement of health care professionals. Nevertheless, health care professionals were involved in the service's development. The focus group participants emphasized the importance of clarifying that the service aimed to enhance their health care, as this was not adequately conveyed to them on the website. Moreover, a lack of information on privacy and a commercial appearance acted as barriers, discouraging citizens from using the service. Participants stressed the need for a suitable amount of clear information to improve the service's usability and encourage its adoption. Moreover, this research found an imbalance between the wishes of the health care professionals involved in the service and those of the citizens. Specifically, the health care professionals involved in the service desired highly detailed information on the website about the diagnostic tests, while the citizens wanted clearer and more concise information about the diagnostic tests. Co-creation with end-users and medical professionals is required to solve this imbalance. In addition, future research could focus on the effect of test results on user behavior.

Chapter 5 examines another service in which the online triage tool from Chapter 3 was implemented. Specifically, it investigates the usability of an online service called Homelab, which enables patients to order diagnostic tests online with the permission of their GP. Thus, GPs can monitor their patients. Homelab provides a range of diagnostic tests, including tests for STIs and hair loss. Within Homelab, an online triage tool guides patients on which tests to request. Homelab aims to minimize visits to a GP, enabling patients to conveniently request tests online and access their results digitally. Nonetheless, if the results are abnormal, it remains the GP's responsibility to communicate this fact to the patient. In Chapter 5, the usability of Homelab was assessed through a post-usage questionnaire that was completed by 74 participants. The most ordered test package was called 'Am I still healthy?'. The results indicated that Homelab primarily attracted well-educated and employed users. They used Homelab instead of going to the GP, and more than 80% were willing to reuse Homelab in the future. Moreover, the users found Homelab easy to use, particularly younger ones. Homelab thus demonstrated its potential to alleviate the workload of GPs by reducing patient visits. Moreover, it could enhance patient self-management and accessibility, particularly among younger patients, by offering them greater control over the management of their health without the need to wait for specific appointments.

Chapter 6 investigates the effectiveness of an online self-management service for patients with asthma and the use of medication for chronic obstructive pulmonary disorder (COPD). The study aimed to examine whether the service was able to decrease exacerbation rates (lung attack) and increase medication adherence. The online self-management tool was called SARA. SARA provides information about medication use and entails follow-up support by pharmacists. Medication dispensing data were used from 382 pharmacies across the Netherlands. In total, 9,452 participants were included, of whom 2,400 were SARA users. Their average age was approximately 61 years. Exacerbation rates were determined by the short-course oral corticosteroids dispensed. Medication adherence was assessed by calculating the proportion of days covered by dispensed inhalation maintenance medication. The outcomes were analyzed for the year before and after SARA implementation, and SARA participants were compared with control patients. The results revealed an increase in mean exacerbation rates for both SARA and control participants. However, this increase was significantly lower among the SARA participants. For participants who used medication for asthma and COPD for a longer period, medication adherence was found to be increased in both the SARA and control groups, although the increase was significantly higher for the SARA group. These findings suggested that SARA holds promise for potentially decreasing exacerbation rates and increasing medication adherence. Furthermore, SARA could potentially have its efficacy extended to the management of other chronic diseases that require medication for disease control and symptom improvement.

Lastly, **Chapter 7** discusses the findings of all of the studies. In addition, it discusses the lessons learned and provides suggestions for future research. The findings suggested that, overall, patients and citizens – particularly younger ones – display receptiveness to online services aimed at aiding their self-management of health and disease. Furthermore, these services were often perceived as user-friendly. Nonetheless, certain obstacles hinder their widespread adoption. Hence, it is imperative to promote collaboration among all stakeholders to improve these services' usability and guarantee that they effectively fulfill their intended purpose and objectives. Throughout this thesis and the implementation of the online services, several lessons were learned. To start, the reliability and ease of use of these services proved to be crucial. In addition, implementing online services is a time-consuming process. Furthermore, it is vital to include all stakeholders in the development and implementation of an online service to increase its usage as well as the chance that it does what it is intended to do. Further research could focus on long-term usage aspects, such as whether users feel more in control of managing their health. A limitation of this research lies in the duration of scientific research compared with the pace of innovation. The tools examined in this thesis could already be outdated by the time research is conducted. It is vital to consider the duration required for both research and implementation in contrast to the rapid pace of technological advancements. Future studies should explore effective methodologies for researching online services. Moreover, upcoming research endeavors might prioritize the validation of the efficacy of online triage tools and the assessment of their comprehensibility among patients. A pivotal aspect is to ensure that patients can interpret and adeptly grasp these online triage tools. The use of online triage tools holds potential for facilitating direct access to health care services, provided that they are comprehensible and well-interpreted by patients. Additionally, services such as Homelab contribute to enhancing health care accessibility. Rather than transitioning everything directly into the digital realm, tools like online triage and services like Homelab can function as intermediaries. Nonetheless, it remains crucial for health care professionals to be actively engaged in these services. In summary, while eHealth offers opportunities for accessible and effective health care, scientifically validating these services is paramount.

Samenvatting

Het zorglandschap verandert continu. Dit komt onder andere door de groeiende vraag naar zorg en de stijgende complexiteit ervan. eHealth ('electronical health') kan een belangrijke rol spelen in het aanpakken van deze uitdagingen. eHealth verwijst naar de informatie- en communicatietechnologie in de gezondheidszorg. eHealth biedt kansen om de druk in de zorg te verlagen, door bijvoorbeeld patiënten meer zelf te laten doen en regie te laten nemen over hun zorg. Daarnaast kan eHealth ervoor zorgen dat de zorg toegankelijker wordt voor iedereen. Het is wel onmisbaar dat de eHealth toepassingen wetenschappelijk gevalideerd zijn, om zeker te stellen dat de digitale toepassingen doen wat ze beogen. Daarnaast is het belangrijk dat de digitale toepassingen praktisch toepasbaar en gebruiksvriendelijk zijn. Deze thesis heeft verschillende digitale toepassingen onderzocht die al (deels) geïmplementeerd zijn in de zorg. De onderzoeken gaan vooral in op de gebruiksvriendelijkheid en effectiviteit van de digitale toepassingen, met als doel het zelfmanagement en toegankelijkheid van de zorg te bevorderen. In **Hoofdstuk 1** worden bovengenoemde uitdagingen in de zorg meer in detail beschreven. Ook wordt in **Hoofdstuk 1** meer uitgelegd over welke rol eHealth kan spelen bij deze uitdagingen en hoe eHealth bij kan dragen aan meer zelfmanagement van de patiënt. Ook worden de doelen van deze thesis beschreven in **Hoofdstuk 1**. Het hoofddoel van deze thesis is om te onderzoeken hoe gebruiksvriendelijk en effectief verschillende digitale toepassingen zijn die directe toegang tot zorg aanbieden. De **Hoofdstukken 2 tot en met 5** richten zich voornamelijk op het gebruik van digitale toepassingen en hun gebruiksvriendelijkheid. Deze digitale toepassingen hebben betrekking op het aanvragen van diagnostische testen, zowel met als zonder betrokkenheid van zorgprofessionals. Met diagnostische testen is het mogelijk aandoeningen te detecteren, zoals bijvoorbeeld een seksueel overdraagbare aandoening. **Hoofdstuk 6** kijkt naar de effectiviteit van een online zelfmanagementprogramma voor patiënten met astma en COPD met betrokkenheid van de apotheek. In **Hoofdstuk 7** worden de resultaten van deze thesis bediscussieerd en een conclusie getrokken.

Hoofdstuk 2 schetst de beschikbaarheid en het gebruik van online toepassingen gericht op directe toegang tot diagnostische testen en de uitslag. Het onderzoek richt zich op online triage, het online bestellen van diagnostische testen (en deze test soms thuis doen) en de uitslag ervan online ontvangen. Dit onderzoek liet zien dat er tot op dat moment 31 verschillende toepassingen onderzocht waren, waarvan 30 toepassingen voor seksueel overdraagbare aandoeningen. De gebruikers vonden de gebruiksvriendelijkheid goed en acceptabel. Een diagnostische test thuis doen was populairder dan een diagnostische test in een kliniek of praktijk doen. Daarnaast vonden mensen het fijn en voelde het veilig om deze test thuis te doen. Nadat patiënten positief waren getest op een seksueel overdraagbare aandoening kregen ze de daarbij behorende zorg. Door directe toegang tot diagnostische testen kan de drempel om te testen op een seksueel overdraagbare aandoening worden verlaagd. Daarnaast

kan het ook leiden tot meer efficiënte zorg, omdat de werkdruk bij huisartsen verlaagd lager wordt. Dit komt omdat sommige taken online en thuis door patiënten zelf gedaan kunnen worden.

Hoofdstuk 3 vergelijkt het advies dat een online triagetool geeft over het wel of niet doen van een diagnostische test voor seksueel overdraagbare aandoeningen met het advies dat tien huisartsen daarover geven. In dit kwalitatieve onderzoek zijn huisartsen gevraagd om hun advies en overwegingen te delen voor zes verschillende vignetten. Deze vignetten representeerde zes verschillende patiëntcasussen, kortom zes verschillende fictieve patiënten. De vignetten waren gebaseerd op risicofactoren met betrekking tot seksueel overdraagbare aandoeningen, zoals bijvoorbeeld onveilige seks of mannen die seks hebben met mannen. De vignetten zijn door de online triagetool gehaald. Het advies dat hieruit naar voren kwam is vergeleken met het advies dat de huisartsen geven. Daarnaast is voor elk specifiek vignet geëvalueerd waarom huisartsen wel of niet een diagnostische test voor het detecteren van seksueel overdraagbare aandoeningen adviseren. Hierbij werd gevraagd welke gedachtes zij hadden bij het maken van een beslissing. De resultaten laten zien dat voor drie van de zes vignetten het advies van de online triagetool hetzelfde was als voor alle huisartsen. Voor de andere drie vignetten verschilde het advies met de online triagetool en de huisartsen onderling. Een verklaring voor de consensus tussen drie vignetten en de huisartsen kan zijn dat bij deze drie vignetten de risicofactoren erg duidelijk waren. Een voorbeeld van zo een risicofactor is een man die seks heeft gehad met mannen. Een belangrijke factor die een rol speelde bij het maken van een beslissing voor het wel of niet doen van een diagnostische test voor seksueel overdraagbare aandoeningen was voor de huisartsen de angst van de patiënt. Ook leeftijd en wensen van de patiënt speelden bij de huisarts mee in de afweging. Bij sommige vignetten vertelden de huisartsen dat ze het liefst de patiënt wat meer vragen zouden willen stellen of dat ze de patiënt lichamelijk zouden willen onderzoeken. Hieruit kan worden geconcludeerd dat huisartsen een meer holistisch perspectief in gedachten houden bij het maken van een beslissing voor het wel of niet doen van een test voor seksueel overdraagbare aandoeningen. De online triagetool volgt strikter de medische richtlijnen dan de huisartsen. De online triagetool zou kunnen werken als vervanging voor persoonlijke triage in de toekomst, maar het is wel belangrijk dat de triage veilig, effectief en gebruiksvriendelijk is. Daarnaast kan het waardevol zijn om in overleg met huisartsen meer holistische vragen te verwerken in online triage, zodat de juiste zorg op de juiste plek terecht komt.

De online triagetool die onderzocht is in **Hoofdstuk 3,** is ook onderdeel van de online toepassingen in **Hoofdstukken 4 en 5**. **Hoofdstuk 4** beschrijft een kwalitatieve studie waarbij, via focusgroepen, de gebruiksvriendelijkheid van de service werd onderzocht. In totaal zijn 19 participanten geïnterviewd over de gebruiksvriendelijkheid,

hun behoeftes en ervaringen. De online toepassing was een website waarop gebruikers zonder tussenkomst van de huisarts een diagnostische test konden aanvragen. Een voorbeeld voor zo een test is een diagnostische test voor seksueel overdraagbare aandoeningen. De participanten benadrukten dat het voor hen belangrijk was om te weten dat de website beschikbaar was om hen te ondersteunen bij hun gezondheid. Dit was op dit moment niet duidelijk genoeg voor hen. Daarnaast mistten zij informatie over de borging van privacy. Ook vonden zij dat de website een commercieel gevoel gaf. Dit gevoel belemmerde hen in het gebruik van de website, maar ook in het gevoel van betrouwbaarheid. Daarnaast gaven participanten aan dat ze behoeften hadden aan meer duidelijke informatie. Ook liet dit onderzoek zien dat de wensen van de zorgprofessionals die betrokken waren bij deze website anders zijn dan de wensen van de participanten. De zorgprofessionals willen veel en gedetailleerde informatie over de diagnostische testen op de website, terwijl dit als te veel en moeilijke informatie werd ervaren door de participanten. Co-creatie met alle eindgebruikers en zorgprofessionals is nodig om deze disbalans te voorkomen. Het effect dat testresultaten die deze website oplevert heeft op het gedrag van de gebruikers, vergt nader onderzoek.

Een andere toepassing waar de online triagetool werd gebruikt is onderzocht in **Hoofdstuk 5**. In dit hoofdstuk wordt de gebruiksvriendelijkheid van een online service genaamd 'Homelab' onderzocht. Homelab laat patiënten zelf diagnostiek aanvragen, maar wel in de digitale omgeving van de huisarts. De huisarts moet de diagnostische testen goedkeuren, waardoor het voor hen mogelijk is de patiënten te monitoren. Homelab biedt verschillende diagnostische testen aan. De online triagetool op Homelab geeft patiënten advies over of- en welke diagnostische test nodig is voor de patiënt. Het doel van Homelab is om het aantal huisartsbezoeken te verminderen. Patiënten doen een aanvraag voor diagnostische testen online in plaats van dat ze naar de huisarts moeten. Daarnaast is het doel van Homelab om de zorg toegankelijker te maken. Patiënten kunnen op ieder moment zo een diagnostische test aanvragen. De resultaten van de diagnostische test van Homelab worden online gecommuniceerd naar de patiënten en naar de huisartsen. De huisartsen blijven verantwoordelijk voor de communicatie naar de patiënt als het resultaat afwijkend is. Voor dit onderzoek was een vragenlijst geïmplementeerd in het systeem, die patiënten konden invullen na het gebruik van Homelab. De vragenlijst bestond uit vragen over demografische kenmerken, maar ook over het gebruik en de gebruiksvriendelijkheid van Homelab. De vragenlijst is door 74 patiënten ingevuld over de tijdsduur van één jaar. Het meest aangevraagde diagnostische testpakket was: 'Ben ik nog gezond?'. De resultaten lieten zien dat het merendeel van de gebruikers theoretisch opgeleid was en een baan heeft. Ook laat het onderzoek zien dat Homelab werd gebruikt in plaats van naar de huisarts te gaan, en niet beide tegelijk. Meer dan 80% van de patienten wilde Homelab nog een keer gebruiken. Patiënten, vooral de wat jongere pati-

enten, vonden Homelab fijn in het gebruik. Homelab zou dus de werkdruk kunnen verlagen bij huisartsen en voor meer toegankelijke zorg kunnen zorgen.

Hoofdstuk 6 beschrijft de effectiviteit van 'SARA.' Dat is een online zelfmanagement-service voor patiënten die medicatie gebruiken tegen astma en COPD. De studie onderzocht of de service ervoor kan zorgen dat het aantal exacerbaties (longaanvallen) minder werd en of het de therapietrouw van medicatie kon verhogen. SARA is een website waarop informatie staat over medicatiegebruik, maar ook konden er bijvoorbeeld vragen gesteld worden aan farmaceuten. Gegevens van medicatie-uitgifte uit 382 verschillende apotheken verdeeld over Nederland werden gebruikt voor de data-analyse. In totaal werden medicatiegegevens van 9452 patiënten geïncludeerd, waarvan 2400 patiënten zich hadden aangemeld voor SARA. De gemiddelde leeftijd van de totale populatie was ongeveer 61 jaar. Het aantal longaanvallen is berekend via de medicatie-uitgifte gegevens van korte termijn orale corticosteroïden. Voor patiënten die inhalatiemedicatie voor een lange tijd gebruikte, is hun therapietrouw berekend. Therapietrouw van medicatie werd berekend via de 'proportion of days covered' methode. Deze methode berekent hoeveel dagen een patiënt 'gedekt (medicatie had voor die dag)' was met inhalatiemedicatie. De patiënten data van voor de start van SARA zijn geanalyseerd en vergeleken met de data van een jaar na de start van SARA, waarbij ook een controlegroep werd vergeleken met de SARA-gebruikers. Ten eerste laat het resultaat zien dat er zowel in de controlegroep als de SARA-groep een stijging was van het aantal longaanvallen één jaar na de start van SARA, ten opzichte van het jaar voor SARA. Maar deze stijging was significant lager voor de SARA-gebruikers. Ten tweede laat het onderzoek zien dat de therapietrouw in beide groepen omhoog is gegaan in het jaar na de start van SARA, ten opzichte van het jaar voor SARA. Maar deze stijging is significant hoger voor de SARA-groep, dan voor de controlegroep. Deze uitkomsten suggereerden dat SARA kan helpen in het verlagen van longaanvallen en dat SARA kan bijdragen aan het verbeteren van de therapietrouw. Verder zou SARA ook voor andere chronische ziekten met medicatie voor ziektemanagement gebruikt kunnen worden.

Hoofdstuk 7 concludeert en bediscussieert de bevindingen van de studies in dit proefschrift. Daarnaast behandelt het lessen die zijn geleerd tijdens de onderzoeken en geeft het suggesties voor toekomstig onderzoek. De bevindingen suggereerden dat over het algemeen patiënten en burgers, met name de jongere generatie, openstaan voor online toepassingen gericht op het ondersteunen van hun zelfmanagement van gezondheid en ziekte. Bovendien werden deze services vaak ervaren als gebruiksvriendelijk. Desalniettemin belemmeren bepaalde obstakels hun brede acceptatie. Het is daarom van essentieel belang om samenwerking tussen alle belanghebbenden te bevorderen om de bruikbaarheid te verbeteren en ervoor te zorgen dat de online toepassingen effectief voldoen aan hun beoogde doel en doelstellingen.

Gedurende dit proefschrift en de implementatie van online toepassingen zijn verschillende lessen geleerd. Ten eerste bleek betrouwbaarheid en gebruiksgemak van deze toepassingen cruciaal te zijn. Bovendien is het implementeren van online toepassingen een tijdrovend proces. Ten tweede is het belangrijk om alle belanghebbenden te betrekken bij de ontwikkeling en implementatie van de online toepassingen om het gebruik te vergroten en de kans te vergroten dat de online toepassing doet wat deze beoogt te doen. Toekomstig onderzoek kan zich richten op de wat langere termijn, zoals onderzoek naar de vraag of gebruikers zich meer in controle voelen bij het beheren van hun gezondheid via een dergelijke online service. Een beperking van dit onderzoek ligt in de duur van wetenschappelijk onderzoek in vergelijking met het tempo van innovatie. Diensten in dit proefschrift kunnen al verouderd zijn tegen de tijd dat het onderzoek wordt uitgevoerd en gepubliceerd. Het is van belang om rekening te houden met de tijd die nodig is voor zowel onderzoek als implementatie, in contrast met het snelle tempo van technologische vooruitgang. Toekomstige studies zouden effectieve methodologieën kunnen bestuderen voor het onderzoeken van online diensten. Bovendien zouden komende onderzoeken prioriteit kunnen geven aan het valideren van de doeltreffendheid van online triagetools en het beoordelen van hun begrijpelijkheid bij patiënten. Een essentieel aspect ligt in het waarborgen dat patiënten deze online triagetools goed kunnen interpreteren en begrijpen. Het gebruik van online triagetools heeft potentieel in het faciliteren van directe toegang tot gezondheidszorgdiensten, mits ze begrijpelijk en goed geïnterpreteerd worden door patiënten. Bovendien dragen diensten, zoals Homelab, bij aan het verbeteren van de toegankelijkheid van de gezondheidszorg. In plaats van alles direct naar een digitale wereld over te brengen, kunnen tools zoals online triage en diensten zoals Homelab fungeren als tussenplatformen. Het blijft wel het cruciaal dat zorgprofessionals actief betrokken zijn bij deze diensten. Kortom, hoewel eHealth kansen biedt voor toegankelijke en effectieve gezondheidszorg, is het van essentieel belang om wetenschappelijke validatie van deze diensten te blijven uitvoeren.

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Curriculum Vitae

Kyma Schnoor, born in 1996 in Delft, the Netherlands, later relocated to Voorhout. She completed her secondary education at Teylingen College Leeuwenhorst in Noordwijkerhout, obtaining a gymnasium diploma in 2014. Subsequently she pursued the study Health Sciences at Vrije University in Amsterdam. Following her Bachelor's degree, Kyma continued her academic journey by pursuing a Master's in Health Sciences, specializing in prevention and public health. However, her thirst for knowledge persisted, leading her to pursue a Master's in Vitality and Ageing (now known as the Master's in Health, Ageing and Society) in Leiden.

During her academic pursuits, Kyma contributed her skills as a caregiver in nursing homes. Her academic journey intersected with an internship at the National eHealth Living Lab (NeLL), an experience that profoundly influenced her trajectory. In 2019, upon completing her studies, she commenced her professional journey as a junior researcher within NeLL. She actively engaged in projects including one at the RIVM.

In September 2020, Kyma embarked on her PhD at NeLL, under the guidance of Prof. Dr. Niels Chavannes, Dr. Esther Talboom-Kamp and Dr. Anke Versluis. Also in 2020, she joined the TWIHC team of Saltro, later transitioning into Unilabs' Digital Innovation Team until the beginning of 2023. Here, she combined research with project management in international projects.

Driven by her academic achievements and professional experiences, Kyma envisions her role as pivotal in ensuring accessible and effective health care for all. Post-thesis completion, she remains steadfast in her mission to contribute towards this significant endeavor.

List of publications and presentations

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NHG wetenschapsdag 2023, oral presentation: 'Use and usability of Homelab: an online diagnostic self-service implemented at the general practitioner'

WeLL Symposium 2023, oral presentation together with Rosian Tossaint-Schoenmakers: 'Implementation of eHealth in daily practice; Evaluate and learn!'

eHealth conference series: the International Conference on eHealth Networking, Application and Services, 2022, oral presentation: 'Direct access for patients to diagnostic testing and results: A systematic review on eHealth and diagnostics'

WONCA,27th Europa Conference, 2022, oral presentation: 'Use and usability of Homelab: an online diagnostic self-service implemented at the general practitioner'

European Respiratory Society, 2021, oral presentation: 'The effectiveness of a pharmacy-based eHealth intervention for individuals with asthma and COPD'

International Conference on Emergency Medicine: technologies for future, 2021, oral presentation together with Esther Talboom-Kamp: 'Community based innovative digital care models in patient centered care'

WONCA 26th Europe Conference 2021, oral presentation: 'Direct access to diagnostic testing and result services'.