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A Cross-Sectional Study Identifying Medication Adherence Technologies (MATech) in Sweden Using Behavior Change Techniques

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Background: Poor medication adherence is a well-recognized problem, and behavior change techniques (BCTs) have shown promise in improving patient adherence to prescribed drug treatment. Through the utilization of medication adherence technologies (MATech), these BCT interventions could be delivered effectively in a person-centered way. MATech can be defined as systems, services or physical devices (hardware), with a digital component, used to support patients in their drug utilization. However, there is a lack of knowledge regarding their availability and to what extent they apply evidence-based BCTs.

Purpose: This study aimed to identify and describe MATech with BCT interventions available in the Swedish language.

Methods: A cross-sectional survey study was conducted in 2023. After identifying potential MATech developers by contacting umbrella organizations in the private sector, public agencies and regions, and conducting an app search, a survey was distributed to 381 potential MATech developers. Included MATech were in Swedish, used by patients, incorporated a BCT intervention, and had survey response from the developer. The survey was based on the BCT taxonomy and the framework of attributes from the COST ENABLE project, and included questions regarding BCT features. Following correspondence with 189 potential developers, 32 with products of interest responded to the survey, and 21 MATech were identified (12 standalone software and nine hardware solutions).

Results: Among the 21 MATech identified, nine were hardware and ten were specifically designed for a particular disease or medication. The majority of technologies incorporated BCTs of reminding the patient to take the medication (81%), information about the treatment (71%) and providing feedback on the monitoring of medication adherence or clinical outcomes (76%).

Conclusion: Swedish-language MATech employing BCTs are available, encompassing both hardware and software solutions. There is a need to enhance the visibility of these technologies, enabling patients to discover and utilize the support they provide.

Keywords: persistence, telemedicine, eHealth, mHealth, behavior intervention, adherence

Introduction

Medication non-adherence is a well-recognized problem in several patient groups. There are many factors influencing medication adherence related to the patient, socioeconomy, therapy, disease or healthcare system.[1,2] Problems with medication non-adherence could also have different solutions depending on the underlying causes; if there are problems arising in the patient-provider interaction, problems with medication acquisition, or problems with managing behaviors or routines in the daily life as a patient.[3] Patients are therefore in need of, not only person-centered support interventions such as individualized interventions according to the patient's preferences and needs, but also multifaceted approaches to support their medication adherence.[4]

The most successful interventions for improving medication adherence focus on behavior change techniques, which have to be personalized according to each patient's individual needs.[5–7] The behavior change technique (BCT) taxonomy[8] includes many BCTs, which could be targeted to improve medication adherence. These may be applied in physical communication between healthcare professionals and patient, or through the use of eHealth technologies. Such technologies can support medicines management in many ways, for example, in the healthcare meeting with remote

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consultations or information sharing, or the daily life of patients in their self-management of their disease.[9] Medication adherence technologies (MATech) are technologies used to monitor or support medication adherence and include mobile applications, web-based systems, telehealth, smart packages and dispensers, wearable devices and ingestible or motion sensors.[9–11] These technologies are either themselves detecting medication adherence, support delivered through a technology (eg video, text message or electronic information) or used for electronic patient self-report. The use of MATech has been suggested as an opportunity to optimize the use of medicines and increase the self-management capability of patients as well as increasing medication adherence.[12,13] Their support mechanisms are preferably delivered through behavior change techniques, and the BCT taxonomy has previously been used to evaluate medication adherence and MATech.[6,14–18] In 2016, Morrisey et al, categorized 166 mobile apps according to the BCT taxonomy and found BCTs in medication adherence apps to be few, and mainly focusing on reminders to take the medication.[15] Similar results were found by Ahmed et al, 2018, although Teo et al, found five to seven BCT per intervention to give the highest chance of success.[16,19] There are also differences between which BCTs are targeted and the success of the intervention. The most common successful adherence enhancing interventions using BCT included "Credible source" (communication from a credible source eg healthcare professional, in favour of taking the medication), "Instruction on how to perform the behaviour" (instructions on how the medication is to be taken in a correct way), "Social support (practical)" (advise, arrange or deliver practical help to take the medication), "Action planning" (detailed planning of how, when and where to take the medication eg electronic reminder), and "Information about health consequences".[19]

The availability of MATech to be used by patients and healthcare professionals is quite unknown and there is a lack of scientific studies on their effect and safety.[20,21] Previous studies on the availability mainly include mobile applications or evaluate a specific product. The lack of an overview of MATech including different types of technologies, not only apps, is primarily caused by the difficulty of finding the MATech. There is a dynamic market with many new products under development, and some technologies are used by healthcare providers, only distributed to selected patients, while other technologies are distributed through the open market and can be used on the individuals own initiative, or after recommendation by the healthcare provider. Since there are many stakeholders involved in the development, distribution and decisions on whether to use the technologies, it is difficult for both patients and healthcare professionals to know which MATech are available and possible to use, and it varies substantially between countries.

Sweden has a high level of digitalization, where patients have had access to their electronic medical records for over a decade, and in 2023, 81% of the Swedish population used internet-based healthcare services.[22,23] Sweden was also one of the countries with the highest availability of teleconsultations and remote refill of prescriptions according to a survey conducted in 38 European countries in 2020.[24] According to the *Eurofound (2022), Living, working and COVID-19 e-survey*, 47% of the Swedish population used teleconsultations the first year of covid-19 compared to 39% for the EU average.[25] Therefore, Sweden could be an useful example for describing the availability of MATech in countries with higher level of digitalization.

Since BCTs have shown to be effective in increasing medication adherence, it is also important to clarify which BCTs are applied in MATech, to meet the individual needs of the patient, and the scientific evidence behind the technologies.[16,20] An overview of MATech available in Sweden today would therefore provide a valuable basis for healthcare professionals and patients to enable decisions on which MATech to use with the subsequent aim to increase medication adherence and improve clinical outcomes.

This study aimed to identify and describe medication adherence technologies (MATech) with BCT interventions available in the Swedish language.

Materials and Methods

Study Design

A cross-sectional survey was sent by email to potential developers of medication adherence technologies (MATech) in November and December 2023. This survey was aiming to identify MATech available in the Swedish language and how these technologies could support medication adherence through BCTs.

The definition of the technologies included in this study was adopted from the EU funded COST ENABLE project definition[10] of MATech (medication adherence technology): "systems, services or physical devices (hardware), with at least one digital component, that can be used to support patients in their drug utilization". Other inclusion criteria were the availability of the technology in Swedish language, that it was available on the market, intended to be used by patients, supporting medication adherence through at least one BCT and that the developer was the respondent.

Population

The target population to identify available MATech were companies developing these technologies. For identifying and contacting potential respondents, three approaches were used: 1) survey distributed through umbrella organizations in the private sector, 2) emails to public agencies and regions, and 3) app search.

The members of four trade organizations were contacted: the Research-based Pharmaceutical Industry (LIF), Swedish MedTech, The Association for Generic Pharmaceuticals and Biosimilars in Sweden (FGL) and the Swedish Pharmacy Association.[26–29] Information emails were sent to all members of the industry organizations LIF, Swedish MedTech and FGL, while the chief pharmacist at the Swedish Pharmacy Association mediated contacts with persons in the pharmacy chains in Sweden.

National Public Agencies and Healthcare Regions

To include technologies developed by healthcare providers in Sweden, public agencies and the Swedish healthcare regions were contacted. The healthcare in Sweden is divided into 21 regions, which are individually responsible for the financing, purchasing and providing of healthcare services in primary, specialist and psychiatric care.[30] National public agencies in Sweden are state-controlled organizations that act independently to implement policies of the Swedish Government.

To find people with relevant knowledge in the 21 Swedish Regions, an email was sent to the regional contact persons at Inera, the digitalization company for municipalities and regions.[31] For the regions who did not answer or did not have a regional contact at Inera, emails were sent to people working with internet-based support in the regions.[32] Finally, emails were sent to the regional Drug and Therapeutics Committees or departments responsible for medication management in each region. The regions were asked if they have developed or if they provided any services or technologies to support medication use. All 21 regions replied to the email, and 10 of them with experience of MATech provided information.

A similar email was sent to 14 national public agencies. The agencies were chosen from a list of all authorities in Sweden and from a report written by the Swedish e-health agency based on their field of being involved in health, innovation or digitalization.[33,34] The information was sent to the info-email addresses except in one case, which had official contact information to the head of the e-health department. The agencies were asked if they knew of any services or technologies to support medication use. Ten out of 14 agencies answered the email, but only 4 provided any information since most of them did not know of any MATech. A list of included agencies can be found in Supplementary Materials.

App Search

App-searches were performed in November 2023. The top lists (consisting of the most popular apps in each specific category, between 30 and 200 apps per category) were reviewed, of both free and payment-apps, of the category medicine in Apple App Store and the category healthcare in Google Play Store. Additionally, the Swedish terms "läkemedel", "medicin" and "behandling" (drug, medicine and treatment) were searched for in these two app stores, no category chosen. The app descriptions were reviewed and apps were included if they had information in or about the app in Swedish and mentioned medication, adherence and/or monitoring in the information text. Apps were excluded if the information text mentioned that the only purpose of the app was fitness, if they only were aimed to be used by healthcare-professionals, in animal-health or if it was an app for video healthcare appointments only.

Through the search for apps, 115 apps were found. The apps were reviewed once again to exclude those not aiming to support medication adherence or self-monitoring. This was done by searching for additional information on the internet.

After the second review, 29 apps were excluded. Of the remaining apps, there were 67 developers, and 47 of them were contacted. The remaining apps had no contact details with any public email address, website or contact form to fill in on their website. For a flowchart of the app search see Figure S1.

Data Collection

The survey consisted of three parts: 1) identifying if the technology was a MATech and available in Swedish, 2) if the technology was supporting medication adherence through BCTs, and 3) other information regarding the intended users, technology features and scientific evidence. If the technology was not available in Swedish language or did not fit the definition of a MATech, the survey ended after part 1. The survey was developed based on the BCT taxonomy and the framework of attributes developed by the COST ENABLE project to be included in the medication adherence technology repository.[8,10] The questions selected regarding BCTs were chosen based on the most common features with BCTs found in apps and interventions, related to the BCT taxonomy, and medication adherence behaviors.[15,17] This included, for example, action planning, prompts and cues, demonstration of behavior and feedback on behavior. Access to information about treatment and where to find support are not themselves alone BCTs, but are included in the questions since in addition to other features they support the delivery of BCTs. No technologies with solely these features was included. Included BCTs and how they are related to the questions about medication adherence can be seen in Table S1. For an overview of the survey, see Figure S2.

The survey was made in REDCap electronic data capture tools hosted at Uppsala University.[35] Three people validated the survey. One of them was working with digital solutions at a pharmaceutical company, one was working at LIF and one was working with implementation science and health informatics. A think aloud technique was used, a method used to improve the validity of surveys.[36]

Potential developers were contacted through email including a cover letter and the request to participate in the study. A link to the survey with a personal password was then sent to the respondents. The link was either sent to them along with the cover letter or after answering that they wanted to participate. Reminders were sent about a week after receiving the first email, and a second reminder about one week later. Half of all the companies contacted (50%) answered the Email and 32 developers with products of interest completed necessary parts of the survey. The companies not answering the survey claimed that they either had lack of resources, lack of MATech or no persons with knowledge of the technologies in use. For 27 companies, it was not possible to find any contact information, resulting in them not being contacted. Potential developers were also found through snowball sampling by including a question aiming to find further technologies in the surveys and email replies. See Figure 1 for more details about the included developers and MATech.

Data Analysis

The collected data was exported to Microsoft® Excel for Microsoft 365 (Version 2310) and analyzed with descriptive statistics in tables and diagrams with counts of answers and means. First, all datasets were cleaned from empty responses, responses including only contact information and the selection done in part 1 of the survey. For the 32 completed surveys, the data were analyzed based on the inclusion criteria for the study. Two technologies should have been excluded in the first step by not being MATech, five companies did not develop the technologies themselves, three had only healthcare professionals as end-users and one did not target any BCTs. This resulted in 21 MATech included in the analysis, see Figure 1. Technology descriptions in Table 1 are derived from the survey, Email responses, and the technology websites.

Results

All 21 technologies identified in this study are listed in Table 1. The majority of technologies included between five and eight features to support medication adherence. The technologies analyzed included hardware with integrated software system, hardware paired with separate software (eg, a digital device and an app), and standalone software systems (eg, apps or web-based platforms). Among the technologies, five were hardware not specific to any disease or medication, while six were software systems that were also not disease- or medication-specific. Additionally, ten technologies were

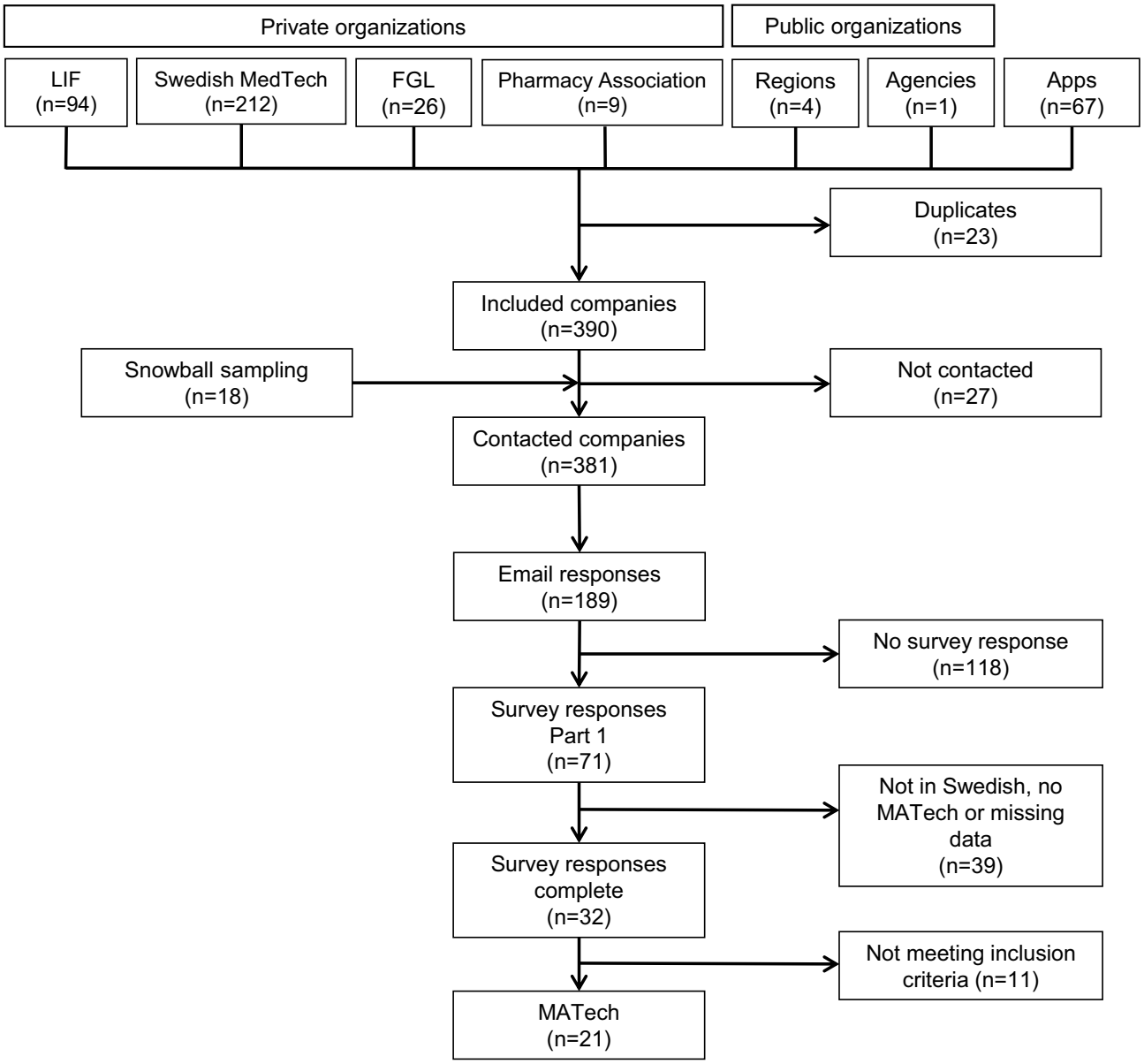

Figure 1 Flowchart of identification approach for potential developers and developers participating in the survey.

designed for specific diseases or medications, of which four were hardware. Seven of the technologies had to be provided by healthcare providers to patients and were therefore not commercially available to everyone.

Figure 2 illustrates how the identified technologies support medication adherence through BCTs, based on the survey responses. Most technologies incorporated the feature of reminding the patient to take the medication (81%), providing information about the treatment (71%), and offering feedback on monitoring the behavior of taking medication (medication adherence) or clinical outcomes (76%). Furthermore, all but one of the technologies claimed that it could be used to increase support from relatives (95%). Setting goals for the treatment was the least common feature in the technologies (29%).

Target users had been involved in the development of all technologies except for one (in addition, one respondent did not know). Approximately half of them, 12 technologies, were certified medical devices, and three claimed they were planning to apply for classification as a medical device. Five of the MATech did not collect any sensitive information,

Table 1 Identified MATech with Brief Descriptions of the MATech. HCP: Healthcare Professionals

Product	Developer	Description*	Provided by HCP	Specific Disease/ Medication
AsthmaTuner	Karolinska University hospital, MediTunerAB	App, hardware (lung function meter). Support in developing and optimize treatment plan, HCP can monitor patients at distance.	Yes	Asthma, COPD
CAMI	Exeltis Sverige AB	App. Reminders when to administer oral contraceptives, medical assistance from specialist.		Anticonception
Dosell	iZafe Group	Hardware. Drug dispensing robot, reminders on administration time, alert HCP on missed dose.		
Easypod, Growzen connect/ Buddy	Merck AB	App, hardware. Reminders, monitor medication and health data, HCP can monitor patients at distance, information about treatment.	Yes	Growth hormone
Elsa app	Elsa Science	App. Track symptoms, support in self-management, HCP can monitor patients at distance, log medications and understand how the treatment influence the disease.		Rheumatoid arthritis
Evondos	Evondos AB	Hardware. Drug dispensing robot, provide instructions and support on administration time, alert HCP on missed dose, send messages from HCP to patient.		
Genia and Antibiotikakollen	Upstream Dream Inc	App. Log medication intake and effect of treatment, share information with HCP.		Cystic fibrosis
Glooko	Glooko AB	App. Monitor health data, medication and activities, HCP can monitor patients at distance, reminders.		Diabetes
Healfy	Nordic Health Innovation AB	App. Self-monitoring shared with HCP.	Yes	
Healo	Empowered Health AB	App. Contact with HCP, information and monitor symptoms.		
HIPR	Medilevel AB	App. Monitor medication, health data and effects of treatment, shared with HCP.	Yes	ADHD
SENO	Medilevel AB	App. Monitor medication, health data and effects of treatment, shared with HCP.	Yes	Antidepressants
Medicin-instruktioner.se	Medicininstruktioner Sverige AB	App. Demonstrate administration of medications by instructional videos.		
MedimiSmart	Medimi AB	Hardware. Drug dispensing robot, reminders on administration time, alert HCP on missed dose.		
Mepill, Medose	Mevia	App, hardware. Filled dose packages, log when a dose is taken.	Yes	
Optilogg	Optilogg	App, hardware. Monitor health data and includes advice for self-management.	Yes	Cardiovascular diseases
Pilloxa	iZafe Group	App, hardware. Design and functions in the app are developed with the HCP. Reminders, information about treatment, motivation features, monitoring of health data and medication.		
Påminnelsetjänst	Apotek Hjärtat	App. Sends reminders when it is time to dispense medications or renew prescription.		

(*Continued*)

Table 1 (Continued).

Product	Developer	Description*	Provided by HCP	Specific Disease/ Medication
Symptoms	Symptoms Europe AB	App. Monitor health data.		
Visuera Information Manager	Visuera Integration AB	Monitor medication and send reminders when to administer medication.		
www.mm-info.se	Janssen-Cilag AB	Website. Information and support about disease and treatment.		Multiple myeloma

Note: *Technology descriptions are derived from the survey, Email responses, and the technology websites.

and 16 had, in some way, acted to prevent unwanted access to collected data. Eight were interoperable with an existing IT-system in healthcare.

Two-thirds of all products (n = 14) were developed based on scientific evidence; among these, ten had conducted their own studies, eight were based on previously published scientific articles and seven used established scientific theories. In 16 of the products, functions could be customized, and the visual appearance could be changed in eight of them.

Discussion

In this study, applying a comprehensive search strategy including contacts with a large number of commercial companies, healthcare regions and national agencies, we found 21 digital technologies available in the Swedish language to support medication adherence with BCTs. The MATech targeted different numbers of behavior change techniques with four products targeting all the BCTs included in this study, and only one technology was excluded for not including a BCT. Support for relatives was the most commonly reported feature, followed by: sending reminders at planned administration time, providing feedback from monitoring of the behavior of taking medication or of clinical outcomes, and providing information about the treatment.

The findings that the most common target interventions were reminders, feedback on monitoring and information about the treatment align with previous studies on MATech where education, monitoring and reminders were frequent features.[37–39] Social support, on the other hand, has not been reported as a common intervention in MATech previously, even, a systematic review from 2020 including digital interventions for medication adherence in hypertension highlighted that social support as a target intervention was lacking in most digital tools to support medication adherence.[5,15] This discrepancy could be caused by different definition of social support, support from relatives and in this survey, support for relatives aiding patients.[5] It could also be due to features not explicitly reported in the MATech information and therefore lacking in content reviews, or that the technologies have developed in the past years in line with the increased focus on patient-centered care.[40] It is important to note that these BCT-features have the possibility to change behaviors to promote medication adherence, but the success is highly dependable on user interaction and experience.[41,42]

For a technology to be effective and utilized, it is important to be able to customize the technology according to personal preference.[41,43] Though this was not the focus of our study, we included a few questions regarding customization and found customization possible in 16 of 21 MATech, but visual appearance could only be changed in eight of them. This could impact the usability from the patient's viewpoint, and is important for long-term use of the technologies. Customization could also be related to eHealth literacy, where older patients have shown to be disadvantaged.[44]

More than half of the found products were classified as medical devices, which is higher than found in other app searches, but since our study also included hardware, which is more commonly classified as medical devices, it was not surprising.[45] A medical device must follow the regulations for medical devices and meet the requirements to be CE-marked, which implies an assurance that the product is safe to use even if there is no scientific evidence of its efficacy.[46] There is, generally, a lack of scientific evidence, or lack of documentation of scientific evidence for medication adherence

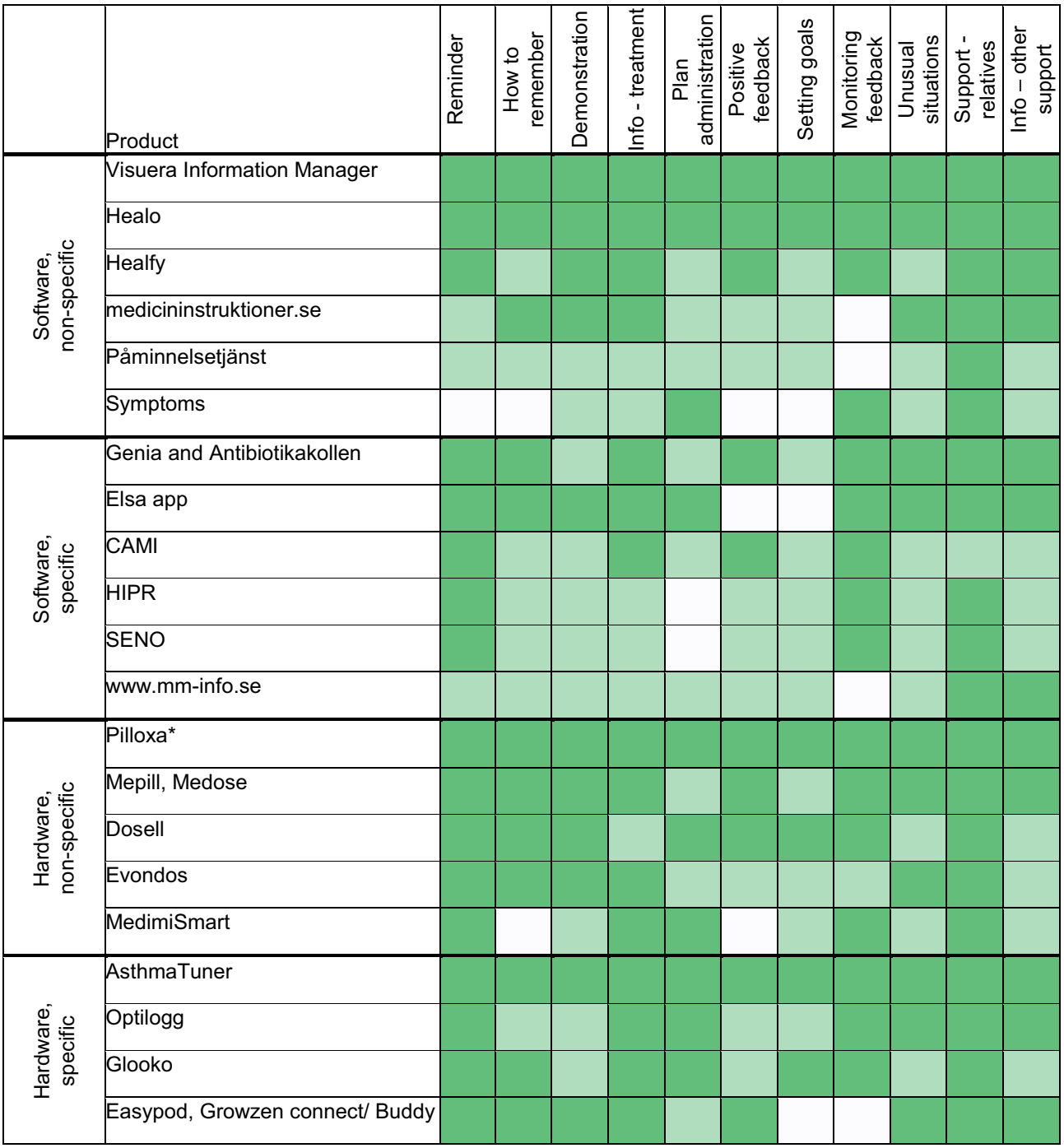

Figure 2 Behavior change techniques included in the MATech; dark green =features included, light green = features not included, white =not reported/ unknown. Specific; specific for a disease or medication. Complete questions and BCTs can be found in Table S1. *Could also be used without the hardware, software only.

apps.[16] It can be contrasted with the rigorous process of introducing pharmaceuticals on the market with strict regulatory requirements for market approval as well as further requirements by HTA-agencies and payers to fund the new drugs.[47] In our study, we found most MATech to be developed based on some level of scientific evidence; ten had performed scientific studies themselves, and eight had some scientific theory or previous research as the foundation. Nonetheless, for eight of the technologies, the survey responder did not know if the MATech was based on scientific evidence, and only three MATech was reported as not developed based on scientific evidence. It is also important to note that the scientific evidence was not always publicly available. We could only find published scientific studies for four MATech

(19%), even if 13 referred to conducted studies on their websites, and ten reported to have conducted their own studies. Even if these results support a more scientific development of technologies than previous studies have found, it does not say if these scientific studies were focusing on the patients experience and usability or efficacy. Furthermore, it is not enough to have developed the technologies based on scientific evidence without sharing the scientific documentation. Dissemination of this documentation is very important for independent validations of MATech quality and important for incorporation in the healthcare.[9] A positive finding, though, was that 19 MATech had been developed together with the target users, representing a significant proportion. In contrast, Tabi et al, found that only 14% of 328 mobile apps were developed with healthcare providers. This discrepancy may be attributed to a lack of documentation regarding the scientific evidence used by the researchers for the content review.[48] Eight of the MATech were interoperable with IT-systems in healthcare in Sweden, which enables sharing of data between patient and healthcare provider, co-creating of health data.[49,50] Such solutions have the potential to enhance patient involvement in healthcare and research; however, they may also raise concerns among patients, potentially creating an atmosphere of perceived control.[13]

There are many studies on disease-specific digital interventions to enhance medication adherence.[51,52] Of the 21 MATech identified in our study, ten had a specific target disease or medication and eleven could be used regardless of disease-type. Specific technologies are usually more tailored for the specific disease and this could increase usability but with a growing group of patients with multimorbidity and polypharmacy, it is not sustainable to over time have one technology for each disease or medication.[53] Future research should therefore focus on evaluating efficacy, safety and patient preferences on MATech, both overall and in selected patient populations. In this study, many developers reported using data from conducted studies when developing the technologies, but it is important that the documentation is publicly available and possible to evaluate. Several studies have reported about low quality of studies evaluating technologies, and there is thus a need for more and better research.[7,12,54] The accessibility of MATech was not assessed in the present study, but many technologies were only available for certain patient groups and through certain types of healthcare. Consequently, there is room for further development, expanding the target for technologies to other populations and settings. To make this possible, it is important with scientific evidence showing that the technologies are cost-effective and contribute to a patient centered healthcare of high quality.

Strengths and Limitations

This cross-sectional survey study to identify MATech in Sweden has several strengths. It is the first study to show specific technologies available in Sweden to support medication adherence, and could therefore assist both healthcare professionals and patients in gaining knowledge about these technologies. This is important since knowledge of the technologies is essential for them to be implemented. Patients may be unaware of which BCTs are necessary to enhance medication adherence. However, utilizing this guide to common BCTs found in MATech can enable them to select MATech options that incorporate multiple BCT features, thereby receiving greater support for medication adherence. Additionally, developers of MATech can leverage this study to further develop their technologies to be integrating more BCTs and prioritize the dissemination of scientific evidence about MATech with the public. Identifying MATech through several different approaches by contacting umbrella organizations, authorities, companies, using snowball sampling, and in addition to this performing an app search resulted in contacting 381 potential developers and finally a variety of technologies including both hardware and software, which gives a broad picture of the landscape of MATech in Sweden today. Previously performed app searches done in the field might have been more comprehensive; using more search terms, including terms in English, but they have only included mobile apps, not often hardware. By implementing a Swedish-language app search, we could assess the technologies actively utilized in a specific country, considering that the majority of apps are in English and not universally accessible due to the language barrier. Mapping technologies available in Swedish is important for the patients who need these technologies today. Further strengths include developing the survey based on previous research; the BCT taxonomy as well as the framework of attributes developed by the COST ENABLE project.[8,10] The survey was piloted with three key informants from different fields and sent out by email, giving the respondents an opportunity to ask questions regarding the survey if needed. Moreover, obtaining survey responses directly from developers enhances the validity of the answers compared to relying on external evaluations.

However, there are also some limitations. The survey could have been more rigorously validated. The purpose of developing the survey and articulating concrete questions, rather than disseminating the entire BCT taxonomy, was to provide respondents with clarity regarding the actual meaning of these diverse BCTs. However, it is acknowledged that this approach may have inadvertently led to potential misinterpretations. There is also always a risk of respondent bias or observer bias, especially in this case when informants answer the survey on behalf of their company. Self-reported BCTs increased the risk of misclassifying BCTs, but since it was not possible to get access to all MATech for evaluation, self-reported data was necessary. Additionally, there is a potential risk that the survey-responder was not the optimal informant to answer certain questions, leading to a high prevalence of "I don't know" responses, particularly in inquiries related to scientific evidence.

There is a difficulty in sending out a survey in a subject, which could be difficult to define. "Medication adherence technologies (MATech)" as a definition, is not clearly established, and even the term "medication adherence" is sometimes difficult to define. Therefore, other words were used when describing what the technologies targeted in this study, such as "supporting medication use". These different terminologies could have affected the number of potential developers who answered the survey, and also inflicted on the results in this study, if we are missing responses from many MATech developers.

The search terms in the app search were few compared with other app searches in the field including between nine and 82 search terms.[15,16,45] However, we aimed to find apps available in Swedish, therefore not necessarily needing English terms, although we could have increased the number of terms in Swedish. The terms used in our app search were wider than the studies using many terms.[45]

Another limitation is the risk of missing technologies. The difficulty of finding the potential developers due to non-public information about technologies led to a high number of potential developers being contacted without being the target group for answering the survey. Some companies replied that they did not have time or resources to participate in the study. This could either indicate that companies belonging to the target population were not included but could also mean that these companies did not have a MATech, and thus were not part of the target population. Nonetheless, this suggests that there are other MATech available on the Swedish market than the ones found in this study. Due to the fast development in this field, it is also possible that newer MATech are under development.

The majority of MATech were found through the umbrella organizations in the private sector (n = 10) and through the app search (n = 8), with an overlap of three technologies. Only one of the included MATech was found from public sector, but this technology was also found through the private sector. The snowball search method contributed with four not previously found MATech. This underscores the inadequacy of relying solely on app searches when identifying MATech, as more than half were discovered in other ways. However, it is noteworthy that the outreach to public agencies and healthcare regions yielded limited additional information. This emphasizes the limited awareness and implementation of MATech in healthcare today. Currently, few technologies are reimbursed throughout Europe, and only two of the found MATech are reimbursed in Sweden.[55–57] Although, including umbrella organizations in the private sector was necessary for a comprehensive identification of available MATech. There are initiatives with specific health app libraries, which we did not include in the app search. To our knowledge, this is not in use in Sweden today and was therefore not included.[58,59]

Finally, although this study only includes MATech available in Sweden, we believe the results to be relevant for other countries with a high degree of digitalization in healthcare. The MATech available for all patients and found online or in app stores is most likely also available in other countries, and those available online and in English could be used in any country. What might be more unique in Sweden are the MATech provided by healthcare organizations, which might differ more between countries, depending on their degree of healthcare digitalization and digital knowledge, but also a range of other factors related to culture and views on person-centered care and patient engagement.[25,60]

Conclusion

Swedish-language MATech employing BCTs are available, encompassing both hardware and software solutions. The majority of technologies included between five and eight features to support medication adherence, and most are reported to have been developed based on scientific evidence, even if the transparency in the public information is lacking. There

is a need to enhance the visibility of MATech for both healthcare and patients, enabling patients to discover and utilize the support they provide. This study assists patients and caregivers when choosing a MATech, giving an overview of available technologies and included features with BCTs to support medication adherence. This field is constantly changing, requiring a continuous update with currently available technologies and ongoing developments.

Abbreviations

BCT, Behavior change techniques; FGL, The Association for Generic Pharmaceuticals and Biosimilars in Sweden; HCP, Healthcare professionals; LIF, The Research-based Pharmaceutical Industry; MATech, Medication adherence technologies.

Ethics Approval and Informed Consent

This study was approved by the Swedish Ethical Review Authority, ID 2023-02812-01.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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