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Medication Apps – A Systematic Search and Classification

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Abstract. The landscape of mobile health applications is evolving rapidly. This includes a growing set of medication-related health apps. Keeping track of the functional diversity in medication apps is a challenge for both practitioners and regulators, limiting the scope of innovative use of digital technologies in healthcare service delivery. In this paper, we present the results of a systematic search and functional classification of medication apps. We combine this with a discussion of the current and future landscape of regulation and reimbursement decision-making. We show that a majority of apps offers a cluster of functions including medication information, interaction checks and/or medication plans. The number of apps in the functional categories most affected by the Medical Device Regulation (identification, dosage, monitoring) is still low. This suggests that there is a window of opportunity for public sector decision-making on quality criteria.

Keywords. mobile applications, telemedicine, mHealth, mobile health, medication adherence

1. Introduction and state-of-the-art

1.1. Background

The field of smartphone applications in the health space has developed rapidly in the past decade. According to market studies, the number of health apps stood at around 300,000 in 2017 [1] [2]. Between 10 and 24% of these apps are in the area of medication, with a specifically strong focus on medication adherence and medication information [2] [3]. The starting point for the present study is the challenge for professionals, users and regulators alike to keep track of the app landscape and relevant developments. Health professionals need to decide what tools they might use in their work or what they might wish to recommend to their patients. Patients need guidance as to what offers are relevant and safe. Regulators need to know about the functionality offered by health apps in order to decide on reimbursement decision-making, necessary forms of quality control and digital health literacy campaigns.

Decision-makers in a number of countries in Europe and beyond are currently developing or experimenting with governance models for health apps (cf. initiatives like the mHealth Hub supported by the EU, ITU and WHO). While the EU's Medical Device Regulation changes the rules of the game in terms of market access, an additional set of

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questions needs to be answered to decide on the integration of apps in public sector healthcare delivery. Having a clear and up-to-date overview of the functional diversity offered by health apps is key in this regard.

1.2. State-of-the-art in the classification of health apps

There is an increasing number of meta-analyses on the health app space. These publications try to provide structure and guidance by proposing a variety of classifications of health apps. Some of the proposed classifications focus on functions of health apps. Terry [4], for instance, distinguishes between apps that provide access to health data, apps that complement medical devices, apps for the monitoring of disease, apps for fitness and wellness, and apps used in a diagnostic or therapeutic context. The German Network for Health Service Research (DNVF) [5] distinguishes seven support functions that apps can provide: inform, measure, document, plan/remind, share (data), advise, motivate. In a publication by Knöppler et al. [6], the Bertelsmann Foundation proposes to distinguish seven so-called functional areas: strengthening health literacy, analysis and knowledge, indirect intervention, direct intervention, documentation, organization/administration, and care supply.

Other classifications combine the functional perspective with additional dimensions. Albrecht and von Jan [7], for instance, propose to also take into account the context of application, distinguishing between: information, education, administration, assessment, care/intervention, support, research, entertainment. Lucht et al. [8] add the perspective of user groups, distinguishing apps for healthy citizens, patients, relatives of patients and health professionals.

While the distinction of user groups is definitely valuable for the analysis of medication apps (distinguishing patients and professional users), it is unclear what the functional spectrum of medication apps is and whether or not it is sufficiently represented by meta-analyses like those mentioned above.

There are currently only a few meta-analyses looking specifically at medication-related apps and their functional scope. Ahmed et al. [9] are an exception. They focus on medication adherence apps and present a taxonomy of adherence strategies distinguishing reminder systems, education approaches and behavioral approaches (gamification, tracking, monitoring). Their analysis of intervention strategies for medication adherence could be used as the basis for a functional classification. However, it would not cover the entire range of medication-related apps. The health app portal HealthOn [10] takes a broader look, distinguishing apps for medication information, adherence, patient safety and logistics. However, the search methodology only covered one app store and only German-language and free apps, resulting in a relatively small sample of 79 apps.

In the present study, commissioned by the Austrian Federal Ministry for Social Affairs, Health, Care and Consumer Protection, we took a different approach, designing a systematic search of medication-related health apps in both major app stores, allowing for a classification according to functions and user groups.

2. Methods

Apart from non-systematic literature reviews concerning app classification systems, app quality assessment approaches and the regulatory framework, the empirical foundation of the present paper is a systematic search of relevant apps.

The systematic search was carried out between September and November 2019 in both the Apple iOS store and the google play store. Given that we searched in the Austrian versions of both stores, the search terms were in German. We had tested in advance whether German search terms would also return English-language apps and confirmed that this is the case. The following search terms were used:

- Medikamente
- Medikation
- Arzneimittel

In another attempt to clarify the validity of our approach, we have tested two English search terms 'medicinal products' and 'medication'. The resulting sample showed a high degree of overlap with the German language search results. Considering this and the limited resources for our study, we chose to limit the search to the German terms.

Apps were first categorized by the individual researchers based on information provided in the app stores or, if these were insufficient, either tested or followed up through research. Unclear cases were reviewed in the team. Duplicate hits within the same store (i.e. matching app and developer names) were excluded ex ante. All other results were documented in an app list. From this list, between-store duplicates (i.e. apps found both in the google play and iOS stores) were removed as were apps meeting one of the following exclusion criteria: purpose of app unclear; app focusing exclusively on price comparison; apps focusing on herbal products and homeopathy; general encyclopedia-type apps without medication focus; symptom checker apps; diary apps; apps for the organization of patient groups; physiotherapy apps; event apps; apps promoting a health lifestyle; other thematically irrelevant apps. The following **Figure 1** summarises the systematic search process.

In the analysis of the search results, we opted for a bottom-up approach. Instead of using one of the above-mentioned existing classification systems and just assigning apps to the given categories, we developed functional categories out of the material we screened. This was an iterative process with new categories being added whenever indicated by the search results.

3. Results

The result of our systematic search and analysis of medication-related apps is a classification by app function and user category. It encompasses 13 categories represented in **Table 1**. We propose to distinguish between apps for patients, apps for health professionals, and apps that can be used by both these user groups.

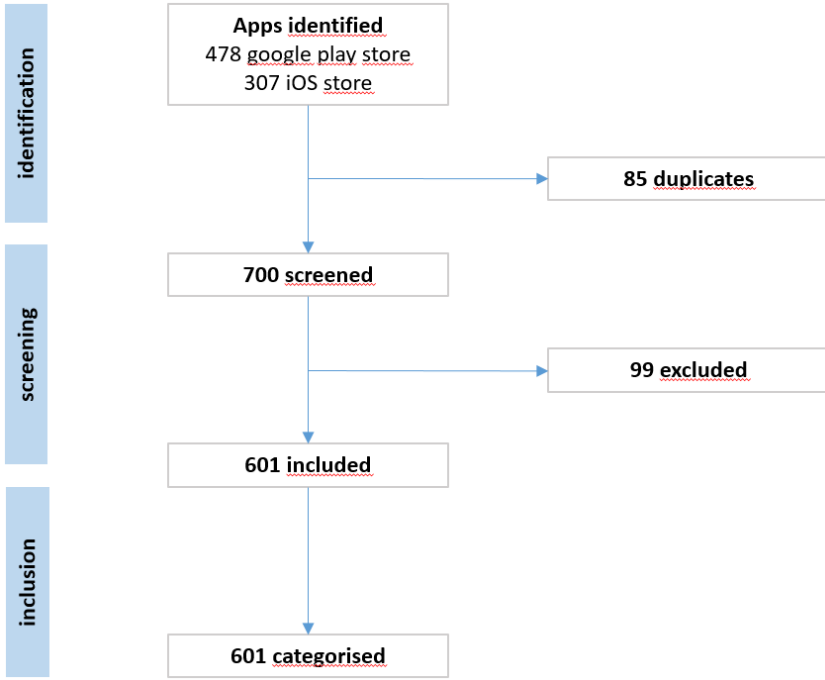

Figure 1: Systematic app search - flowchart

Table 1: Medication app classification - user categories and functional classes

Patients	Patients and health professionals	Health professionals
Digital medication plans	Medication information	Medication dosage
Medication effects monitoring	Interaction checks	Therapy and prescription advice
Pill checkers	Emergency information	
Feedback to producer/agency	Reimbursement information	
Online pharmacies		
Medication management at home		
Medication donation		

3.1. Apps for patients

The most frequently applied category of apps focuses on helping patients in managing their medication. Users can, for instance, log medications they take, specify recommended dosage and schedule reminders.

A related functional cluster of apps offers monitoring the effects of medication, e.g. by logging patient-reported outcomes (in addition to medication taken). One app also illustrates the relation between medicinal product substances and DNA variants influencing effectiveness. Some apps communicate with medical devices like smart inhalers in order to track intake and effects.

Pill checkers offer patients the opportunity to identify medication whose packaging might have been lost. Typically, these apps work by taking a picture of a pill, uploading

the image to some server-side image analysis software and returning information on the identified medication.

A small class of apps offers patients to report feedback on a specific medication and its performance to the producer. This helps pharmaceutical companies to learn about the side effects and/or performance of their products (also in terms of real-world data used for post-market surveillance). It can help patients to learn about other users' feedback on a specific product. In one occasion, there is also the opportunity of reporting side effects to the responsible market regulation agency.

The category of online pharmacy services, on the one hand, encompasses the stores of pharmacies operating exclusively online. On the other hand, there is also a large number of apps from individual pharmacies offering information (opening hours, etc.) or expanding their regular service at the pharmacy's physical location(s).

A number of apps focus on supporting users to manage medicinal products they have at home (making sure there is enough stock of relevant products, etc.). There are also a few apps trying to reduce the amount of unused medicinal products going to waste by offering donation opportunities.

3.2. Apps for patients and health professionals

The most frequent app category in our analysis concerns medicinal product information. This can include information on substances and medicinal product brands, information on dosage and intake, patient information leaflets, side effects, or warnings (product or substance-specific, or information under what conditions not to take the information).

A related category concerns apps offering interaction/incompatibility checks or information on possible intolerance. In most cases, this is combined with more general medication information.

Emergency information apps offer the opportunity to specify emergency contacts, and relevant personal data (intolerance, etc.). Some apps also allow to call emergency services directly out of the app.

Reimbursement information apps inform about what medicinal products are available for clients and sometimes also allow to directly file for cost reimbursement.

3.3. Apps for health professionals

There is a number of apps supporting physicians in calculating medication dosage. Another group of apps actually provides therapy and prescription advice. We did not identify so-called computerised physician order entry (CPOE) apps where physicians can directly prescribe medication via the app. The reason for this might be the missing technical infrastructure in the German-speaking health systems as well as the proprietary nature of possible mobile app solutions of specific software vendors.

3.4. Functional scope

The main goal of our classification work was to show the functional breadth of the current medication-related app landscape. As we have seen, this ranges from simple information provision to apps that establish and sophistically exploit two-way communication channels, the integration of smartphones into people's everyday lives or the potential of machine learning and data analysis for treatment support.

The following chart shows the distribution of the 601 apps over the various functional categories.

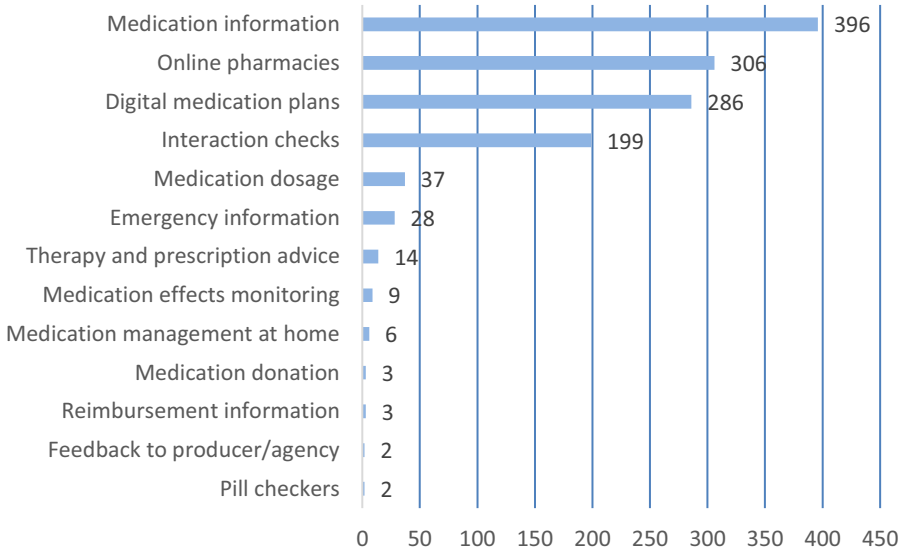

Figure 2. Apps per category

Almost two thirds of the categorised apps fall within the medication information class, followed by over 300 online pharmacy apps, almost 300 medication plan apps and around 200 apps offering interaction checks. All other classes have a relatively low numbers of apps. In our analysis, each classified app can serve more than one function, i.e. fall in more than one category. The largest cluster of apps offers both medication information and online pharmacy services (277 apps). 183 apps combine medication information, medication planning and online pharmacy services.

4. Discussion

Compared to other approaches to the classification of health apps and medication-related apps in particular [9], we have opted for a broad search strategy, both in terms of the sources and the thematic scope. Looking beyond medication adherence, we have identified categories like medication identification, management, dosage and effects monitoring that are not described in detail elsewhere [10]. More importantly, we have confirmed that the number of medication-related apps going beyond e-commerce, diary-like functions built on user-provided data, or generic encyclopedia-like information is still low. This is important in the context of the EU's Medical Device Regulation[2], which introduces stricter market approval standards for medical devices, including for software-as-a-medical-device. Apps calculating medication dosage or interactions or analysing medical images will be considered a medical device in the future. Depending

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0745

on the risk class, software developers will have to go through specific conformity assessment, vigilance and post-market surveillance activities, in many cases including the requirement for clinical evaluation. Currently, there is only a small number of apps that are considered medical devices[3]. While the MDR might change this situation, the various transition periods suggest that it might still take a few years for the new regulations to become visible to the users. Consequently, neither professionals nor laypeople can rely on the CE sign on medication-related apps as an indication of quality.

How then, can users assess the quality of an app in an increasingly large market? With market access still being largely unregulated, another possibility is to consider reimbursement decision-making. However, there are few countries where a health professional could prescribe a specific medication plan app to a patient. Germany has recently started to go in this direction with the Digital Healthcare Act, DVG. Countries like the UK opt for public authority sanctioned lists of recommended health apps (with the NHS App Library).

In the middle ground between market access regulation and government reimbursement or promotion are quality assessment tools for patients and health professionals. The patient safety platforms of Austria, Germany and Switzerland, for instance [12], offer a checklist for individuals interested in critically question the health app of their choice. With support from the German Health Ministry, Bertelsmann Foundation and Fraunhofer FOKUS [13] have developed a set of health app quality criteria. eHealth Suisse has published a catalogue of nine app quality criteria [14]. And there is quality scales like the Mobile App Rating Scale (MARS) [15] that propose dimensions for the critical evaluation of apps. These tools are also relevant for health professionals and institutional users in the health sector. These can, however, also increasingly rely on the outputs of discussions on health app quality in professional societies, e.g. the statement of the Association of the Scientific Medical Societies in Germany [16].

Software developers (as well as institutional evaluators) can also rely on a number of tools: First, authorities like NHS [17] or the Haute Autorité de Santé in France [18] have published information on evidence requirements for their assessment of health apps. Secondly, there is certification opportunities and Codes of Conduct or Practice, e.g. the EU's proposed Privacy Code of Conduct on Mobile Health Apps [19] or ISO/AWI TS 82304-2 on Health software, which is currently under development and aims to include a Code a Practice.

For countries that have not decided yet on how they want to structure and/or facilitate the use of medication apps or health apps in general, the number of apps as well as the increasingly sophisticated use cases (and underlying business cases) suggest there is some urgency. Both patients and health professional users will require guidance for an appropriate use of the available apps. The transition period towards the MDR and the ongoing efforts in other countries and at EU level (e.g. through projects like the mHealth Hub) indicate that there is still a window of opportunity for public sector decision-making.

[3] https://apps.healthskouts.com/ lists around 100, last access: 10.2.2020.

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