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Digital Transformation of the Mobile Connected Pharmacy: A First Step Towards Community Pharmacy 5.0

Abstract

Objective: Community pharmacies have made significant advances in digital technology; however, mobile systems are only emerging in this sector and mostly focusing patient-centric connections. This study reveals a case of digital transformation in a mobile connected pharmacy, balancing efficient pharmaceutical services and digital innovation. A mobile connected pharmacy solution (mPharmaCare) is developed for a community of near 100.000.

Methods: The first stage includes a bibliometric analysis and a structured literature review of the mobile connected pharmacy. In the second stage, action research was conducted to evaluate mPharmaCare adoption. A dual organizational structure was tested to cope with innovation and efficient exploration of pharmacy services.

Results: Community Pharmacy 5.0 is an inspiring vision that will take advantage of mobility. However, there are tensions between the core pharmacy business and the new technology layers of community connections. Community pharmacies require both client-centric and community-centric approaches to achieve individualization of patient care and horizontal and end-to-end digital integration of pharmacy data.

Conclusions: Digital transformation can remove silos in the community pharmacy. Creating an - internal or outsourced - innovation division may be suitable for medium and large community pharmacies. Moreover, pharmacies must consider shifting to a product-service system offer, deploying synchronization mechanisms with different stakeholders.

Keywords: Digital Transformation, Product-Service Continuum, Community Pharmacy 5.0, Mobile Connected Pharmacy

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Introduction

Community pharmacies are vital touchpoints to implement effective health policies. Their value as providers of optimized care [1] has shifted from pure physical product suppliers (e.g., medicine and medical devices) to a layered modular architecture [2] that also perform clinical analyses, support other organizations (e.g., compounding and support to elderly care), and deliver health guidance to local populations. The service expansion to fitness training, nutrition support, and general healthcare guidance is now on the agenda of many pharmacy owners when competition increases [3]. Pharmacists are already intensive users of information technologies [4]; however, the real capacity of digital transformation with mobile apps in "connected community pharmacy" is still in its infancy [5], and practical cases are rare in the literature.

Pharmacy information systems may include "medicine labelling, patient medication records, decision support for drug interactions and other warnings, stock control, ward inventory management, order processing and functions to support pharmacy manufacturing processes" [6]. These systems have been widely studied from the perspective of pharmacy staff, for example, adopting barcode scanners [7] evaluating users satisfaction [8] or using decision support [9]. More recently, they are also "online" [10] and "mobile", extending the pharmacy interaction using web portals and smartphone applications [11]. However, many studies address the context of hospital pharmacies (e.g., [12]) and, when applied to community pharmacies, it is necessary to go "beyond the reminder (…) to improve patient outcomes" [13].

Pushing the boundaries of digital integration in physical products, as happens in current pharmacy practice, is one of the most challenging tasks for this sector. The goal is to

develop new value propositions using digital technologies [14] to integrate products and services that offer more than the sum of the parts. The inspiring concept of product-service systems that emerged in the industry can be adapted to this purpose, aiming at a joint offer that integrates different phases of the product lifecycle (from manufacturing to disposal), aiming at sustainability [15].

The mobile community pharmacy promises to transform the entire medicine supply chain, influencing the global space of mobile health (mHealth) policies and solutions. Therefore, the following research objectives are addressed in this paper:

RO1: Identify key research areas in the digital transformation of community pharmacies;

RO2: Develop a mobile connected pharmacy solution (mPharmaCare) and evaluate the potential changes in professional pharmacy services.

The remainder of this paper continues with the background of this research, followed by an analysis of relevant literature. Next, the action research approach [16] is explained. Afterwards, the design and development of mPharmaCare are presented, followed by the discussion and lessons learned. The paper closes by stating the study implications, limitations, and future research opportunities for the mobile connected pharmacy.

Background and Study Motivation

The fourth industrial revolution (Industry 4.0) is a global initiative of industry transformation using digital technologies, for example, the internet of things, big data, cloud, mobile systems, simulation, or augmented reality. The technological portfolio is vast but, according to [17] the main motivations to change are (1) individualization of production, (2) horizontal collaboration in collaborative networks, and (3) end-to-end

digital integration. More recently, the term Industry 5.0 also emerged in healthcare literature, showing a human-centric transformation of business using digital technologies and personalized products [18]. The "5.0" movement is now a priority for the European Commission that goes "*beyond efficiency and productivity as the sole goals, and reinforces the role and the contribution of industry to society*" [19].

The vision of "Community Pharmacy 5.0" is appealing. On the one hand, community pharmacies are human centric organizations with essential societal value in healthcare [1], where the concept of connected pharmacy (with multiple stakeholders links) is a central pillar [5]. On the other hand, the pharmaceutical services are not yet fully exploring the potential of digital technologies or prepared for the significant changes ahead. Community Pharmacy 5.0 is an ongoing transformation of the pharmaceutical service supply chain that uses digital technologies for highly personalized healthcare, producing a new product-service system[15] offer to the market, simultaneously generating data to different stakeholders, moving beyond efficiency.

Being connected [5] is the primary purpose of a Portuguese community pharmacy (FS) addressed in this research. FS has fourteen employees in two regions and a 2,6M€ turnover. Their investments in digital transformation started in 2015 with national and European co-funded projects, which is rare in their sector. Several pilot projects included Internet-of-Things to monitor health parameters, QR labelling of their compounds, and developing a public database of medicines, symptoms, and initial guidance to users.

On the one hand, mobility restrictions that increase with the age of the population and global pandemics like we are facing with the new coronavirus (2019-nCOV), demand for different forms of interaction, and, sometimes, limited social distance. On the other

hand, proximity [20] and resilience in healthcare supply chains are essential to keep the population informed and healthy. Technology is essential, but not enough to manage the "continuum" of multiple touchpoints in community pharmacies, where customer segments are so vast that they may, in many cases, be represented by a single customer.

FS already takes advantage of pharmacy information systems, online presence, and e-commerce websites. More recently, the pharmacy owners knew about the fourth industrial revolution and the emergence of Health 4.0 or Medicine 4.0 concepts. More specifically, FS wanted to include mobile systems to support business growth (new services to the community such as fitness classes, counseling, and health programs) and improve their interaction in the community. However, FS is aware of the difficulties of including new technologies in daily practice (e.g., the cost-benefit of more time spent in data inputs and processing). It is crucial to balance the priority of pharmacy care with the constant changes in their services and competitive environment. The capacity to balance the exploration of innovative technologies and the optimum exploitation of existing resources in organizations is crucial [21].

For the scope of this paper, we adopt the term mobile connected pharmacy as *the decentralization of professional pharmacy services using mobile technologies in specific service touchpoints that optimize the care of each individual, obtaining synergies from all the stakeholders*. It is the first step towards the patient centric digital transformation of the community pharmacy (5.0). Action research [16,23] was selected to address this challenge at FS.

Literature Review

The review process following the guidelines presented by [24] is presented in Figure 1.

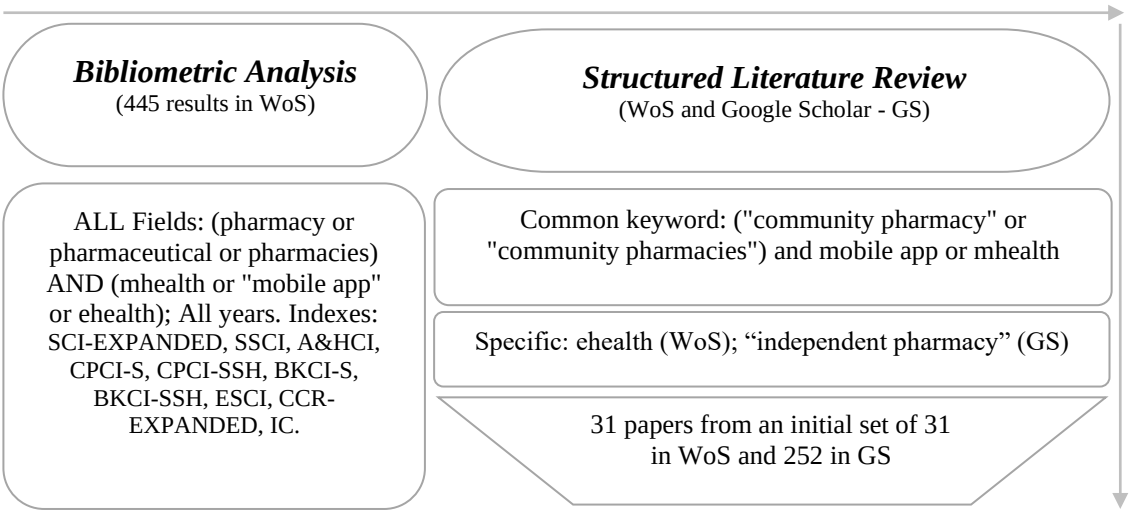

Figure 1. Analysis and assessment of key literature for the mobile connected pharmacy.

The literature analysis encompasses two distinct steps. First, an overall evaluation of studies published in Web of Science (WoS). A total of 445 papers were analyzed using VOS Viewer tool [25], identifying key clusters. Second, a deeper evaluation of 31 representative studies of the clusters using Mendeley to classify each paper (in English, peer reviewed, mobile related, excluding electronic prescription; when multiple papers represented the same cluster, the authors selected the first in the search results).

Pharmacy Care in the Complex Network of eHealth

The 445 results found in the WoS database include 295 articles, 74 proceedings papers, 51 reviews, and 36 other types (e.g., early access, editorials). This selection shows an h-index of 29 and 8.9 average citations per item with a significant increase since 2014 (129 – 1177). Figure 2 presents the main clusters and links found in the literature.

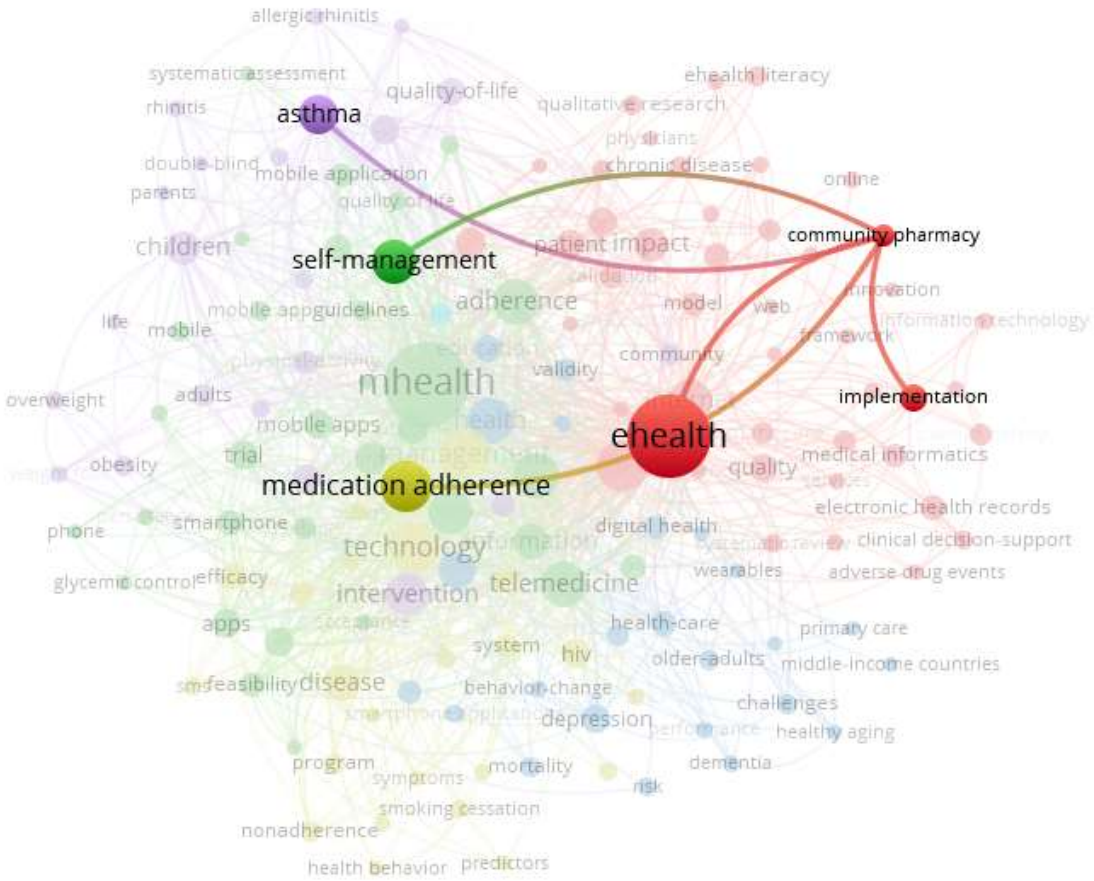

Figure 2. Bibliometric network of community pharmacies and eHealth (all keywords).

The model presented in Figure 2 reveals five main clusters. Community pharmacies pertain to the red cluster, having the most popular topic “eHealth” (the size of each sphere represents the number of papers using the keyword). The prevailing topics are self-assistance, implementation (of mobile apps), medication adherence, and support to specific diseases (e.g., asthma). Interestingly, the concept “mHealth” (green cluster) does not present a direct link with community pharmacies, aggregating more technical concepts such as “telemedicine” or “apps”. The other clusters include topics such as specific diseases related to the younger population (e.g., asthma, rhinitis included in the purple cluster that also displays concepts like “children” and “parent”), elderly care

(more strong in the blue cluster that also incorporates wearables and "digital health" – curiously, lacking links with community pharmacies in this sample) and finally, the yellow cluster (on the bottom) suggesting an association with public health initiatives. For example, support for medication adherence, health behavior, or smoke cessation. Figure 3 presents a complementary perspective.

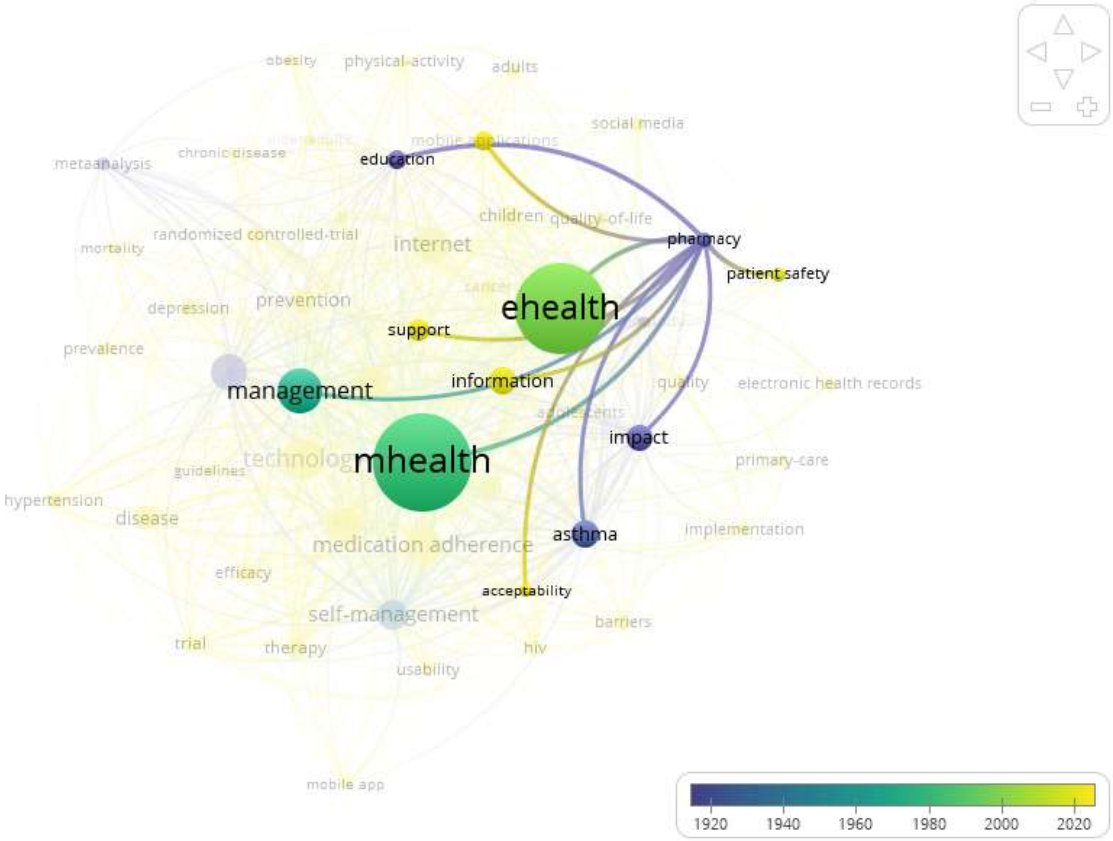

Figure 3. Bibliometric links between words with 8 or more occurrences.

Several analyses were made using VOS Viewer to tune the findings. The term "community pharmacy" stopped appearing in the example presented in Figure 3 (merged in the term "pharmacy" that also includes other contexts such as hospitals). However, this visualization also reveals essential aspects, namely, patient safety, support, and information. Examples of terms such as "physical activity", "obesity",

"social media", or "trials" and "efficacy" (the adjacent yellow cluster) are particularly relevant to modern pharmacies.

Having identified vital clusters and subtopics to deepen the evaluation of the mobile connected pharmacy, the following section presents the content analysis of 31 selected papers.

Theoretical Foundations for the Mobile Connected Pharmacy

The Digital Network of Community Pharmacies

Locating community pharmacies in the vast e-health landscape is an ongoing endeavor. Strengthening the pharmacy – patient relationship is the first step, for example, with more advanced mobile interfaces and mechanisms to warn the client about medication [13] or prescription pickup that can improve in around 16 hours with this type of system [26]. Then, implementing feedback mechanisms that go beyond the "reaction metaphor": "[SMS] are the health care equivalent of a lighthouse beacon alerting ships at night; it warns that action must be taken because consequences lie in wait, but it fails to provide individual guidance to each captain on how to steer clear of danger". Decision support systems or drug interaction analysis are examples in this area. Finally, recognizing that the mobile connected pharmacy has still many obstacles in the near future, but the sustainability of healthcare depends on its successful design [27].

There are many apps available to compete in the market, but most of the solutions are fragmented, addressing particular conditions (e.g., HIV, asthma, diabetes, allergic rhinitis, or hypertension) [3,28–30]. This approach may be missing opportunities to involve other stakeholders in the pharmacy supply chain, and several groups may be necessary. For example, the work of [31] identified ten groups of stakeholders in preventing cardiovascular diseases, including less mentioned cases such as the insurance

companies, academic and research institutions, pharmaceutical industry, media, or software companies. Similarly to the fourth industrial revolution concept, the mobile connected pharmacy needs a strategy for digital transformation and passing the barriers of the most direct stakeholders, for example, in pharmacy care, supporting the patient network of contacts, namely, family and carers (which, in some cases, are intermediaries of pharmacy care and buy the medicines to others), or physiotherapist [31], but also looking at the needs of external stakeholders such as pharmaceutical industry trials, or integration with hospital information systems [32].

The Social Opportunities in the Mobile Connected Pharmacy

The connected community pharmacy [5] can take advantage of social media in the daily pharmacist practice and reach specific targets of the population with advertising or health literacy campaigns [33,34]. For example, the recent recommendations to adopt mHealth solutions in adolescents with asthma to improve medication adherence [35]. The benefits of using social networks by the pharmacy clients can also contribute to psychological wellbeing in the case of chronic diseases [36].

One option is the creation of areas in the pharmacy website with private access to the electronic medication administration record and allows some interaction between pharmacists and patients [37]. However, current mobile solutions do not yet explore the possibility of extending the pharmacy – patient connection with patient – "other stakeholders" in the care process, and the overhead that these new platforms to pharmacists also deserve attention [38].

The Technical Layer of the Mobile Connected Pharmacy

Digital platforms in the pharmacy sector are evolving at an accelerated pace. On the one hand, online pharmacies are popular nowadays, but there are still some problems in the

quality of the information provided [39]. On the other hand, many community pharmacies already explore the online presence and e-commerce, combining commercial and professional services [40]. Some authors created online platforms tailored to each patient [4,41], revealing benefits for monitoring patient parameters online (e.g., blood pressure or glycaemia levels) and seeing medication dispensing. However, there are also difficulties, for example, the "advanced age of patients (65-80 years); lack of time; lack of an adequate space to practice pharmaceutical care supported by the platform; populations' lack of awareness; and patients refusal to share their data with a pharmacy" [10]. Moreover, the "lack of communication with a GP [general practitioner] was felt by most of the patients and by all of the pharmacists" [10], suggesting that a single pharmacy-patient interaction is important, but not enough.

Some limitations of web platforms can be addressed with mobile systems, more accessible to the elderly population that uses smartphones but also to younger generations [11], interactive anywhere, but also requiring enhanced protection of patient data. A recent example is presented by [32] for the portability of medication and vaccines. However, pharmacists' distraction and company policies (for example, in chain pharmacies), privacy concerns, suitability for "low risk conditions", frustration to education, and overall trust in the app are examples of the limitations in this area [11,42].

The Contribution to Global Programs of Optimized Health and Pharmacy Care

The implementation of health policies and desirable health behavior may be improved with monitoring mechanisms, for example, to prevent errors in self-medication and misuse of over the counter analgesic [43]. Nevertheless, there are gaps in the timeline of patient care and the priority of each stakeholder. For example, medication adherence is a main concern of physicians (but this information is more accessible to be identified by

the pharmacy). At the same time, pharmacists need rich contextual information about the client [44]. Moreover, the initiatives to improve medication adherence may start in the pharmacy contact, using mobile apps [45] and daily SMS reminders that revealed efficacy in older population [46]. Why every pharmacy needs a digital strategy becomes clear when the mobile apps are increasing exponentially, as revealed by a study that found 824 medication adherence apps in the market [47].

Digitalization can improve the inclusion of people with disabilities, and there are examples to provide medicine information for clients with visual impairment[48] or to facilitate communication with the deaf community [49]. The adoption of "augmented information" is also possible to achieve using QR codes, for example, for medical devices [50] or electronic labelling of compounds produced in the pharmacy.

Remote monitoring using wearable technology, for example in cardiology, involves pharmacists, cardiologists, and patients in an integrated care model [3]. Extending this interaction in clinical trials [51] is also a possibility, but current studies using mobile systems in pharmacies are rare. Nevertheless, the integration of smartphones, cloud infrastructures, and electronic devices increases, as shown by the SELFIE program [52] for self-management maintenance inhalation therapy. Considering the diversity of services available to community pharmacies and wellbeing-related apps, this is another prospect that requires data integration to be effective.

The literature review identified critical studies to support the development of the mobile connected pharmacy: individualization of care and comprehensive data integration in within the supply chain. The subsequent section presents the research approach.

Method

Among its multiple possible forms, canonical action research following the five main steps presented by [16] is one of the most widely used in information systems development [53]. The project addresses a specific client system architecture (FS) involving researchers and practitioners in cycles of diagnosing, action planning, action taking, evaluating, and specifying learning [16]. Theory has an influential role in guiding the action research and ensuring rigor [54]. After the bibliographic and structured literature review, our work evaluates the innovation structures and team behavior [21,22] in FS digital transformation. Two overlapping cycles can be identified in action research, namely, the problem-solving interest and the research interest [55]. The field intervention is described in the next section, followed by a discussion of the theoretical contribution.

Developing mPharmaCare: An Instantiation of the Mobile Connected Pharmacy

The literature review clarified some of the main gaps: the need to integrate different stakeholders in the mobile system. In this project, a dual structure of the pharmacy is considered: one, for business exploitation (managed by manager FS-MA) and the other, for exploration (led by manager FS-MB), with a team of IT developers sharing the pharmacy site. The proximity between pharmacists and developers is important to focus on the daily practice of pharmacists and to ensure direct contact with the clients or third-party institutions (e.g., suppliers, healthcare experts, other pharmacies). Both managers, FS-MA and FS-MB had regular joint meetings with the team.

The initial steps aimed to identify stakeholders with value to provide individualization of pharmaceutical care (e.g., their network of family, healthcare professionals, conditions, key parameters, or institutions). As presented in the literature review,

several stakeholders also have an interest in the pharmacy data, requiring horizontal and end-to-end digital integration. The stakeholder's analysis is shown in Figure 4.

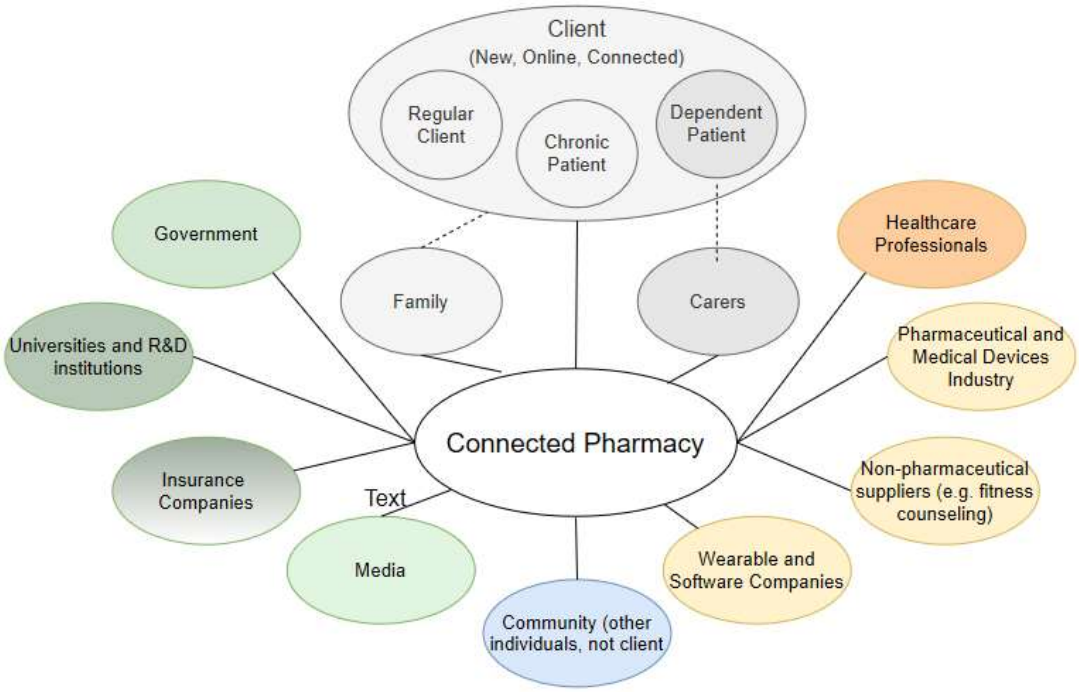

Figure 4. Stakeholder analysis of the connected pharmacy (adapted from [31]*).*

Four main types of stakeholders were identified as the most relevant for our case pharmacy, namely, (1) the *client ecosystem* (the term "client" encompasses all people that benefit from the pharmacy offer, for example, medicines, mobile app features, fitness counselling, or other pharmacy services) – on the top of Figure 4, (2) the *pharmacy supply chain* (on the right) that may contact directly with the clients, (3) the entities that may benefit from pharmaceutical data (green color, on the left), and (4) the community in general, as potential clients. The touchpoints of each stakeholder were modeled using customer journey maps, illustrated in Figure 5.

Figure 5. Customer journey extract – main steps using physical or digital interfaces.

The product-service continuum of the connected pharmacy is not restricted to the physical presence at the site. For example, there are opportunities to assist the pre-service and post-service situations (e.g., monitoring, scheduling), strengthening the connections with each stakeholder in the process. Informatics is the enabler of individualization and integration that also influences the emotional journey of each stakeholder (represented at the bottom of Figure 5).

A summary of key elements of the mPharmaCare is presented in Figure 6.

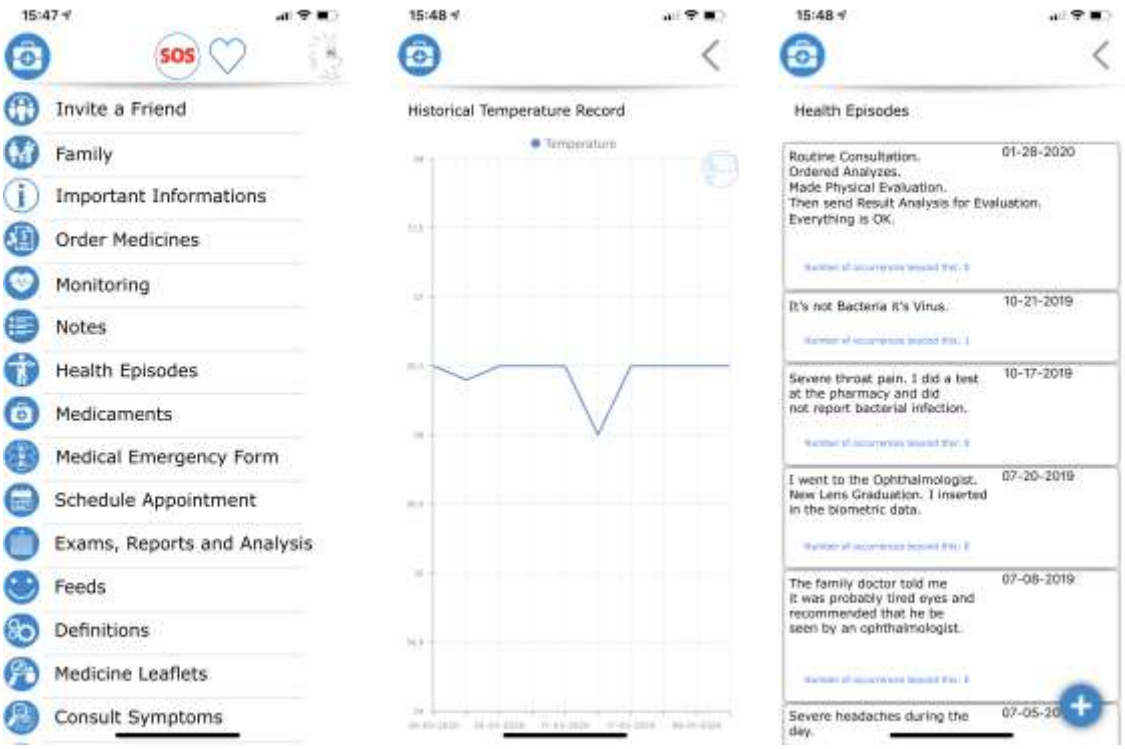

Figure 6. Examples of mPharmaCare mobile interface

Figure 6 shows the main menu (on the left), an example of historical record (temperature), and health episodes (on the right). The layered modular architecture includes the following main groups of functionalities (excluding more technical aspects such as data integration or wearable interface):

- Administration: This area includes pharmacy-related data, for example, general configurations, medicine database, symptoms, and guidelines. The user profile also has specific permissions, for example, define who can access personal data and in which conditions (e.g., read/write/comment);

- User Ecosystem: Family and friends' network, agenda, health episodes, emergency medical file, medicine indications, and health literacy (e.g., symptoms).

- Pharmacy-Client Interaction: Typical touchpoints identified in the customer journey maps to schedule visits, for example, order medication, ask questions, dispensing list, search medicine properties, record parameters, remainders;

- Pharmacy-Community Communication: The pharmacists contribute with the information to the public area of the system (mobile and online) and validate information included by the exploitation team (IT experts). For example, the feeds and symptoms database. Therefore, clients know that the platform is an extension of their pharmacy and not a third-party solution that was added between them. Trust is crucial in the mobile connected pharmacy[5]. On the one hand, it allows sharing information among pharmacists and other suppliers (e.g., fitness counselors). On the other hand, keeps the community informed and involved with the pharmacy updates;

- Pharmacy Decision Support: Warnings for parameters and interactions (may be blocked by the user in the app), data analytics to contrast parameters with the associated medicines and identify trends in medicine prescription;

- Pharmacy Compounding: Specific module to manage and create labels for each patient and estimate needs. The QR code opens a page with specific indications.

Examples of the mPharmaCare online dashboards are presented in Figure 7.

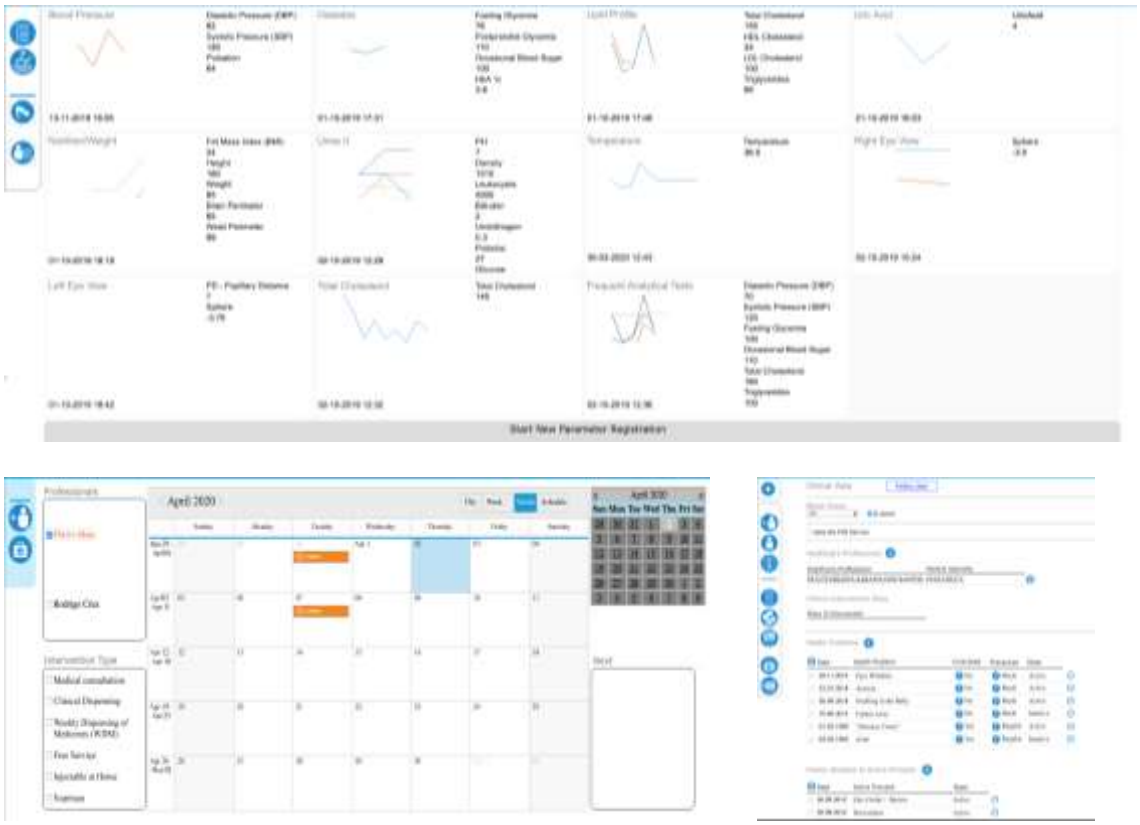

Figure 7. Examples of mPharmaCare online interface

Figure 7 presents an example of the main dashboard (topmost image), scheduling (bottom-left), and an episode form (on the bottom-right). A coherent design was used in both mobile and online channels. The web interface extends the functionalities for pharmacists (e.g., data analytics) and external stakeholders, for example, the client (when using a computer or tablet), family, carers, or healthcare professionals.

This system is being tested in three pharmacies and one nursing home, with a total of 100.000 registered users. The tool is continuously under development by the exploration structure that (1) deliver internal support to the pharmacists, (2) provide helpdesk assistance to the app users, and (3) is the primary connection with external stakeholders such as research institutes, other pharmacies, and pharmaceutical industry to take

advantage of the data market. The following section summarizes the lessons learned for the mobile connected pharmacy.

Discussion

The mobile connected pharmacy cannot be achieved with short-term investments in e-commerce websites and internal information systems. Individualization and integration [17] are two strong motives to extend digital transformation to all stakeholders. Moreover, improving patient adherence to medication also requires patient adherence to the IT layer of the infrastructure.

Individualization of care must have contextual information enriched by the patient ecosystem (directly when possible, or via nursing homes, family, doctors, therapists), but this will only happen if their value proposition is embedded in the app. The pharmacy-client relation is important, but not sufficient to the connected community pharmacy [5], requiring to extend the app interaction to the patient ecosystem. This change is profound, involves more time for the pharmacists, and there are also risks of losing pharmacists' adherence over time if the benefits are not visible to them.

Balancing exploration and exploitation in community pharmacies is challenging because the pharmacy's priorities are medicines and its users [3,42]. However, the new services provided in modern pharmacies [1] and the opportunities of digitalization require a strategy to manage change. A separate structure for exploitation, with proper links and interaction between both teams, had positive results in this case, but not all pharmacies have the possibility to extend their team. The creation of separate structures and practices seems more appealing to medium and large pharmacies. Moreover, FS started the development in 2016, suggesting that mobile connectivity is a long process. Failing to create a proper strategy − even if a unified structure is selected, will make community

pharmacies more dependent on software companies and less able to influence their community adherence to the app.

The digital transformation of community pharmacies is creating a product-service continuum. Recent studies of Pharmacy 2030 vision (https://www.pgeu.eu/pharmacy-2030/) reveal the enormous impact of community pharmacies in global health and the advanced services that now complement core pharmaceutical roles such as medicine dispensing. Many sectors of the economy faced similar transformations, for example, in industry, where the creation of exploitation departments for innovation and product development are common. Community pharmacies may follow that path, as the case presented in this paper. However, there are also alternatives to establish partnerships with IT companies and research institutions to evolve towards a more comprehensive vision of Community Pharmacy 5.0. Either way, it is necessary to include patient-centric (individualization), pharmacist-centric (internal integration), and community-centric actions (external integration) to make it a reality.

Study Implications

For theory, this work reports a paradigmatic case of digital transformation in a mobile connected community pharmacies. Mobility has benefits in the individualization of pharmacy care, with superior accessibility to segments of the population that prefer smartphone devices (e.g., adolescents). However, a long-term strategy must be identified. Contrasting with the hundreds of unrelated apps available in the market, community pharmacies can use mobile systems to implement more integrated and community-centric infrastructures. In this strategy, integration modules are mandatory.

For practice, we present an example of pharmacy structure and exploration practices to manage digital transformation in the connected community pharmacies using mobile

technologies. The field work identifies the main stakeholders to address in the first stage of development and a set of mPharmaCare features for a mobile connected community pharmacy [5].

Although community pharmacies are not IT-related or data market-related companies, the creation of exploration structures and tailored action plans (even if the development is outsourced) presented two main advantages in this case: (1) overcome the difficulties of pharmacists and (2) reduce the lack of trust that this type of mobile systems still face by both, pharmacists, and clients. Moreover, mobile solutions can support the traditional pharmacy services (e.g., medication adherence, scheduling, health literacy initiatives) and support new digital-enabled services for the pharmacy. FS is a leader in their region and is already planning a version of the system that can be personalized and used by other pharmacies, starting the partnership with their current compound customers. According to FS strategy, the *exploration* of this IT service to other pharmacies will lead to a start-up company able to explore the solution (online at http://drbox.pt/), while keeping the *exploitation* team free to innovate in data market.

Conclusion

This paper describes an action research project of digital transformation in community pharmacy. The particularities of this case include (1) a separate structure, links, and context for exploration of mobile technologies, (2) a mobile system tailored to the needs of community pharmacies with a combination of patient-centric and community-centric functionalities, and (3) a vision of connected community pharmacy moving beyond the traditional silo basis of operation [5].

Some limitations must also be stated. First, this study presents the results of a single pharmacy, albeit an important one in the region. Other pharmacies may not have the

capabilities available (e.g., financial and human resources, physical space) to create a separate structure for steering their digital transformation. Second, the study evolves in a country with few cases of digital transformation in community pharmacies, contrasting with more mature markets, particularly in the United States (US). US chain pharmacies started a similar strategy, revealing an opportunity to test the proposed approach in independent pharmacies struggling with increasing competition. Third, the Hawthorn effect is a common risk in social studies because people's behavior can change when they are being observed [56]. The research included an extensive literature analysis, document collection, and triangulation of different sources to minimize this risk.

In the short term, the authors are testing the adoption of this mPharmaCare tool with a sample of patients and their ecosystem to evaluate the information links in the patient-centric and community-centric dimensions. Paradoxically, diseases like COVID-19 demand more (physical) social distance but may also promote digital proximity. There are also improvements in the tool that needs further testing, namely, analysis of social interactions to generate alarms (e.g., nursing homes). However, the most promising research opportunities are not in FS setting. For example, new studies will be necessary on how to increase trust in health-related mobile systems (e.g., certification) and identify in more detail all the financial and sociotechnical impact of digital transformation. Moreover, connectivity is only a small part of the Community Pharmacy 5.0 research landscape. Addressing the needs of different stakeholders also increases the complexity of pharmaceutical service, and the creation of digital strategies is not yet familiar to this important healthcare sector. Additional research is necessary to evaluate how pharmacies and other health and social care organizations can balance exploration and exploitation in product-service systems transitions.

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Declaration of Interest

The first author reports no conflict of interest. The second and third authors are the case pharmacy shareholders.

References

1. Moullin JC, Sabater-Hernández D, Fernandez-Llimos F, Benrimoj SI. Defining professional pharmacy services in community pharmacy. Res Soc Adm Pharm. 2013;9(6):989–95.

2. Yoo Y, Henfridsson O, Lyytinen K. The New Organizing Logic of Digital Innovation : An Agenda for Information Systems Research. Inf Syst Res. 2010;21(4):724–35.

3. Cornell WK, Clauson KA, Cain J. Updating the Model: The Case for Independent Pharmacy to Embrace Digital Health. Inov Pharm. 2019;10(1):15.

4. Spanakis M, Sfakianakis S, Kallergis G, Spanakis EG, Sakkalis V. PharmActa: Personalized pharmaceutical care eHealth platform for patients and pharmacists. J Biomed Inform [Internet]. 2019;100(October):103336. Available from: https://doi.org/10.1016/j.jbi.2019.103336

5. Goundrey-Smith S. The connected community pharmacy: Benefits for healthcare and implications for health policy. Front Pharmacol. 2018;9(NOV):1–10.

6. Goundrey-Smith S. Pharmacy Management Systems. In: Information Technology in Pharmacy - An Integrated Approach. 2013. p. 151–73.

7. Nanji KC, Cina J, Patel N, Churchill W, Gandhi TK, Poon EG. Overcoming Barriers to the Implementation of a Pharmacy Bar Code Scanning System for Medication Dispensing: A Case Study. J Am Med Informatics Assoc. 2009;16(5):645–50.

8. Batenburg R, Van Den Broek E. Pharmacy information systems: the experience and user satisfaction within a chain of Dutch pharmacies. Int J Electron Healthc. 2008;4(2):119–31.

9. Hines LE, Saverno KR, Warholak TL, Taylor A, Grizzle AJ, Murphy JE, et al. Pharmacists' awareness of clinical decision support in pharmacy information systems: An exploratory evaluation. Res Soc Adm Pharm [Internet]. 2011;7(4):359–68. Available from: http://dx.doi.org/10.1016/j.sapharm.2010.10.007

10. Lapao LV, da Silva MM, Gregorio J. Implementing an online pharmaceutical service using design science research. BMC Med Inform Decis Mak. 2017;17(31):1–14.

11. Davies MJ, Collings M, Fletcher W, Mujtaba H. Pharmacy Apps: a new frontier on the digital landscape? Pharm Pract [Internet]. 2014;12(3):1–11. Available from: green

12. Mahoney CD, Berard-Collins CM, Coleman R, Amaral JF, Cotter CM. Effects of an integrated clinical information system on medication safety in a multi-hospital setting. Am J Heal Pharm. 2007;64(18):1969–77.

13. Gatwood J, Hohmeier KC, Brooks IM. Beyond the reminder: The next steps in pharmacist-driven, mHealth patient engagement. J Am Pharm Assoc. 2019;59(2):S21–4.

14. Vial G. Understanding digital transformation: A review and a research agenda. J Strateg Inf Syst. 2019;(xxxx):0–1.

15. Mont O. Clarifying the concept of product–service system. J Clean Prod [Internet]. 2002 Jun;10(3):237–45. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0959652601000397

16. Susman GI, Evered RD. An Assessment of the Scientific Merits of Action Research. Adm Sci Q. 1978;23(4):582–603.

17. Brettel M, Friederichsen N. How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective. Int J Mech Aerospace, Ind Mechatron Manuf Eng. 2014;8(1):37–44.

18. Haleem A, Javaid M. Industry 5.0 and its applications in orthopaedics. J Clin Orthop Trauma. 2019;10(4):807–8.

19. European Commission. Industry 5.0 [Internet]. 2021 [cited 2021 Nov 6]. Available from: https://ec.europa.eu/info/research-and-innovation/research-area/industrial-research-and-innovation/industry-50_en

20. Ruhi U, Turel O. Driving Visibility , Velocity and Versatility : The Role of

Mobile Technologies in Supply Chain Management. J Internet Commer. 2005;4(3):37–41.

21. Gibson CB, Birkinshaw J. The Antecedents, Consequences, and Mediating Role of Organizational Ambidexterity. Acad Manag J [Internet]. 2004 Apr;47(2):209–26. Available from: http://journals.aom.org/doi/10.5465/20159573

22. Hahn T, Pinkse J, Preuss L, Figge F. Ambidexterity for Corporate Social Performance. Organ Stud. 2016;37(2):213–35.

23. Rapoport RN. Three dilemmas in action research. Hum Relations. 1970;23(6):499–513.

24. Tranfield D, Denyer D, Smart P. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. Br J Manag. 2003;14(3):207–22.

25. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523–38.

26. Mitrzyk BM, Bici A, Barras M, Holm J, Marshall V, Farris KB. Implementation of a text message reminder service in an independent community pharmacy: A retrospective analysis of time to prescription pickup and satisfaction. J Am Pharm Assoc [Internet]. 2019 Mar;59(2):S67–70. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1544319118304126

27. Lapão LV. The Future of Healthcare: The Impact of Digitalization on Healthcare Services Performance. In: The Internet and Health in Brazil [Internet]. Cham: Springer International Publishing; 2019. p. 435–49. Available from:

http://link.springer.com/10.1007/978-3-319-99289-1_22

28. Tan R, Cvetkovski B, Kritikos V, O'Hehir RE, Lourenço O, Bousquet J, et al. Identifying an effective mobile health application for the self-management of allergic rhinitis and asthma in Australia. J Asthma [Internet]. 2019;0(0):1–12. Available from: http://dx.doi.org/10.1080/02770903.2019.1640728

29. Kosse RC, Murray E, Bouvy ML, de Vries TW, Stevenson F, Koster ES. Potential normalization of an asthma mHealth intervention in community pharmacies: Applying a theory-based framework. Res Soc Adm Pharm [Internet]. 2020;16(2):195–201. Available from: https://doi.org/10.1016/j.sapharm.2019.05.004

30. Kosse RC, Bouvy ML, de Vries TW, Koster ES. Evaluation of a mobile health intervention to support asthma self-management and adherence in the pharmacy. Int J Clin Pharm [Internet]. 2019;41(2):452–9. Available from: https://doi.org/10.1007/s11096-019-00798-3

31. Franco-Trigo L, Marqués-Sánchez P, Tudball J, Benrimoj SI, Martínez-Martínez F, Sabater-Hernández D. Collaborative health service planning: A stakeholder analysis with social network analysis to develop a community pharmacy service. Res Soc Adm Pharm [Internet]. 2020;16(2):216–29. Available from: https://doi.org/10.1016/j.sapharm.2019.05.008

32. Coons JC, Patel R, Coley KC, Empey PE. Design and testing of Medivate, a mobile app to achieve medication list portability via Fast Healthcare Interoperability Resources. J Am Pharm Assoc [Internet]. 2019 Mar;59(2):S78-S85.e2. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S1544319119300019

33. Shcherbakova N, Shepherd M. Community pharmacists, Internet and social media: An empirical investigation. Res Soc Adm Pharm [Internet]. 2014;10(6):e75–85. Available from: http://dx.doi.org/10.1016/j.sapharm.2013.11.007

34. Benetoli A, Chen TF, Schaefer M, Chaar BB, Aslani P. Professional use of social media by pharmacists: A qualitative study. J Med Internet Res. 2016;18(9).

35. Kosse RC, Bouvy ML, de Vries TW, Koster ES. Effect of a mHealth intervention on adherence in adolescents with asthma: A randomized controlled trial. Respir Med. 2019;149(February):45–51.

36. Merolli M, Gray K, Martin-Sanchez F. Health outcomes and related effects of using social media in chronic disease management: A literature review and analysis of affordances. J Biomed Inform [Internet]. 2013;46(6):957–69. Available from: http://dx.doi.org/10.1016/j.jbi.2013.04.010

37. de Jong CC, Ros WJG, van Leeuwen M, Schrijvers G. Exploring the effects of patients taking a vigilant role in collaborating on their e-medication administration record. Int J Med Inform [Internet]. 2016;88:18–24. Available from: http://dx.doi.org/10.1016/j.ijmedinf.2016.01.001

38. Gregório J, Ferreira TL, Cavaco A, Da Silva MM, Lovis C, Lapão LV. Community pharmacies and eHealth services: Barriers and opportunities for real Primary Healthcare integration. Proc CBMS 2013 - 26th IEEE Int Symp Comput Med Syst. 2013;393–6.

39. Orizio G, Merla A, Schulz PJ, Gelatti U. Quality of online pharmacies and websites selling prescription drugs: A systematic review. J Med Internet Res. 2011;13(3):1–25.

40. Zwier S. Click for closer care": A content analysis of community pharmacy websites in four countries. J Med Internet Res. 2017;19(6).

41. Lapaõ LV, Gregorio J, Mello D, Cavaco A, Mira Da Silva M, Lovis C. Using Design Science Research to develop Online Enhanced Pharmaceutical Care Services. Stud Health Technol Inform. 2014;205:266–70.

42. Cobelli N, Chiarini A. Improving customer satisfaction and loyalty through mHealth service digitalization. TQM J [Internet]. 2020 Feb 21;ahead-of-p. Available from: https://www.emerald.com/insight/content/doi/10.1108/TQM-10-2019-0252/full/html

43. Perrot S, Cittée J, Louis P, Quentin B, Robert C, Milon JY, et al. Self-medication in pain management: The state of the art of pharmacists' role for optimal Over-The-Counter analgesic use. Eur J Pain (United Kingdom). 2019;23(10):1747–62.

44. Mercer K, Burns C, Guirguis L, Chin J, Dogba MJ, Dolovich L, et al. Physician and pharmacist medication decision-making in the time of electronic health records: Mixed-methods study. J Med Internet Res. 2018;20(9).

45. Didonato KL, Liu Y, Lindsey CC, Hartwig DM, Stoner SC. Community pharmacy patient perceptions of a pharmacy-initiated mobile technology app to improve adherence. Int J Pharm Pract. 2015;23(5):309–19.

46. Haramiova Z, Stasko M, Hulin M, Tesar T, Kuzelova M, Morisky DM. The

effectiveness of daily SMS reminders in pharmaceutical care of older adults on improving patients' adherence to antihypertensive medication (SPPA): Study protocol for a randomized controlled trial. Trials. 2017;18(1):1–15.

47. Dayer LE, Shilling R, Van Valkenburg M, Martin BC, Gubbins PO, Hadden K, et al. Assessing the Medication Adherence App Marketplace From the Health Professional and Consumer Vantage Points. JMIR mHealth uHealth. 2017;5(4):e45.

48. Madrigal-Cadavid J, Amariles P, Pino-Marín D, Granados J, Giraldo N. Design and development of a mobile app of drug information for people with visual impairment. Res Soc Adm Pharm [Internet]. 2019;16(1):62–7. Available from: https://doi.org/10.1016/j.sapharm.2019.02.013

49. Chong EYC, Palanisamy UD, Jacob SA. A qualitative study on the design and development of an mHealth app to facilitate communication with the Deaf community: Perspective of community pharmacists. Patient Prefer Adherence. 2019;13:195–207.

50. European Commission. Green Paper on mobile Health ("mHealth") [Internet]. 2014. Available from: http://ec.europa.eu/digital-agenda/en/news/green-paper-mobile-health-mhealth

51. Sommer C, Zuccolin D, Arnera V, Schmitz N, Adolfsson P, Colombo N, et al. Building clinical trials around patients: Evaluation and comparison of decentralized and conventional site models in patients with low back pain. Contemp Clin Trials Commun [Internet]. 2018;11(February):120–6. Available from: https://doi.org/10.1016/j.conctc.2018.06.008

52. Kuipers E, Poot CC, Wensing M, Chavannes NH, De Smet PAGM, Teichert M. Self-management maintenance inhalation therapy with eHealth (SELFIE): Observational study on the use of an electronic monitoring device in respiratory patient care and research. J Med Internet Res. 2019;21(5):1–10.

53. Davison R, Martinsons MG, Kock N. Principles of canonical action research. Inf Syst J. 2004;14(1):65–86.

54. Davison R, Martinsons MG, Ou CXJ. The Roles of Theory in Canonical Action Research. MIS Q. 2012;36(3):763–86.

55. McKay J, Marshall P. The dual imperatives of action research. Inf Technol People. 2001;14(1):45–59.

56. French J. Experiments in field settings. In: Festinger L, Katz D, editors. Research methods in behavioral sciences. Dryden Press, 101; 1953.