Smartphone-Based Strategy for Quality-of-Life Monitoring in Head and Neck Cancer Survivors

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Abstract. Smartphone-based IoT systems have the potential to predict and keep control of Quality of Life measurements with the adequate design. This work aims to provide a comprehensive strategy for the development of a disease-specific application to monitor Quality of Life in Head and Neck Cancer survivors. This research first presents the results from a literature review focused on mHealth services for cancer patients. Second, we provide a complete overview of a clinical trial protocol where patients are encouraged to (1) perform self-management by actively reporting symptoms, (2) keep healthy lifestyles, (3) interact with an embedded artificial intelligence that serves as an additional patient-physician communication channel, and (4) fill in Quality of Life standard questionnaires from a web platform from home. The challenges addressed, the unobtrusive data collection procedures chosen, and the quality data obtained from physical, social, and behavioral measures, provide a resourceful set of guidelines and requirements for future research works aimed at after-treatment cancer patients monitoring through IoT portable devices.

Keywords: IoT systems · IoT-based monitoring systems · cancer research · head and neck cancer · quality of life

1 Introduction

The advances in digital technologies for data gathering, analysis and monitoring of patients has allowed the incorporation and standardization of novel healthcare services, such as Internet of Things (IoT) systems, that constitute portable cloud-connected tools able to record personal metrics unobtrusively, through sensors and custom applications.

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The most prominent IoT devices are smartphones, mobile devices integrated in daily life routines. Their huge potential for health monitoring and disease management is being widely explored by researchers and physicians. In particular, eHealth smartphone applications are currently being used for patient self-management, continuous symptom monitoring in chronic diseases, and as an additional communication bridge between patients and physicians [1, 2]. The engagement of individuals with smartphone applications that promote healthier and stress-free lifestyles have shown general positive outcomes and, precisely, cancer patients showed high technology acceptance [3], which is a major reason why the use of IoT in cancer research is growing. In terms of diagnosis, for instance, work has been done to use IoT (i.e., tactile neuron devices) with Artificial Intelligence (AI) technology for more accurate cancer diagnosis [4]. Other IoT devices are commonly embedded or synchronized with smartphones (e.g., sensors and wearables), gathering a broader diversity of patient data. The continuously updating of technologies has led to the integration also of 5G for faster communication, and blockchain services to ensure the security of the data gathered [5].

Current data-driven strategies aid clinicians on continuous monitoring the quality of life of patients and serve to raise public awareness of the importance of prevention measures in modifiable risk factors for cancer. Physical and psychological problems can be derived because of treatment causing long-term consequences. Therefore, preventing long-term effects, and anticipating the early deterioration of quality of life is of paramount importance to minimize the effect of these problems in their daily routines [6]. Apart from collecting patient self-reported outcomes, through standard questionnaires or other analyzed surveys, multiple domains of well-being using big data can offer valuable information for monitoring health status after cancer treatment. Information collected from traditional sources of health data (e.g., electronic health records (EHR) or clinical registries) being complemented with new sources of data (i.e., IoT such as mobile health) could support this continuous monitoring and therefore prevent Quality of Life (QoL) deterioration [7].

Head and Neck Cancers (HNC) are a malignant neoplasm group that mainly develops in the squamous cells that line the mucosal surfaces inside the head and neck [8]. In 2020, this cancer may have affected approximately 151,000 new patients in Europe and 833,000 new patients worldwide [9], being the seventh most common cancer worldwide. In the last five years, the cancer survival rate has increased due to a better knowledge of the scientific advances on the origin of cancer and the existence of new treatments that are improving day by day [10]. This rise of cancer survival rates has led to a higher number of survivors, increasing the need to emphasize health-related quality of life (HRQoL). As a result, the study of HRQoL has grown significantly and has become an essential component in cancer care in the last years [11]. Among all the HNC survivors, their QoL is mainly affected by the pain perceived in the cervical and shoulder regions, the perception of their physical fitness, and the long-term fatigue reported after completion of medical treatment. Therefore, an adequate treatment strategy is needed so that the quality of life of these survivors is not diminished. For this reason, the use of IoT can facilitate and obtain a better treatment strategy and help maintain and improve the QoL of HNC survivors, through the use of health-related data and patient monitoring [12]. To ultimately improve the QoL of Head and Neck Cancer (HNC) survivors, IoT tools

can help on controlling adverse effects, signs and symptoms, physical activity routines, and sleep patterns [13].

The use of a mobile application for patient monitoring, as well as the use of their data, entails several challenges, such as data quality, transparency, data protection and trustability. Current personal data behavior monitoring based on smartphones used by patients, include two main categories of data collected: a) raw data from smartphone sensors, or b) calculated, more advanced level of data from third party applications (e.g., Samsung, Google). The decision on which of these two types of data should be collected is based on privacy, unobstructiveness, and clean (or low energy) computing on the edge. Regarding the data protection, privacy issues emerge when collecting data from third parties' data hubs, which need to be addressed through encryption and/or pseudoanonymisation techniques. If only raw data collected and if data analysis processes are implemented only at the edge node, then privacy can be ensured at highest level. Although raw and some calculated data can be collected unobstructively, there are types of personal IoT based data (such as sleep behavior or skin temperature) that can be currently only collected through the user's specific action. Finally, major challenge remains the ability to enable as low and clean computing energy at the edge (the smartphone device), to allow resources (battery, memory) to remain at an adequate level for both data collection and analysis, without blocking the rest of the smartphone operations.

There are also other types of challenges when developing health monitoring services, these are the difficulties related to patients. The receptiveness of patients to use digital technology after-treatment is closely related to their motivation. The degree of willingness to use tools or technologies to monitor physical activity depends on the patient's attitude towards physical activity, and the patient's attitude toward technology-assisted physical activity. These two characteristics reflect the motivation of cancer survivors to exercise and use technology, since not all patients are receptive to and able to use digital technologies to improve their physical activity [14, 15]. Another difficulty is the level of technology literacy of cancer survivors, a high level of use of technologies (e.g., computers, smartphones, internet etc.), has a positive impact in the level of physical activity and QoL of the participants [16]. In addition, another of the great barriers is the possibility to have internet access, especially in people over 65 years of age. The cancer survivors that lack digital services that work and suit individual needs, are more likely to have a decrease in motivation and use of eHealth technology, which can lead to a decrease in their physical activity and a worsening of their QoL [15].

To solve these challenges, the BD4QoL project aroused, whose main objective is to improve HNC survivor's Quality of Life through person-centered monitoring and follow-up planning by contribution of artificial intelligence (AI) and big data (multidisciplinary medical, environmental, personal feelings, socioeconomic and behavioral data) unobtrusively collected from commonly used mobile devices, in combination with multi-source clinical, socioeconomic data and patients reported outcomes, to profile HNC survivors for improving personalized monitoring and support. The analysis of newly QoL indicators will allow anticipating risks, inform patients and caregivers for personalized interventions to timely intercept and prevent long-term treatment effects.

2 Materials and Methods

This project is based on a multidisciplinary collaboration. The BD4QoL Consortium is a strong and balanced partnership composed of 16 organizations, located in 7 different European countries, including: 3 outstanding cancer reference centers, 6 research institutions, 2 large corporation and 1 industrial partner, 2 SMEs and 2 Government/Public bodies [17]. With this work modality, the aim is to take the maximum advantage of individual expertise form each team of experts to monitor the clinical research and the technology challenges which the project brings about. Figure 1 represents the steps that have been followed to carry out this study: a literature review, analysis of the possible scenarios, implementation of the mobile app and services, and the ongoing validation in a clinical trial.

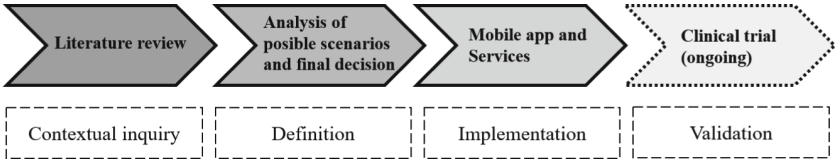

Fig. 1. Diagram of the materials and methods of the study.

To assess which mHealth devices have being used for QoL monitoring, a literature review was conducted. It was carried out following search terms "mhealth app for QoL monitoring" and "wearable devices in cancer research" in PubMed in February 2021. Three different authors search first for title and abstract and later of the full-text manuscript and reject the ones that were not satisfying the scope (i.e., studies using mobile apps to monitor QoL). The goal of this search was to identify conventional operating systems, most convenient measures from smart devices, minimum data required for daily monitoring, challenges addressed, and quality rules considered in the implementation. Limitations were also analyzed and filtered for the case study of cancer survivors. With the results of the literature review, we evaluated and proposed to clinical partners a set of scenarios with pros and cons to evaluate, discuss and agree together with is the most appropriate one to implement within the BD4QoL project.

A prospective study (randomized controlled trial) has been set-up and launched where HNC survivors are enrolled and randomly assigned to an intervention arm equipped with mobile apps for continuous monitoring and support or to a control arm that will be monitored by means of QoL standard questionnaires issued by the European Organization for Research and Treatment of Cancer (EORTC). More than 400 HNC survivors are expected to be enrolled in this study, coming from four differences centers in Italy and UK. Details of the protocol can be found at ClinicalTrials.gov with the NCT05315570 identifier. This is a multicenter, international, two-arm, randomized (2:1 ratio), open label, superiority trial, designed to evaluate the proportion of HNC survivors experiencing a clinically meaningful QoL deterioration (reduction of at least 10 points in EORTC QLQ-C30 global health status [18, 19]) between at least 2 visits during post-treatment follow-up (up to 24 months from randomization) with the use

of BD4QoL platform in comparison to those without the BD4QoL platform ("standard FU"). Mobile data from intervention arm participants will be also used to recognize behavioral changes due to the participants' mobile usage. In addition, BD4QoL project aims to assess other mobile app features like lifestyle self-management, counseling, communication and detection of affective traits. With the mobile apps and QoL proxies' data collection, risk models will be implemented to possibly identify behavioral changes that might be associated with QoL modifications (improvement or deterioration) in association with patient's reported outcomes and experience measures (PROMs/PREMs). This clinical trial has been carried out in conjunction with the clinical and technical partners of the project to include all the relevant aspects, using the SPIRIT AI [20] and CTTI [21] guidelines for clinical trials.

3 Results

3.1 Literature Review

As a result of the literature review, we collected and examined 67 papers, from peer-reviewed journals and conference proceedings, illustrating the application of IoT and mobile technologies in healthcare research. The main characteristics extracted from these papers are summarized in Table 1.

Challenges addressed cover 1) telemonitoring, to enable healthcare professionals (including practitioners and nurses) to care for more patients with no decrease in quality of service; 2) self-monitoring and symptoms self-management, to empower patients to deal with the less risky aspects of their health and well-being, reducing the need for resorting to more expensive healthcare resources; 3) counselling, to coach patients towards healthy behaviors that will prevent future health decays; 4) collection of PROM and PREM questionnaires, to assess quality of life and quality of care dimensions; and 5) support for adherence to therapy and medications.

The wide number of clinical domains covered, also summarized in Table 1, is testament to how IoT and mobile health technologies promise to transform the whole healthcare landscape in the coming years. Applications are directed to patients suffering from (possibly multiple) chronic conditions, who need long term care; patients recovering from surgery who need continuous support, although for a limited, pre-defined period; patients with specific diseases, that each have their correspondingly specific requirements in terms of remote support to be provided, etc. Healthy subjects are also targeted with health promotion applications, addressing primary prevention.

On the interoperability side, 50% of papers report the specific operating system they relied on. The majority of research endeavors still rely on the Android operating system, likely due to its higher *openness*, which is mentioned in 49% of the papers. However, 24% of the papers also support iOS devices, in addition to Android. Only 1 paper report supporting iOS only.

Information on data collection and data quality is still not widespread. Only 9% of the examined papers report explicitly the strategy for collecting the data they used (e.g., frequency of collected measurements, procedures to be enacted by users, etc.). On the other hand, a relevant number of papers (19%) reports about data quality rules. In many cases, these are in the form of post-hoc rules included in study protocols to determine

Table 1. Characteristics of surveyed papers.

Total number of papers reviewed	n = 67
Challenges addressed *Telemonitoring, self-monitoring, symptoms self-management, counselling, PROM/PREM collection, adherence promotion*	
Clinical domains addressed *Health promotion (physical activity, nutrition, diet), asthma, cancer, obesity, heart failure, stroke, peripheral arterial disease, diabetes, Parkinson disease, kidney disease, inflammatory bowel disease, amyotrophic lateral sclerosis, chronic obstructive pulmonary disease, complex chronic conditions, orthopedy, surgery follow up, pain treatment, autism, mental health*	
Papers reporting mobile OS Only Android Only iOS Both	25% (n = 17) 1% (n = 1) 24% (n = 16)
Papers reporting information on data collection protocol	9% (n = 6)
Papers reporting information on data quality rules	*19% (n = 13)*

when a participant is to be part of the analysis. However, in other cases, quality rules to be specifically enacted during the data collection process (e.g., minimum percentage of data collected by the step counter over daily hours, for the data point to be considered as valid), are indicated. This is very important, for instance, in those cases in which the IoT data are used to enact a clinical workflow, such as for instance when alerting the Point of Care that a check with the patient is recommended, to verify why her physical activity measurement (e.g., obtained through the pedometer) consistently decreased over the last few days.

3.2 Analysis of Possible Scenarios and Final Decision

Data collection of behavioral (personal) being accessible and available for analysis data requires to be authorized under a secure network and GDPR compliant procedures. The main challenge here is to allow data collection of all three agreed BD4QoL domains of analysis, named a) physical, b) social and c) sleep behavioral of patients, while satisfying at the same time the need of obstructiveness and protocol compliance.

Towards this direction, the main options identified involved to a) include or not include personal wearable devices, named smartwatches, and b) to allow use of both Android and iOS smartphone operating systems used by patients, under the intention to include as much as possible clinical trial population. These options were analyzed with pros and cons for each followed scenario, as described below.

a) Use of smartwear devices – smartwatches:

   a. Pros

      – Accurate sleep monitoring behavior.

- Accuracy in physical behavior.
- Data collection can include a more *mature* and coherent set of measurements based on algorithms using raw data sensors.
- Low level granularity of data measurements (data can be collected at different levels of granularity, from less than 1 s to summary aggregated daily data through third party web services).
- Low energy utilization of resources based on smartwatch data.

b. Cons

- Technical implementation is device specific unless a completely different architecture is followed that could lead to scalability.
- Obstructiveness of clinical experiment which could lead to faulty assumptions based on mis-wearing behavior of wearables.
- Cost is high for both use of wearables and API access for some brands.
- High energy resources for batter and memory capacity needed to compute data collection and baseline calculations at the edge level, i.e., the smartphone device.

b) Use of Android compared to iOS for smartphone devices:

a. Pros

- Ability to include a larger number of populations for the clinical trial.
- Greater level of un-objectiveness of the experiment.

b. Cons

- Missing the social domain related data for the clinical experiment since iOS operating systems do not allow related data to be collected for privacy issues (e.g., Call and SMS logs).
- Data collection of location related activities could be available (at the time of design decisions) every 15 min for iOS devices, in contrast with 1 min data measurements collected for Android devices, concluding in several implications for the recognition algorithm used to recognize the semantic location of the places one visits.

Based on the above analysis, it was decided to opt for the use of only Android smartphones for data collection (Fig. 2), based on a mixed scenario for the acquisition process. Raw level data such as screen status (ON, OFF), light level, accelerator, and GPS measurements would be collected through the phone's baseline sensors, whereas more higher-level data groups, such as steps, physical activities and phone based social data (i.e., calls, SMS, applications used, etc.) would be collected through third party API services (Google Fit and device OS packages). To enable compliance with GDPR, all data are pseudoanonymized, whereas sensitive private social data (such as calls and SMS) are also encrypted.

Fig. 2. Features included in the scenario selected

3.3 Implementation of the Mobile App and Services

The BD4QoL platform obtained as a result, is made up of a mobile application that collects patient data, and a Point of Care tool where clinicians view and manage patient data. The main objective of the mobile app is to continuously collect data from the device's available sensors and operating system. It also has self-administered questionnaires, for the collection of additional QoL items, to be measured between one follow up visit and the next, including supporting sub-functions (e.g., reminders, consistency checks). The mobile app also includes a self-management e-coach, consisting of a patient empowerment, natural language-based chatbot, offering to participants: 1) visualization of their own QoL data and related trends, as collected and inferred by the platform, according to rules established with clinicians, 2) counseling on symptoms self-management and providing relevant suggestions and recommendations for guided self-help, 3) establishing a communication channel with the clinician, and 4) detecting affective traits relevant to the participant's QoL assessment (e.g. depression, anxiety) from the analysis of the dialog among the participant and the chatbot, through natural language processing and understanding algorithms.

Finally, machine learning-based data analysis algorithms that use the data collected through the mobile app during the prospective BD4QoL trial, will be developed to improve predictive modeling for the early detection of HRQoL or other health outcome deterioration.

4 Discussions and Conclusions

The concept of IoT is expanding rapidly and has been integrated into the standard of living for a great portion of the population in the form of smart devices, such as personal mobile phones. Researchers and physicians are taking advantage of this technology's readiness to enhance healthcare workflows, but every health condition has its particular needs, and thus disease-specific settings must be designed to optimize the performance of the application. In this work we have presented the results obtained from a literature review in terms of mHealth applications for QoL monitoring and the use of wearable devices in cancer research, demonstrating that IoT is a fast-growing and broadly applicable tool

for improving conventional healthcare strategies applied in the management of cancer survivors. Additionally, the design of the app ensured fundamental principles to avoid any patient's discomfort: unobtrusiveness guarantees that the system does not interfere with the patient's routines unless willing, high security measures provide confidence that no personal data will be breached, privacy rights are preserved during the monitoring process and, to provide trust, the application follows transparency criterions by allowing users to check which kind of data is collected, permissions can be removed and withdrawal is permitted at any time with no detrimental to the patient's standard of care protocol.

Previous works already noticed the role of smartphones as pervasive tools to entangle clinical procedures with IoT-based monitoring systems for other cancer patients [22, 23] but a specific design for Head and Neck cancer patients was missing. More importantly, the needs of patients going through treatment differ from survivors dealing with after-treatment sequelae, a chronic condition that is usually revised only though scheduled but sporadic medical visits.

Self-management of the disease, patient empowerment and promotion of healthy lifestyles are clear strengths of IoT-based strategies for cancer survivorship. However, there is still room for improvement in terms of machine learning algorithms, not analyzed in this work, to optimally gather clinically relevant knowledge from IoT devices and offer the best possible support to these patients. With the emergence of an avalanche of healthcare applications in the market, the use of data model standards to ensure semantic harmonization and interoperability will provide an unprecedented multi-source resource to better understand disease progression and personalize out-of-the-clinic therapies.

Thus, the BD4QoL application is a co-creation effort from a multidisciplinary team and the guidelines obtained from this work will serve future studies and trials to develop tailored disease specific IoT applications for better monitoring of quality of life.

References

1. Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B.B., Ginsburg, A.S.: Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. J. Med. Internet Res. **17**(2), e52 (2015). https://doi.org/10.2196/jmir.3951
2. Kwan, Y.H., et al.: Evaluation of mobile apps targeted at patients with spondyloarthritis for disease monitoring: systematic app search. JMIR mHealth uHealth **7**(10), e14753 (2019). https://doi.org/10.2196/14753
3. Moses, J.C., Adibi, S., Shariful Islam, S.M., Wickramasinghe, N., Nguyen, L.: Application of smartphone technologies in disease monitoring: a systematic review. In Healthcare, vol. 9, no. 7, p. 889. MDPI (2021). https://doi.org/10.3390/healthcare9070889
4. Evans, S.: Researches use IoT for cancer diagnosis (2022). https://www.iotworldtoday.com/2022/07/14/researches-use-iot-for-accurate-cancer-diagnosis/. Accessed 18 Oct 2022
5. Muhsen, I.N., et al.: Current status and future perspectives on the Internet of Things in oncology. Hematol. Oncol. Stem Cell Ther. (2021). https://doi.org/10.1016/j.hemonc.2021.09.003
6. Alonso, I., Lopez-Perez, L., Guirado, J.C.M., Cabrera-Umpierrez, M.F., Arredondo, M.T., Fico, G.: Data analytics for predicting quality of life changes in head and neck cancer survivors: a scoping review. In: 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC), pp. 2262–2265. IEEE (2021)

7. FUNDING & TENDERS: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/sc1-dth-01-2019. Accessed 18 Oct 2022
8. Head and Neck Cancer—Patient Version (2022). https://www.cancer.gov/types/head-and-neck. Accessed 18 Oct 2022
9. Boscolo-Rizzo, P., et al.: The evolution of the epidemiological landscape of head and neck cancer in Italy: is there evidence for an increase in the incidence of potentially HPV-related carcinomas? PLoS ONE **13**(2), e0192621 (2018). https://doi.org/10.1371/journal.pone.0192621
10. Kocarnik, J.M., et al.: Cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life years for 29 cancer groups from 2010 to 2019: a systematic analysis for the global burden of disease study 2019. JAMA Oncol. **8**(3), 420–444 (2022). https://doi.org/10.1001/jamaoncol.2021.6987
11. Taylor, K., DipOnc, G., Monterosso, L.: Survivorship care plans and treatment summaries in adult patients with hematologic cancer: an integrative literature review. In: Oncology Nursing Forum, vol. 42, no. 3 (2015). https://doi.org/10.1188/15.ONF.283-291
12. Ortiz-Comino, L., et al.: Factors influencing quality of life in survivors of head and neck cancer: a preliminary study. In: Seminars in Oncology Nursing, vol. 38, no. 4, p. 151256. WB Saunders (2022). https://doi.org/10.1016/j.soncn.2022.151256
13. de Queiroz, D.A., da Costa, C.A., de Queiroz, E.A.I.F., da Silveira, E.F., da Rosa Righi, R.: Internet of things in active cancer treatment: a systematic review. J. Biomed. Inform. **118**, 103814 (2021). https://doi.org/10.1016/j.jbi.2021.103814
14. Rossen, S., Kayser, L., Vibe-Petersen, J., Christensen, J.F., Ried-Larsen, M.: Cancer survivors' receptiveness to digital technology–supported physical rehabilitation and the implications for design: qualitative study. J. Med. Internet Res. **22**(8), e15335 (2020). https://doi.org/10.2196/15335
15. Duman-Lubberding, S., van Uden-Kraan, C.F., Peek, N., Cuijpers, P., Leemans, C.R., Verdonck-de Leeuw, I.M.: An eHealth application in head and neck cancer survivorship care: health care professionals' perspectives. J. Med. Internet Res. **17**(10), e4870 (2015). https://doi.org/10.2196/jmir.4870
16. Ester, M., McNeely, M.L., McDonough, M.H., Culos-Reed, S.N.: A survey of technology literacy and use in cancer survivors from the Alberta Cancer Exercise program. Digital Health **7**, 20552076211033424 (2021). https://doi.org/10.1177/20552076211033426
17. Partners - BD4QoL. https://www.bd4qol.eu/wps/portal/site/big-data-for-quality-of-life/about-bd4qol/partners. Accessed 30 Nov 2022
18. Osoba, D., Rodrigues, G., Myles, J., Zee, B., Pater, J.: Interpreting the significance of changes in health-related quality-of-life scores. J. Clin. Oncol. **16**(1), 139–144 (1998). https://doi.org/10.1200/JCO.1998.16.1.139
19. Cocks, K., et al.: Evidence-based guidelines for interpreting change scores for the European Organisation for the Research and Treatment of Cancer Quality of Life Questionnaire Core 30. Eur. J. Cancer **48**(11), 1713–1721 (2012). https://doi.org/10.1016/j.ejca.2012.02.059
20. Chan, A.W., et al.: SPIRIT 2013 statement: defining standard protocol items for clinical trials. Ann. Intern. Med. **158**(3), 200–207 (2013). https://doi.org/10.7326/0003-4819-158-3-201302050-00583
21. Clinical Trials Transformation Iniciative. https://ctti-clinicaltrials.org/. Accessed 18 Oct 2022
22. Kapoor, A., Nambisan, P., Baker, E.: Mobile applications for breast cancer survivorship and self-management: a systematic review. Health Inform. J. **26**(4), 2892–2905 (2020). https://doi.org/10.1177/1460458220950853
23. Charbonneau, D.H., et al.: Smartphone apps for cancer: a content analysis of the digital health marketplace. Digital Health **6**, 2055207620905413 (2020). https://doi.org/10.1177/2055207620905413