Healthcare Transformation with Informatics and Artificial Intelligence
J. Mantas et al. (Eds.)

doi:10.3233/SHTI230500

Wearable Device Health Data Mapping to Open mHealth and FHIR Data Formats

Iris FALKENHEIN[a,c], Bianca BERNHARDT[a], Sonja GRADWOHL[a], Michael BRANDL[a], Rada HUSSEIN[b] and Sten HANKE[a,1]
[a] *University of Applied Sciences - FH Joanneum, eHealth Institute, Graz, Austria*
[b] *Ludwig Boltzmann Institute for Digital Health and Prevention, Salzburg, Austria*
[c] *Dräger Medical – Application Excellence, Lübeck, Germany*
ORCiD ID: Rada Hussein https://orcid.org/0000-0003-1257-4848, Sten Hanke https://orcid.org/0000-0003-3833-4252

Abstract. Health data collected by wearables and apps can be useful as part of patient-generated health data (PGHD) or personal health data for medical diagnosis or general health monitoring. Mobile health apps are more and more accepted, generate evidence and might be increasingly used in personal medicine. Data retrieved from wearables and apps are mostly not following a medical data standard and cannot be retrieved from the vendors in a straightforward way. The present work started the implementation of a Digital Health Convener and described the process to collect data from several wearables – starting with Fitbit data – and transforms this data to standardized JSON files following the Open mHealth (OmH) IEEE and the HL7 FHIR standard. The project achieved is provided as open source and can be extended and used in future projects to generate OmH and FHIR conform PGHD.

Keywords. PGHD, mHealth, OmH, FHIR

1. Introduction

PGHD can be used for better management of chronic conditions and improve quality of care as well as quality of life. Especially PGHD from wearables and mobile applications can lead the way to a completely new understanding of healthcare based personalized medicine [1]–[4]. The use of this data will lead to a shift in digital health, providing more objective, frequent and unbiased health information, which may currently lack quality, but recent developments have shown that evidence and medical device certification are on the rise [2], [3]. Acceptance and use in clinical settings is currently due to a lack of evidence as well as missing interoperability of data. Several vendors on the market offer different wearables and apps that capture PGHD in diverse and mostly proprietary data formats [2]. Moreover, it is often not straightforward to collect PGHD in a simple way. Existing projects and trials already experience similar issues. Gay et al. tried to integrate fitness data from multiple wearable devices into a fitness app but reported problems due to no standard conform data formats [5]. Khader et al. describe an attempt of integrating wearable data in real-time with a data dashboard and reported lacking standards [6]. In addition, Saripalle et al. report on an attempt of leveraging FHIR to integrate activity

[1] Corresponding Author: Sten Hanke, University of Applied Sciences - FH Joanneum, eHealth Institute, Graz, Austria. Email: sten.hanke@fh-joanneum.at.

data from wearables into an EHR [7]. For coherent use of data, vendors must comply with data standards and open APIs. Also, conveners must be able to provide transformation in commonly used data formats.

The current project examines the use of Fitbit exported personal health data and a transformation to the IEEE 1752.1-2021™ Standard for Open Mobile Health Data (OmH) [8] and Fast Healthcare Interoperability Resource (FHIR) [9]. The advantages of OmH for using the standard as an open architecture to improve individual- and population-level health have been demonstrated by Chen et al. [10].

Based in the findings, problems in the mapping between Fitbit generated health data and the mentioned standards are discussed.

The presented work is part of the Digital Health Convener (DH-Convener) initiative which aims to realise the concept of 4P medicine (personalised, preventive, precision and participatory medicine) by introducing a networked health model to integrate PGHD with electronic health records (EHR) [11].

2. The Health Data Mapper

Figure 1 shows the process flow of the presented project. Fitbit health data has been pulled from the API provided by Fitbit Charge 5 device. The data furthermore have been converted to IEEE OmH. Finally, different FHIR resources have been created allowing an interoperable exchange of PGHD from a Fitbit wearable.

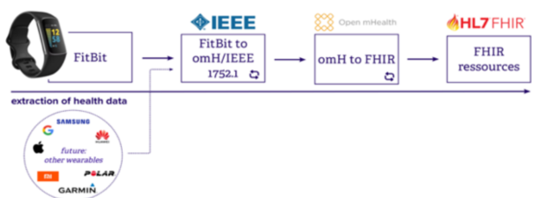

Figure 1. Planned standardization of fitness data formats with IEEE OmH/IEEE 1752.1 and HL7 FHIR.

An OmH to FHIR use case scenario where a patient provides health data to a primary care physician has been described under [12] and explains better a use case with the need of transforming data from FHIR to OmH. The general mapping between OmH and FHIR is explained under [13] and shows which OmH elements can be used in which FHIR observations. It explains the key implementation model and shows which parameters need to be mapped to which referring parameters.

Existing health data such as heart rate, bodyweight, body mass index and steps have been extracted from the Fitbit model Charge 5 using the Fitbit API. We started with some initial parameters to show the principle of the method. In next steps, the model can be extended with additional parameters provided by Fitbit or other wearables on the market e.g., sleep patterns, activity, etc.). The files with the mentioned parameters were exported as MyFitbitData.zip folder, and the unzipped folder contained parameters in the form of a JSON file that served as a starting point for the mapping [14].

The mapping was done manually using JOLT [15]. Figure 2 shows an easy example of a Fitbit (Input) to OmH (Output) mapping applying the operations shift and default in the JOLT Spec Transformation section. Shift is used to change the structure and keep values contained, default to add new fields to the output JSON. Following the process in Figure 1, the same would then have been done for OmH to FHIR.

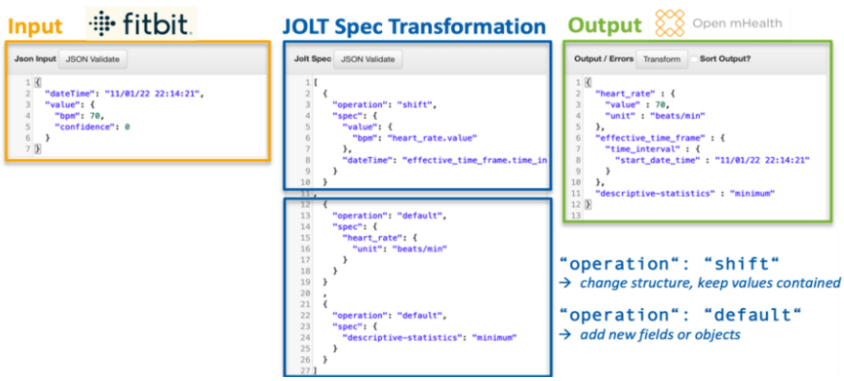

Figure 2. Easy example of a Fitbit to OmH mapping using JOLT transformation for one heart rate measurement.

For each parameter an OmH [16] and FHIR [17] JSON file was generated using the OmH Schema Library and FHIR Artifacts Summary. These files were then transferred into a Maven project with the tool IntelliJ to automize the entire mapping process. This makes it possible to parse even multiple JSON files exported from Fitbit and FHIR resource bundle containing several measurements in one JSON file in FHIR format.

In future, the IntelliJ project can be extended, and JSON files exported from other wearables can be joined. Furthermore, the project can be enlarged by other parameters wearables can provide. Both options would enhance the project and lead to a comprehensive mapper generating unified OmH files as well as FHIR bundles which can be stored in a standardized way in EHRs and be part of a personal PGHD repository.

3. Discussions and Conclusion

PGHD in future will be increasingly relevant for personalized medicine approaches, as they provide more objective and continuous data. In particular, PGHD of wearables and apps could be of interest in this context. However, these data mostly do not follow any standard and, at best, can only be accessed in a proprietary format via vendor API. Initiatives like RADAR-BASE already try to streamline the process of data collection here [17]. For storing PGHD in a common format, several standards exist such as IEEE OmH and FHIR. This paper describes a process and provides a model that can be extended and used to transfer data retrieved from a Fitbit wearable into internationally accepted standards. In terms of processing JSON files to different standards, a detailed analysis is required as to which PGHD can be stored in which format. It is recommended not to lose information through the transformation process. Especially OmH offers only a limited possibility to store PGHD. As well, FHIR follows an 80/20 approach, which means that edge cases and disagreements are kept out of the specification. The limitations of the approach described are basically two-sided and should be addressed in follow-up projects. First, the transformation of Fitbit JSON format to FHIR and OmH standard already causes the first loss of data, as not all Fitbit-provided features can be stored in FHIR or OmH. Secondly, it needs to be clear if several Fitbit JSON exports resolve in one or many FHIR resources. As well it needs to be considered in which granularity data need to be collected (e.g., to store the total steps taken on a day on FHIR or different values for activity phases etc.).

For future extensions, it might therefore be useful to use openEHR [18], a real and comprehensive data model, to store PGHD and provide OmH and FHIR transformations based on it. The project is available under Gitlab[i].

References

[1] Austin L, Sharp CA, van der Veer SN, Machin M, Humphreys J, Mellor P, et al. Providing “the bigger picture”: Benefits and feasibility of integrating remote monitoring from smartphones into the electronic health record. Rheumatol (United Kingdom). 2020;59(2):367–78, doi: https://doi.org/10.1093/rheumatology/kez207.

[2] Subramaniam R, Sanjeev R, Kuruvilla S, Joy M, Muralikrishnan B, Paul Jargon: A barrier in case history taking? - A cross-sectional survey among dental students and staff. Vol. 14, Dental Research Journal. 2017. p. 203–8. doi: https://doi.org/10.4103%2F1735-3327.208763.

[3] Jim HSL, Hoogland AI, Brownstein NC, Barata A, Dicker AP, Knoop H, et al. Innovations in research and clinical care using patient-generated health data. CA Cancer J Clin. 2020;70(3):182–99. doi: https://doi.org/10.3322/caac.21608.

[4] Omoloja A, Vundavalli S. Patient generated health data: Benefits and challenges. Curr Probl Pediatr Adolesc Health Care. 2021;51(11):101103. doi: https://doi.org/10.1016/j.cppeds.2021.101103.

[5] Gay V, Leijdekkers P. Bringing health and fitness data together for connected health care: Mobile apps as enablers of interoperability. J Med Internet Res. 2015 Nov;17(11). doi: https://doi.org/10.2196/jmir.5094.

[6] Shameer K, Badgeley MA, Miotto R, Glicksberg BS, Morgan JW, Dudley JT. Translational bioinformatics in the era of real-time biomedical, health care and wellness data streams. 2017;18(September 2015):105–24. doi: https://doi.org/10.1093/bib/bbv118.

[7] Saripalle RK. Leveraging FHIR to Integrate Activity Data with Electronic Health Record. Health Technol (Berl). 2020;10(1):341–52. doi: https://doi.org/10.1007/s12553-019-00316-5.

[8] Estrin D, Sim I. Open mHealth architecture: An engine for health care innovation. Vol. 330, Science. 2010. p. 759–60. doi: https://doi.org/10.1126/science.1196187.

[9] Walinjkar A. FHIR Tools for Healthcare Interoperability. Biomed J Sci Tech Res. 2018;9(5):4–7. doi: https://doi.org/10.26717/BJSTR.2018.09.001863.

[10] Chen C, Haddad D, Selsky J, Hoffman JE, Kravitz RL, Estrin DE, et al. Making sense of mobile health data: An open architecture to improve individual- and population-level health. J Med Internet Res. 2012;14(4):1–10. doi: https://doi.org/10.2196/jmir.2152.

[11] Hussein R, Crutzen R, Gutenberg J, Kulnik ST, Sareban M, Niebauer J. Patient-generated health data (PGHD) interoperability: An integrative perspective. Public Heal Informatics Proc MIE 2021. 2021;228–32. doi: https://doi.org/10.3233/shti210154.

[12] Open mHealth to FHIR Use Cases [Internet]. FHIR & Open mHeahlth; [cited 2023 Mar 20] Available from: https://healthedata1.github.io/mFHIR/use_case.html.

[13] OMH to FHIR mapping [Internet]. FHIR & Open mHeahlth; [cited 2023 Mar 20] Available from: https://healthedata1.github.io/mFHIR/mapping.html#omh-to-fhir-mapping.

[14] Fitbit. Web API Reference [Internet]. Fitbit 2021; [cited 2023 Mar 23] Available from: https://dev.fitbit.com/build/reference/web-api/.

[15] Jolt Transform Demo Using v0.1.1 [Internet]. Publisher unknown; [cited 2023 Mar 24] Available from: https://jolt-demo.appspot.com/#inception.

[16] Open mHealth Schema library [Internet]. Open mHealth; [cited 2023 Mar 23] Available from: https://www.openmhealth.org/documentation/#/schema-docs/schema-library/.

[17] Radar-Base [Internet]. RADAR-base; [cited 2023 Apr 24] Available from: https://radar-base.org./.

[18] OpenEHR [Internet]. openEHR; [cited 2023 Mar 23] Available from: https://www.openehr.org/.

---

[i] https://gitlab.com/eHealthFHJoanneum/mhealthwrapper/