



Digital Health Interventions

Prof. Dr. Tobias Kowatsch

Professor for Digital Health Interventions, Institute for Implementation Science in Health Care, University of Zurich (UZH)

Affiliated Professor, Department of Informatics, UZH

Director, School of Medicine, University of St.Gallen (HSG)

Scientific Director, Centre for Digital Health Interventions, UZH, HSG & ETH Zurich

Lead Principal Investigator, Mobile Health Interventions, Singapore-ETH Centre, Singapore

Advisor, Center for Technology and Behavioral Health, Geisel School of Medicine, Dartmouth College, USA

Ordinary Member, Competence Centre for Rehabilitation Engineering and Science, ETH Zurich

24 May 2024

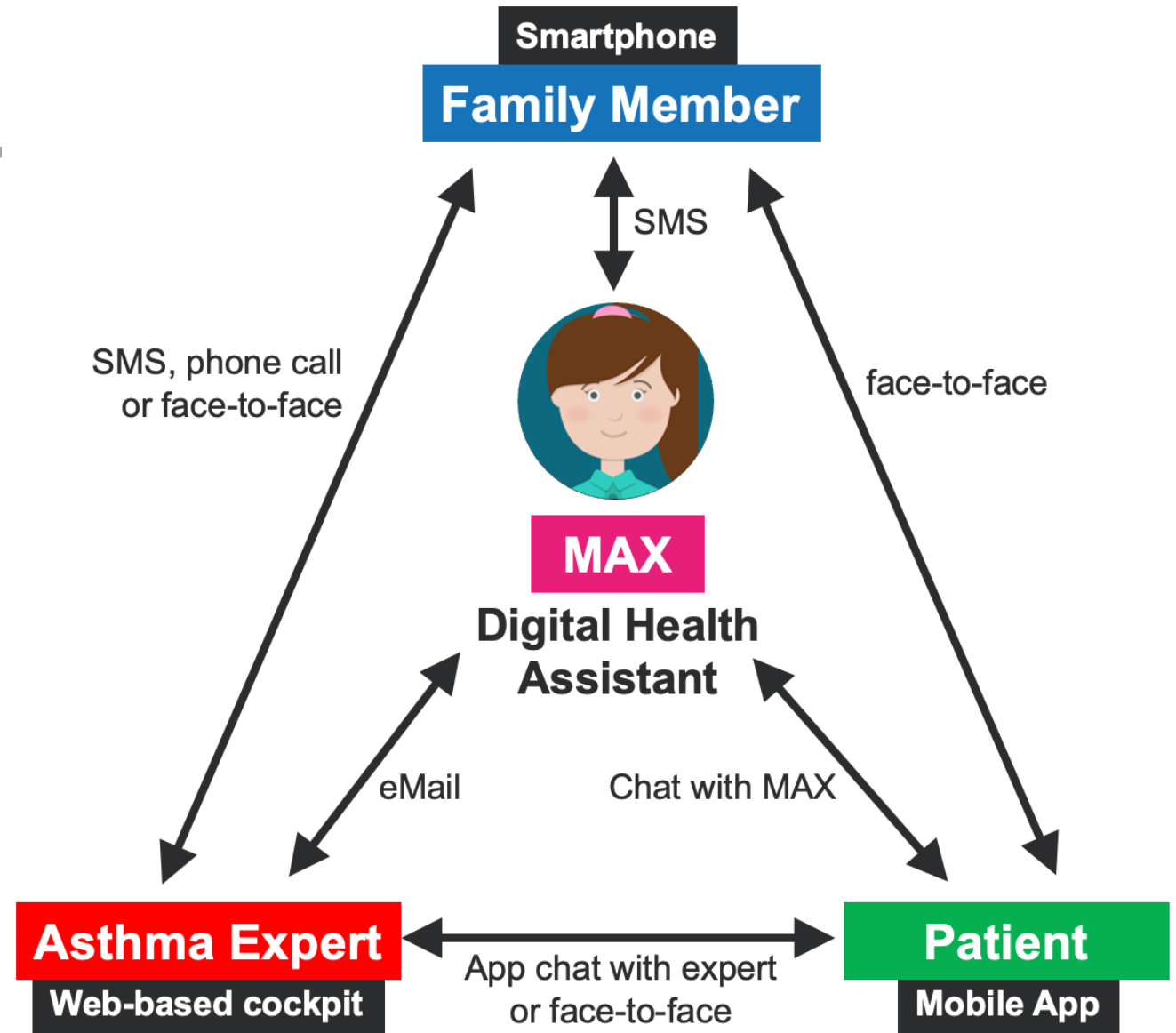
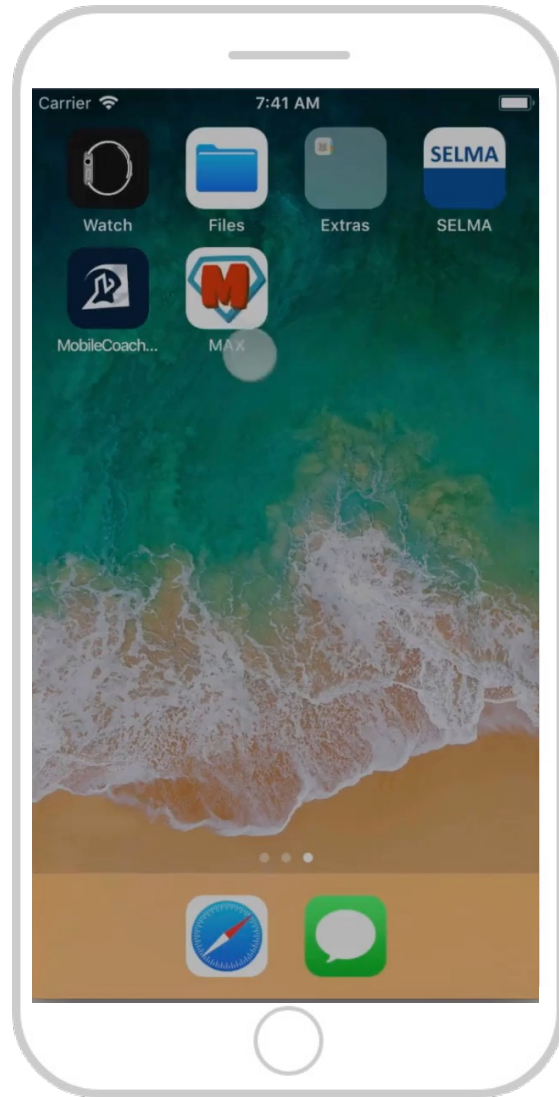


What is a Digital Health Intervention?



MAX, a digital health literacy intervention for children with asthma

Interaction with MAX



Kowatsch, T., Schachner, T., Harperink, S., Barata, F., Dittler, U., Xiao, G., Stanger, C., Oswald, H., Fleisch, E., von Wangenheim, F., Möller, A. (2021) **Conversational Agents as Mediating Social Actors in Chronic Disease Management Involving Health Care Professionals, Patients, and Family Members: Multisite Single-Arm Feasibility Study**, Journal of Medical Internet Research (JMIR) 23(2):e25060 [10.2196/25060](https://doi.org/10.2196/25060)

Inhalation assessment of Norah, 12

Informed consent was received from the patient and parent to use video, name, and age for presentation purposes

1. Video recording by family member



2. Expert rating

1. Konnten Sie das Video betrachten?

Ja Nein

2. Ist die Qualität des Videos gut genug, so dass alle kritischen Inhalations-Schritte zu sehen sind?

Ja Nein

Prima!

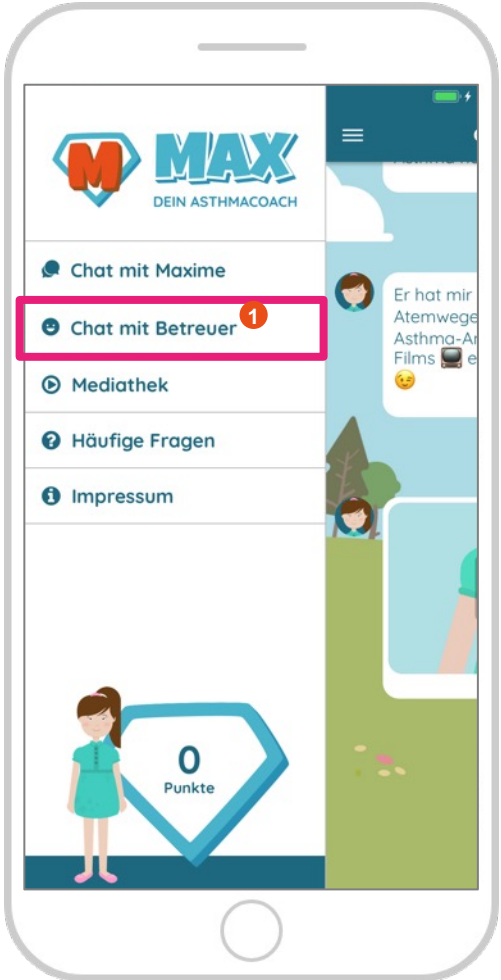
Bitte beurteilen Sie nun die Inhalation anhand der folgenden Fragen. Wurden Fehler möglichst kurzen und prägnanten Hinweis zur korrekten Inhalation im Kommentarfeld kurz und prägnant darauf hin.

3. Hat Nathi die richtige Körperhaltung, d.h. einen aufrechten Oberkörper, während der Inhalation?

Ja
 Nein
 Nicht im Video gesehen

+ Automated feedback generation based on inhalation guidelines

3. Feedback to Norah



Kowatsch, T., Schachner, T., Harperink, S., Barata, F., Dittler, U., Xiao, G., Stanger, C., Oswald, H., Fleisch, E., von Wangenheim, F., Möller, A. (2021) **Conversational Agents as Mediating Social Actors in Chronic Disease Management Involving Health Care Professionals, Patients, and Family Members: Multisite Single-Arm Feasibility Study**, Journal of Medical Internet Research (JMIR) 23(2):e25060 [10.2196/25060](https://doi.org/10.2196/25060)

MAX: Main results of the pilot study

1. The average **adherence rate** of **49 subjects** was **80.4%**.
2. The result of a **pre-post test** shows that **asthma knowledge** was **improved significantly** with a **large effect size** ($d=0.9$).
3. On average, **1 inhalation mistake** was identified in each **video clip**; **3 serious inhalation mistakes** could be directly **addressed and eliminated** by the experts' feedback.



Ladina

Nr. 5145

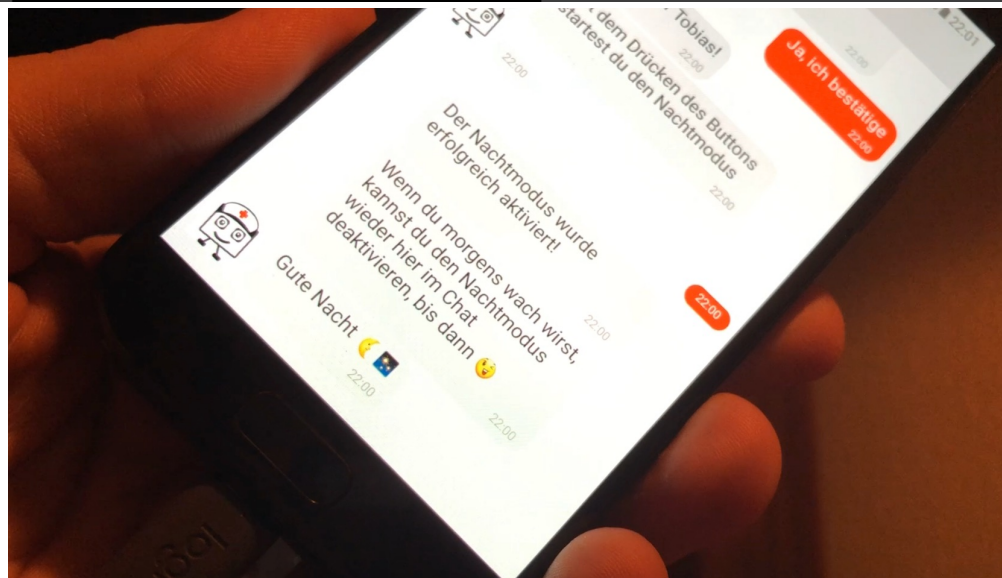
A formal definition

Digital health interventions deliver software-based interventions to prevent, manage or treat disease.

Jacobson, N., Kowatsch, T., & Marsch, L. (Eds.). (2023). *Digital Therapeutics for Mental Health and Addiction: The State of the Science and Vision for the Future* (1st ed.). Elsevier, Academic Press. [10.1016/C2020-0-02801-X](https://doi.org/10.1016/C2020-0-02801-X)
Kowatsch, T., & Fleisch, E. (2021). Digital Health Interventions. In O. Gassmann & F. Ferrandina (Eds.), *Connected Business: Create Value in a Networked Economy* (pp. 71-95). Springer International Publishing. [10.1007/978-3-030-76897-3_4](https://doi.org/10.1007/978-3-030-76897-3_4)
Kowatsch, T., Otto, L., Harperink, S., Cotti, A., & Schlieter, H. (2019). A design and evaluation framework for digital health interventions. *it - Information Technology*, 61(5-6), 253-263. [10.1515/itit-2019-0019](https://doi.org/10.1515/itit-2019-0019)
<https://dtxalliance.org/understanding-dtx/dtx-evaluation-toolkit/> & https://dtxalliance.org/wp-content/uploads/2023/06/DTA_FS_ISO-Definition.pdf

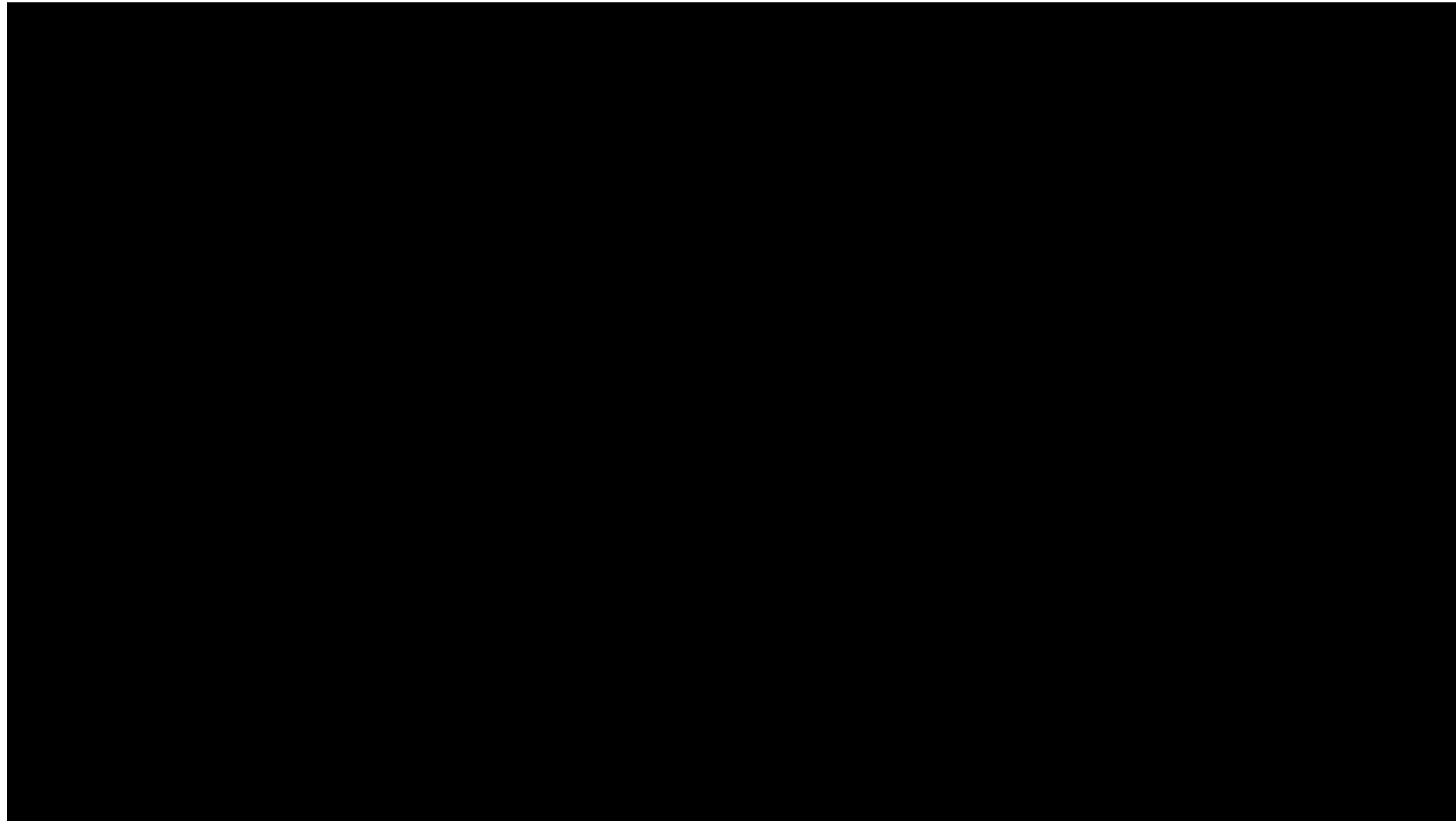


How does an **ideal**
digital health intervention
look like?



Design of a prognostic digital biomarker for asthma control




Asthma control and nocturnal cough



<https://www.c4dhi.org/projects/css-mobile-asthma-companion/>

Step 1: Cough Detection with Smartphones is Feasible

Automatic Recognition, Segmentation, and Sex Assignment of Nocturnal Asthmatic Coughs and Cough Epochs in Smartphone Audio Recordings: Observational Field Study

Filipe Barata ¹ ; Peter Tinschert ² ; Frank Rassouli ³ ; Claudia Steurer-Stey ^{4, 5} ; Elgar Fleisch ^{1, 2} ; Milo Alan Puhan ⁴ ; Martin Brutsche ³ ; David Kotz ^{1, 6, 7} ; Tobias Kowatsch ^{1, 2} 

Authors Cited by (21) Tweetations (4) Metrics

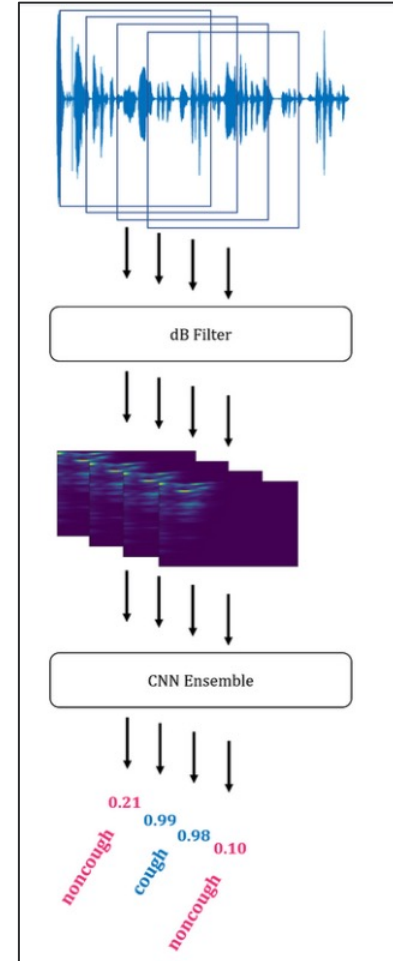
Abstract

Background:

Asthma is one of the most prevalent chronic respiratory diseases. Despite increased investment in treatment, little progress has been made in the early recognition and treatment of asthma exacerbations over the last decade. Nocturnal cough monitoring may provide an opportunity to identify patients at risk for imminent exacerbations. Recently developed approaches enable smartphone-based cough monitoring. These approaches, however, have not undergone longitudinal overnight testing nor have they been specifically evaluated in the context of asthma. Also, the problem of distinguishing partner coughs from patient coughs when two or more people are sleeping in the same room using contact-free audio recordings remains unsolved.

Objective:

The objective of this study was to evaluate the automatic recognition and segmentation of nocturnal asthmatic coughs and cough epochs in smartphone-based audio recordings that were collected in the field. We also aimed to distinguish partner coughs from patient coughs in contact-free audio recordings by classifying coughs based on sex.



Barata, F., Tinschert, P., Rassouli, F., Steurer-Stey, C., Fleisch, E., Puhan, M. A., Brutsche, M., Kotz, D., & Kowatsch, T. (2020). Automatic Recognition, Segmentation, and Sex Assignment of Nocturnal Asthmatic Coughs and Cough Epochs in Smartphone Audio Recordings: Observational Field Study. *J Med Internet Res*, 22(7), e18082. [10.2196/18082](https://doi.org/10.2196/18082)

Step 2: Prediction of asthma control and attacks?

Nocturnal Cough and Sleep Quality to Assess Asthma Control and Predict Attacks

This article was published in the following Dove Press journal:
Journal of Asthma and Allergy

Peter Tinschert^{1,*}
Frank Rassouli^{2,*}
Filipe Barata³
Claudia Steurer-Stey^{4,5}
Elgar Fleisch^{1,3}
Milo Alan Puhan⁴
Tobias Kowatsch^{1,3}
Martin Hugo Brutsche^{1,2}

¹Center for Digital Health Interventions, Institute of Technology Management, University of St. Gallen, St. Gallen, Switzerland; ²Lung Center, Cantonal Hospital St. Gallen, St. Gallen, Switzerland; ³Center for Digital Health Interventions, Department of Management, Technology, and Economics, ETH Zurich, Zurich, Switzerland; ⁴Epidemiology, Biostatistics and Prevention Institute, University of Zurich, Zurich, Switzerland; ⁵mediX Group Practice Zurich, Zurich, Switzerland

*These authors contributed equally to this work

Introduction: Objective markers for asthma, that can be measured without extra patient effort, could mitigate current shortcomings in asthma monitoring. We investigated whether smartphone-recorded nocturnal cough and sleep quality can be utilized for the detection of periods with uncontrolled asthma or meaningful changes in asthma control and for the prediction of asthma attacks.

Methods: We analyzed questionnaire and sensor data of 79 adults with asthma. Data were collected in situ for 29 days by means of a smartphone. Sleep quality and nocturnal cough frequencies were measured every night with the Pittsburgh Sleep Quality Index and by manually annotating coughs from smartphone audio recordings. Primary endpoint was asthma control assessed with a weekly version of the Asthma Control Test. Secondary endpoint was self-reported asthma attacks.

Results: Mixed-effects regression analyses showed that nocturnal cough and sleep quality were statistically significantly associated with asthma control on a between- and within-patient level ($p < 0.05$). Decision trees indicated that sleep quality was more useful for detecting weeks with uncontrolled asthma (balanced accuracy (BAC) 68% vs 61%; Δ sensitivity -12%; Δ specificity -2%), while nocturnal cough better detected weeks with asthma control deteriorations (BAC 71% vs 56%; Δ sensitivity 3%; Δ specificity -34%). Cut-offs using both markers predicted asthma attacks up to five days ahead with BACs between 70% and 75% (sensitivities 75 - 88% and specificities 57 - 72%).

Conclusion: Nocturnal cough and sleep quality have useful properties as markers for asthma control and seem to have prognostic value for the early detection of asthma attacks. Due to the limited study duration per patient and the pragmatic nature of the study, future research is needed to comprehensively evaluate and externally validate the performance of both biomarkers and their utility for asthma self-management.

Keywords: asthma, digital biomarker, nocturnal cough, sleep quality, asthma control assessment, asthma attack prediction

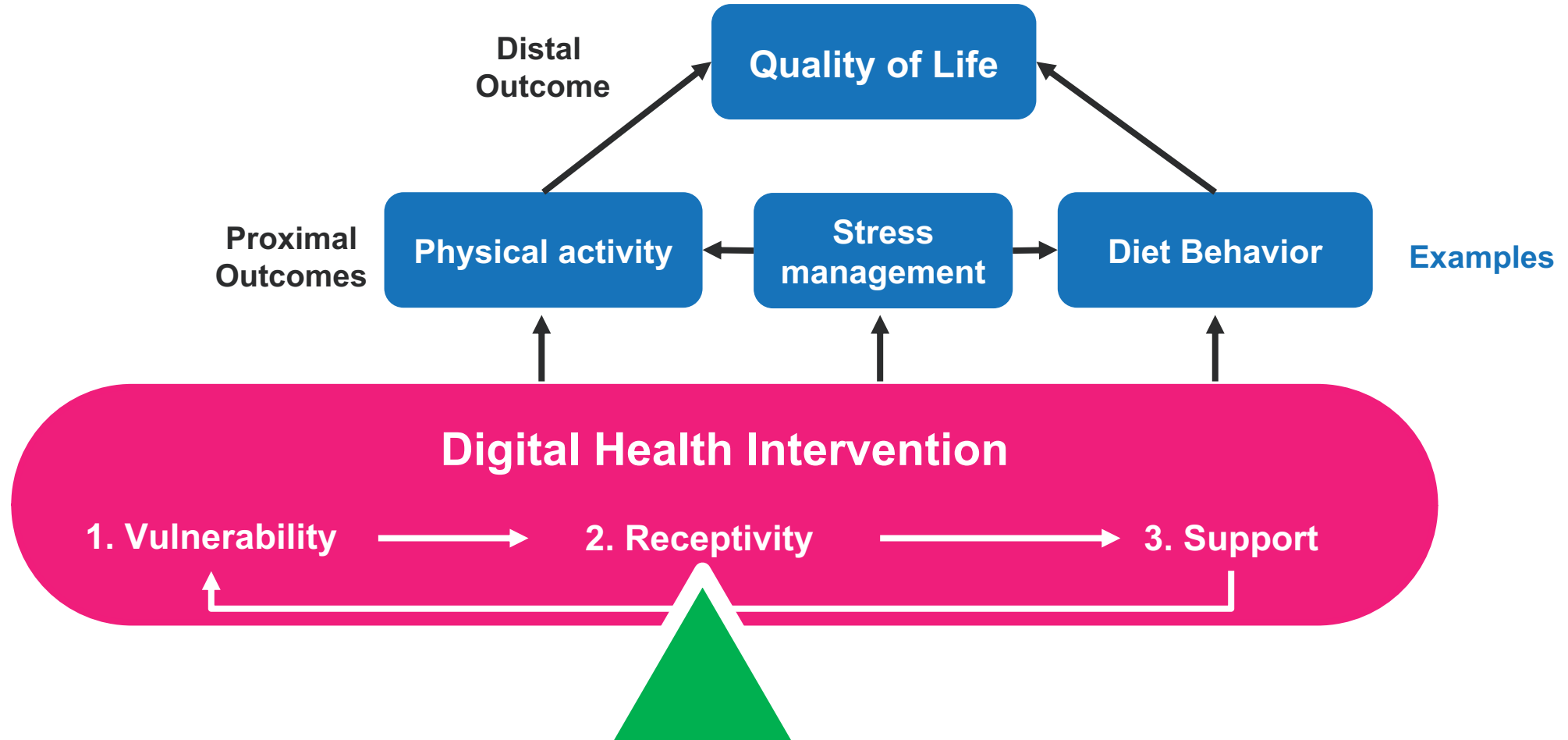


www.resmonics.ai

Tinschert, P., Rassouli, F., Barata, F., Steurer-Stey, C., Fleisch, E., Puhan, M., Kowatsch, T., Brutsche, M., **Nocturnal cough and sleep quality to assess asthma control and predict attacks**, Journal of Asthma and Allergy 13, 669-678 [10.2147/JAA.S278155](https://doi.org/10.2147/JAA.S278155).

Rassouli, F., Tinschert, P., Barata, F., Steurer-Stey, C., Fleisch, E., Puhan, M., Baty, F., Kowatsch, T., Brutsche, M., **Characteristics of Asthma-related Nocturnal Cough: A Potential New Digital Biomarker**, Journal of Asthma and Allergy 13, 649-657 [10.2147/JAA.S278119](https://doi.org/10.2147/JAA.S278119).

Anatomy of an ideal digital health intervention





Ally The **A**ssistant to **L**ift Your **L**evel of Activity



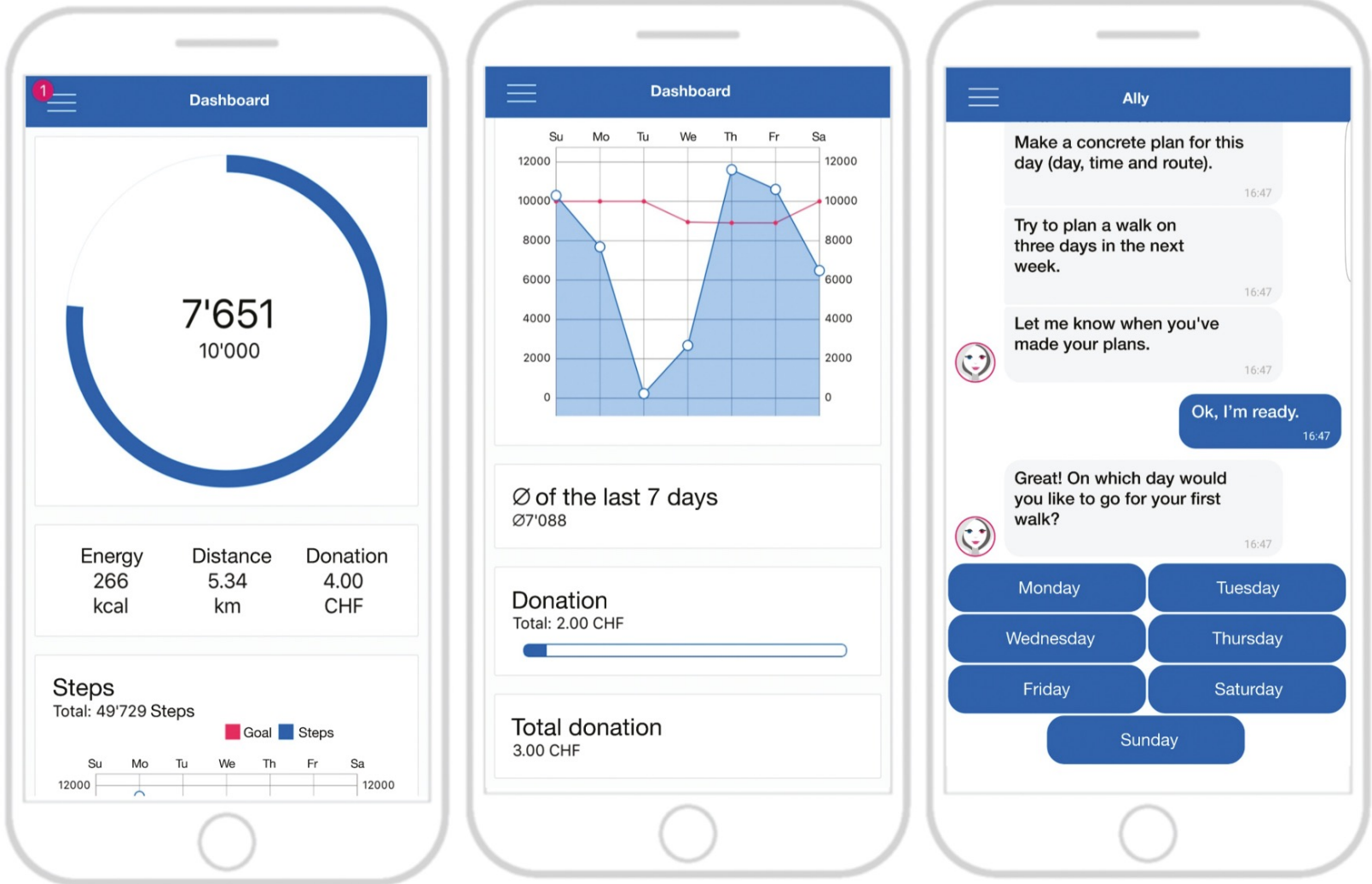
DARTMOUTH



University of
Zurich^{UZH}



The Ally App – Collecting state of receptivity data



Kramer, J., Künzler, F., Mishra, V., Preet, B., Smith, S.N., Scholz, U., Kotz, D.F., Kowatsch, T. (2019) Investigating Intervention Components and Exploring States of Receptivity for a Smartphone App to Promote Physical Activity: Protocol of a Microrandomized Trial, JMIR Research Protocols, 8(1), e11540 [10.2196/11540](https://doi.org/10.2196/11540)
 Kramer, J., Künzler, F., Mishra, V., Smith, S.N., Kotz, D.F., Scholz, U., Fleisch, E., Kowatsch, T. (2020) Which Components of a Smartphone Walking App Help Users to Reach Personalized Step Goals? Results from an Optimization Trial, Annals of Behavioral Medicine, [10.1093/abm/kaaa002](https://doi.org/10.1093/abm/kaaa002)

Results from the Ally Study

141 iOS and 48 Android users, 6 weeks, 3 notifications/interventions a day

Participants were more receptive if ...



10am-6pm (vs before 10 am
or after 6pm)



android



iOS

weekdays only



Smartphone was
unplugged (vs charging)



android



android

Android
(vs iOS devices)

Personalized prediction models?

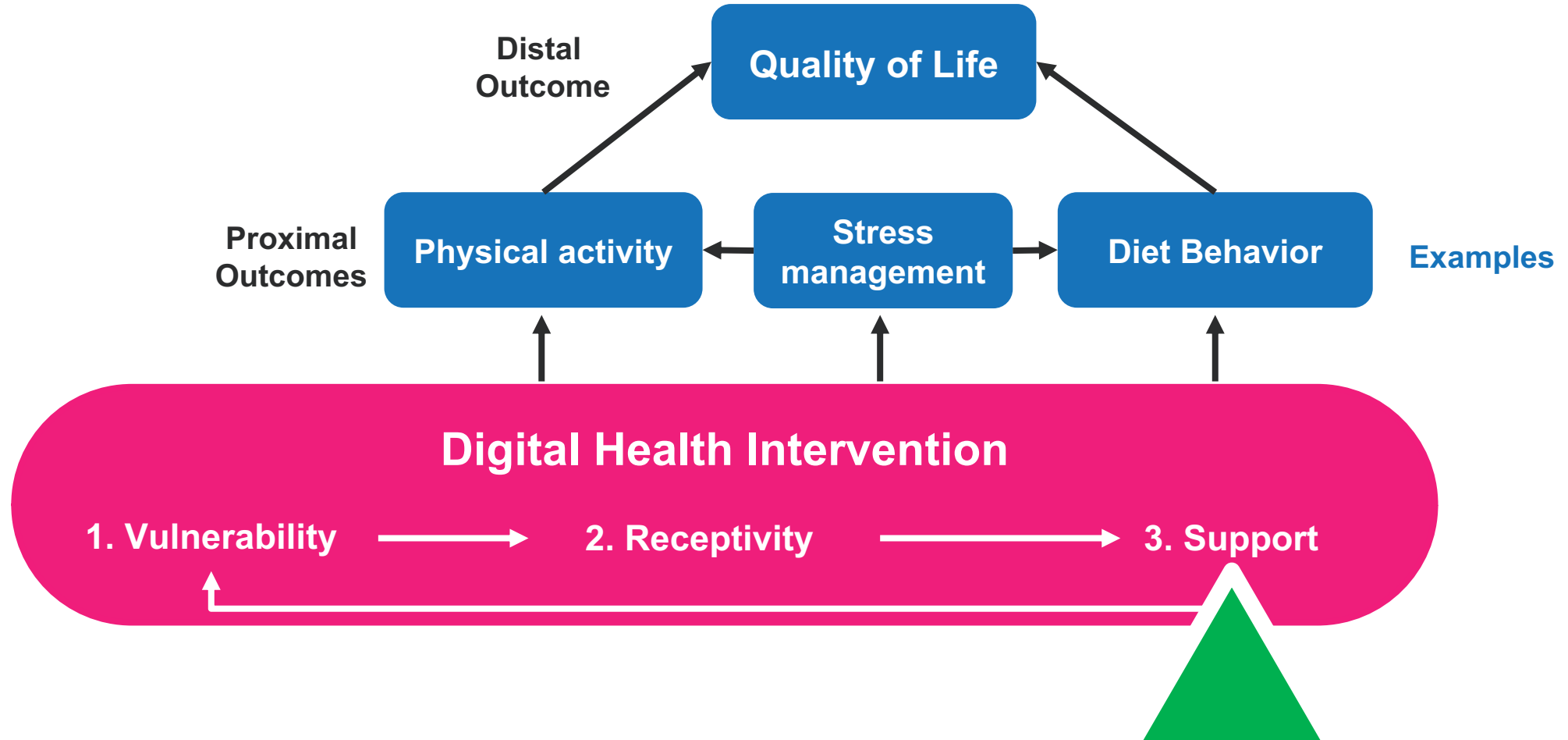
Mishra, V., Künzler, F., Kramer, J.-N., Fleisch, E., Kowatsch, T., & Kotz, D. (2023). Detecting Receptivity for mHealth Interventions. *GetMobile: Mobile Comp. and Comm.*, 27(2), 23–28. [10.1145/3614214.3614221](https://doi.org/10.1145/3614214.3614221)

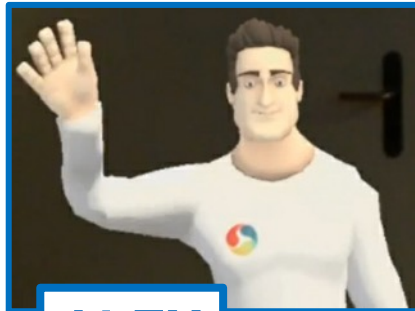
Keller, R., Wangenheim, F. v., Mair, J., & Kowatsch, T. (2023). Receptivity to mobile health interventions. In N. Jacobson, T. Kowatsch, & L. Marsch (Eds.), *Digital Therapeutics for Mental Health and Addiction* (pp. 65-77). Academic Press. <https://doi.org/10.1016/B978-0-323-90045-4.00006-X>

Künzler, F., Mishra, V., Kramer, J., Kotz, D.F., Fleisch, E., Kowatsch, T. (2019) **Exploring the State-of-Receptivity for mHealth Interventions**, Proc of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies (IMWUT) 3(4): Paper 140 [10.1145/3369805](https://doi.org/10.1145/3369805).

Mishra, V., Künzler, F., Kramer, J., Fleisch, E., Kowatsch, T., Kotz, D.F. (2021) **Detecting Receptivity for mHealth Interventions in the Natural Environment**, Proc. of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies (IMWUT), [10.1145/3463492](https://doi.org/10.1145/3463492)

Anatomy of an ideal digital health intervention





ALEX

Scalable treatment for individuals suffering from chronic back pain



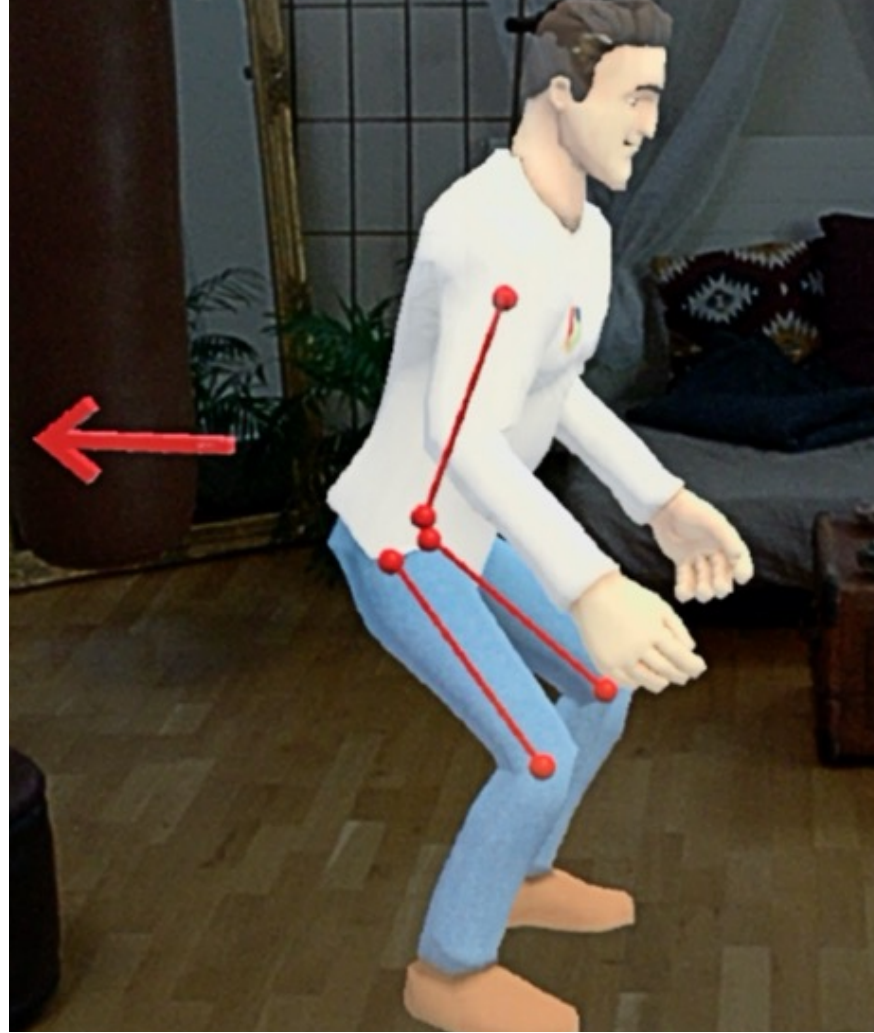
Applied Health Care



University of
Zurich^{UZH}



Interaction with ALEX



Kowatsch, T., Lohse, K.M., Erb, V., Schittenhelm, L., Galliker, H., Lehner, R., Huang, E.M. (2021) **Hybrid Ubiquitous Coaching With a Novel Combination of Mobile and Holographic Conversational Agents Targeting Adherence to Home Exercises: 4 Design and Evaluation Studies**, *Journal of Medical Internet Research*, 23(2):e23612, [10.2196/23612](https://doi.org/10.2196/23612)

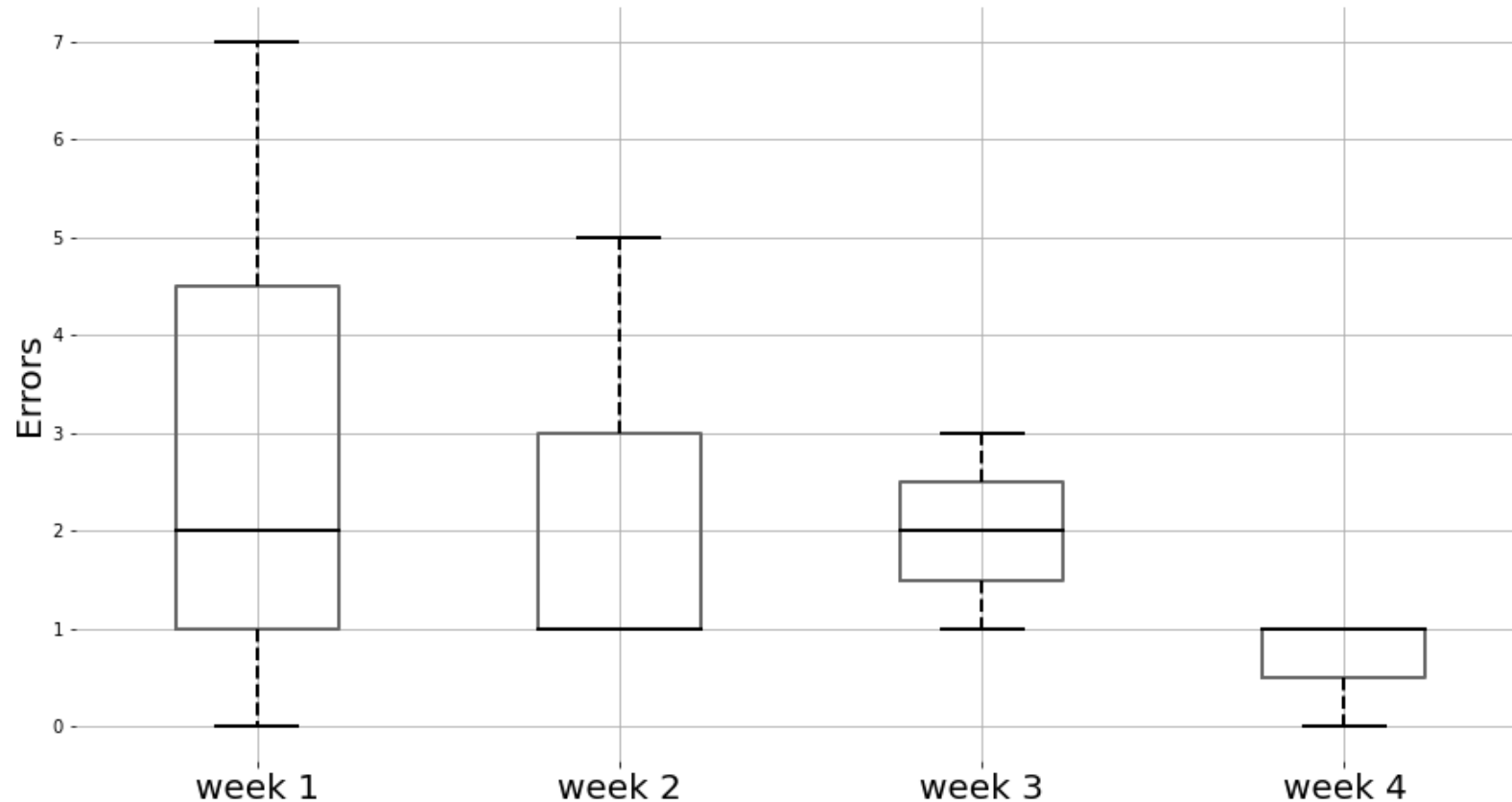
ALEX

Der digitale Physiocoach

Stand upright and press the trigger to start.

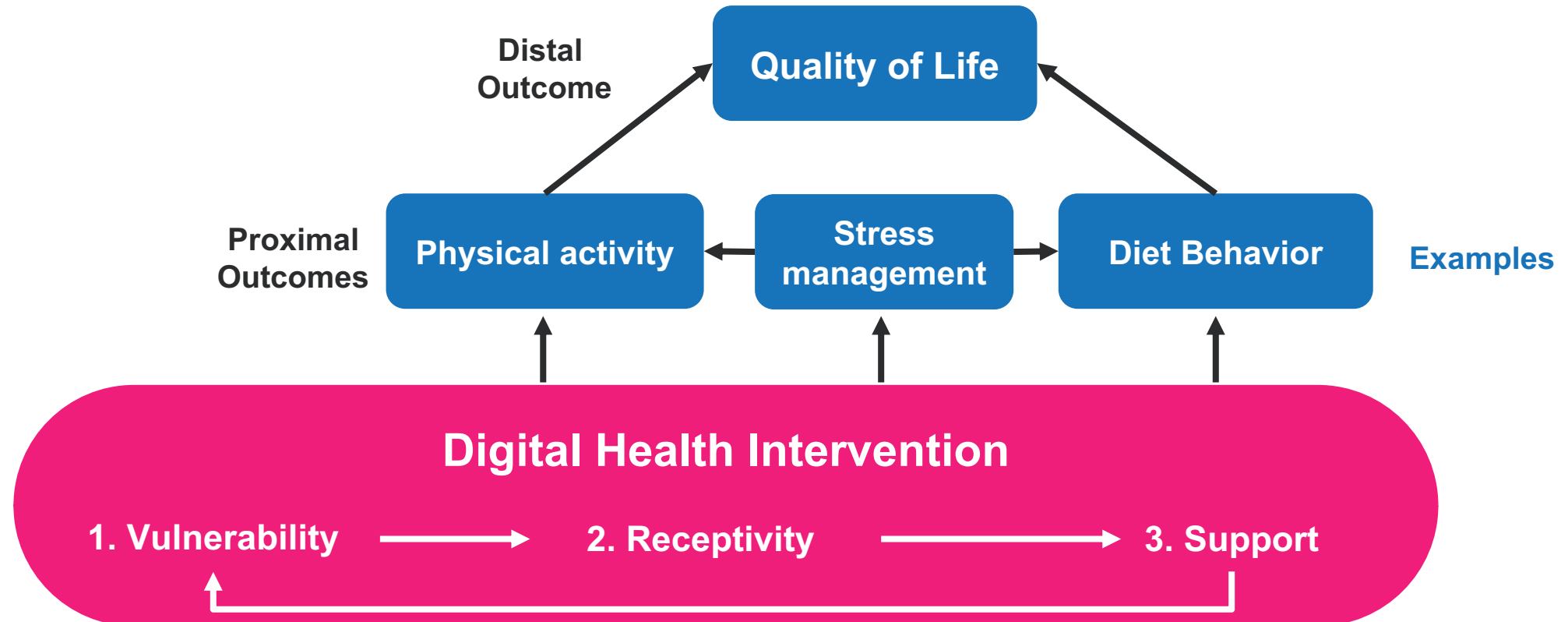
Results from the 4-week intervention in the field (N=1)

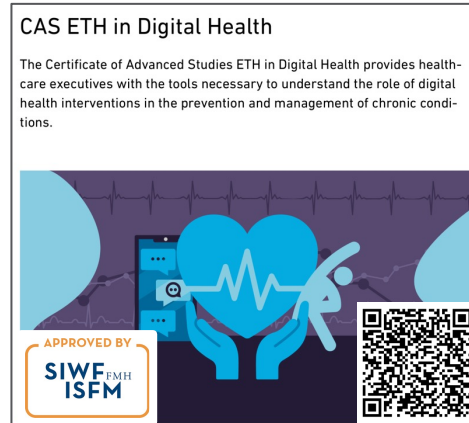
Box plot of the exercise execution errors during the 4 weeks. The number of errors was aggregated for each week.



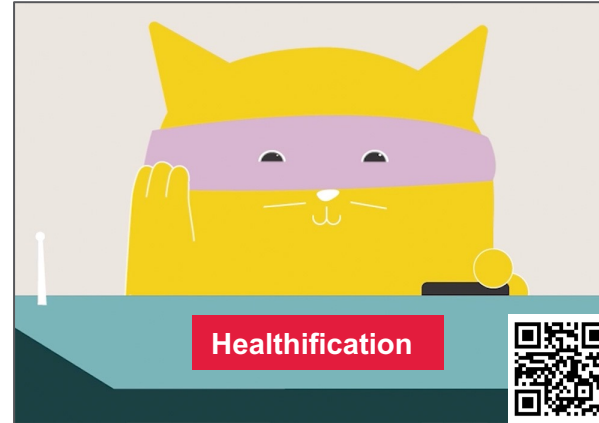
Kowatsch, T., Lohse, K.M., Erb, V., Schittenhelm, L., Galliker, H., Lehner, R., Huang, E.M. (2021) **Hybrid Ubiquitous Coaching With a Novel Combination of Mobile and Holographic Conversational Agents Targeting Adherence to Home Exercises: 4 Design and Evaluation Studies**, *Journal of Medical Internet Research*, 23(2):e23612, [10.2196/23612](https://doi.org/10.2196/23612)

Recap: Anatomy of an ideal digital health intervention

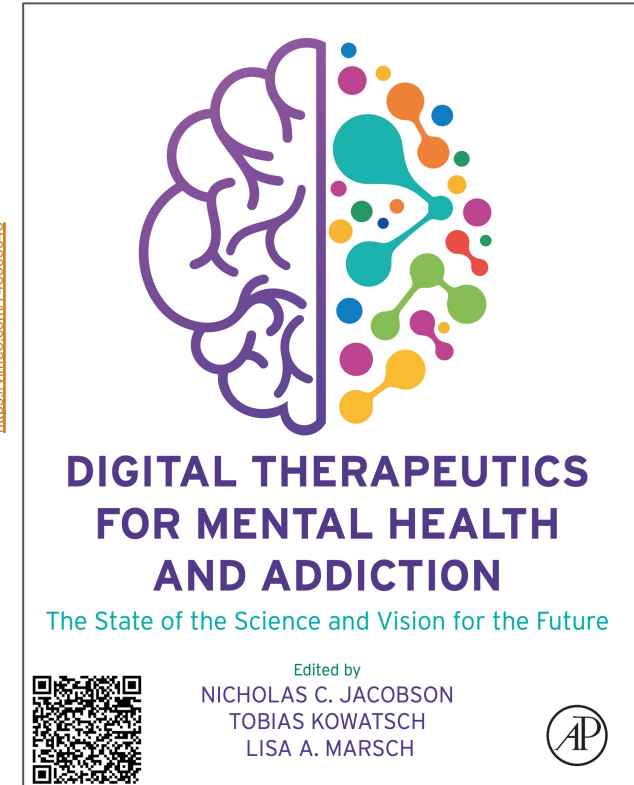




<https://mtec.ethz.ch/continuing-education/continuing-education-programmes/cas-digital-health.html>



<https://vimeo.com/748303043>



Prof. Dr. Tobias Kowatsch

Professor for Digital Health Interventions, Institute for Implementation Science in Health Care, University of Zurich (UZH)
 Director, School of Medicine, University of St.Gallen (HSG)
 Scientific Director, Centre for Digital Health Interventions, UZH, HSG & ETH Zurich, Switzerland
 Affiliated Professor, Department of Informatics, UZH
 Lead Principal Investigator, Mobile Health Interventions, Singapore-ETH Centre, Singapore
 Advisor, Center for Technology and Behavioral Health, Geisel School of Medicine, Dartmouth College, USA
 Ordinary Member, Competence Centre for Rehabilitation Engineering and Science, ETH Zurich, Switzerland
www.c4dhi.org | www.mobile-coach.eu | tobias.kowatsch@uzh.ch