Co-Funded by the Horizon 2020 programme of the European Union

Grant Agreement: 875358

Deliverable D8.1

Market Analysis

Work package:	WP8 – Exploitation, Business Modelling & Sustainability
Prepared By/Enquiries To:	Stefanos Venios – SUITE5
Reviewers:	Christine O'Meara – TSSG WIT Tom Flynn – TFC Research and Innovation Limited
Status:	Final
Date:	09/04/2021
Version:	1.0
Classification:	Public

Authorised by:

Gary McManus
WIT

Authorised date: 09/04/2021

Disclaimer:

This document reflects only authors' views. Every effort is made to ensure that all statements and information contained herein are accurate. However, the Partners accept no liability for any error or omission in the same. EC is not liable for any use that may be done of the information contained therein.

FAITH Project Profile

Contract No H2020-ICT-875358

Acronym	**FAITH**
Title	**a Federated Artificial Intelligence solution for moniToring mental Health status after cancer treatment**
URL	**https://www.h2020-faith.eu/**
Twitter	**https://twitter.com/H2020_Faith**
LinkedIn	**https://www.linkedin.com/company/faith-project/**
Facebook	**https://www.facebook.com/H2020.FAITH**
Start Date	**01/01/2020**
Duration	**42 months**

FAITH Partners

List of participants

Participant No	Participant organisation name	Short Name	Country
1 (Coordinator)	WATERFORD INSTITUTE OF TECHNOLOGY.	WIT	Ireland
2	UPMC Whitfield, Euro Care Healthcare Limited.	UPMC	Ireland
3	Universidad Politécnica de Madrid.	UPM	Spain
4	Servicio Madrileño de Salud.	SERMAS	Spain
5	UNINOVA, Instituto de Desenvolvimento de Novas Tecnologias.	UNINOVA	Portugal
6	Fundação D. Anna de Sommer Champalimaud e Dr. Carlos Montez Champalimaud.	CF	Portugal
7	Deep Blue.	DBL	Italy
8	Suite5 Data Intelligence Solutions Limited.	SUITE5	Cyprus
9	TFC Research and Innovation Limited.	TFC	Ireland

SC1-DTH-01-2019: Big data and Artificial Intelligence for monitoring health status and quality of life after the cancer treatment

H2020-SC1-DTH-2019

FAITH is co-funded by the European Commission - Agreement Number 875358 (H2020 Programme)

Document Control

This deliverable is the responsibility of the Work Package Leader. It is subject to internal review and formal authorisation procedures in line with ISO 9001 international quality management system procedures.

Version	Date	Author(s)	Change Details
0.1	30/09/20	Stefanos Venios (SUITE5)	Table of Contents defined
0.2	06/11/20	Stefanos Venios (SUITE5)	Table of Contents updated
0.3	19/01/21	Stefanos Venios (SUITE5), Christine O'Meara (WIT), Fernando Ferreira (UNINOVA)	Added content in sections 2.1, 3.3, 3.4, 3.6 and 3.8
0.4	08/03/21	Stefanos Venios (SUITE5), Vera Ferraiuolo (DBL), Samanta Villanueva, M.E. Beltran, Diego Carvajal (UPM)	Added content in sections 2.2, 3.1, 3.2 and 3.7
0.5	18/03/21	Stefanos Venios (SUITE5)	Added content in section 3.5
0.6	24/03/21	Stefanos Venios (SUITE5)	Added Executive Summary, Introduction and Conclusions
0.7	29/03/21	Stefanos Venios (SUITE5)	Updates in all sections Final Draft Version
0.8	08/04/2021	Stefanos Venios (SUITE5), Fernando Ferreira, Joao Giao (UNINOVA), M.E. Beltran (UPM), Christine O'Meara – TSSG WIT	Final Version Incorporating Reviewers Comments
0.9	09/04/2021	Tom Flynn (TFC)	Review and QA'd version
1.0	09/04/2021	Gary McManus (WIT)	Final release for submission to European Commission portal

Executive Summary

Objectives:

The present deliverable is the result of the execution of a market analysis process, mainly in the areas of mHealth apps and mental health support apps, which would naturally be among the first identified by our project and of interest for the targeted market sectors with potential competitors or collaborators. The deliverable also explores the particularities of the natural language processing market, the activity tracking apps market, the sleep tracking apps market and the nutrition tracking apps market. We believe that the exploration of such markets could give us an understanding of the features that are most valued, and which are the main opportunities.

In the main section of the deliverable, a description of each market is given, as well as a forecast of the market evolution for the next 3-5 years. Additionally, for each market, market barriers and market opportunities are identified, and the competitive landscape is explored. We believe that starting from this deliverable and through our work and experience in FAITH, we shall obtain further knowledge and understanding in order to strengthen the position of FAITH's outputs, which are centred on the combination of AI based technologies and mental health monitoring. Presently, this combination does not exist in the market in its full envisaged potential.

In order to build the value proposition for the uptake of the project's key exploitable assets, we must also know who we are addressing in terms of possible users or buyers of our solution. Therefore, in the present deliverable we explore categories of stakeholders who could be interested in FAITH framework from a commercial point of view.

It needs to be noted, that as FAITH is a RIA project, a substantial amount of effort would be necessary in the post-project era in order to turn the direct outputs of the project into a market-ready product that shall be in a position to compete with the other solutions that exist. As a result, the consortium is following a structured approach that starts with analysing the market (present deliverable) and then will go on with defining the appropriate exploitation pathways and business plan, which will be constantly updated during the course of the project and is considered to be dynamic. This will allow to monitor the landscape of the market and identify the strong points and opportunities of the different FAITH outputs, which will provide to the consortium a clear idea on where, how and against whom to compete once the outputs reach the maturity levels necessary to enter the market.

Results:

The primary results of this deliverable are the:

- identification of market sectors interesting for FAITH, their outlook for the next 3-5 years and an overview of other solutions and competitors in each market sector;
- identification of stakeholders interested in FAITH framework from a commercial point of view.

ABBREVIATIONS & ACRONYMS

Term	Description
AI	Artificial Intelligence
CAGR	Compound annual growth rate
DoA	Description of the Action
FHIR	Fast Healthcare Interoperability Resources
GDP	Gross Domestic Product
GP	General Practitioner
ISO9001-2015	International Quality Management Systems
ML	Machine Learning
MVPA	Moderate-to-Vigorous Physical Activity
NLP	Natural Language Processing
RIA	Research & Innovation Action
RISE	Research & Innovation Staff Exchange
SME	Small-Medium Enterprise
SotA	State of the Art
WP	Work Package
WP2	Stakeholders identification, uses cases definition, requirements specification and architecture design
WPL	Work Package Leader

TABLE OF CONTENTS

TABLE OF FIGURES

LIST OF TABLES

1 Introduction

1.1 Scope of the Deliverable

The purpose of this deliverable (D8.1) is to present the results of the market analysis work carried out in WP8 "Exploitation, Business Modelling & Sustainability".

All partners who have been allocated effort in developing one or more parts of the overall FAITH solution (namely TSSG WIT, UPM, Suite5 and UNINOVA) have contributed to identifying, exploring and presenting market sectors related to FAITH. Furthermore, DBL in their role as coordinator of the work related to use cases and to identification of end-users and stakeholders, has curated parts of Section 2, in cooperation with Suite5.

1.2 Relation to Other Tasks/WPs

As seen in the project's exploitation approach already defined in the DoA [1], this deliverable is the first step of WP8, covering exploitation goals E2 and E4. More detailed layout of the exploitation plan, covering the exploitation goals up to the middle of the project (E1, E3 & E4) and initial considerations about business model definition (E5) will come in D8.2 deliverable, due at M18 of the project.

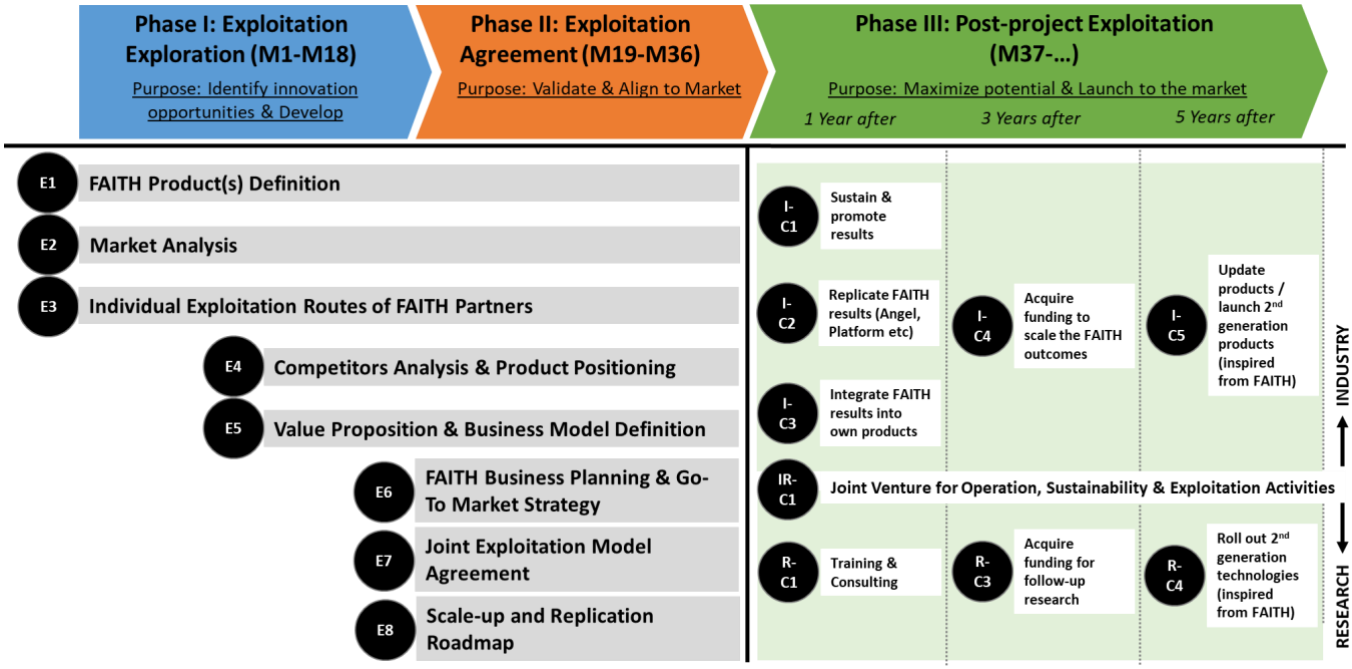

Figure 1 FAITH high-level exploitation approach

The deliverable at hand has used input from WP2, in particular D2.1 "Domain SotA & Data Assets" for the identification of other solutions in the market and D2.2 "FAITH Requirements, Methodology and MVP" related to the identification of stakeholders. It is expected to act as input for the next WP8 deliverables, namely D8.2 and D8.3, the two versions of "Business & Exploitation Plan". Finally, WP7 "Dissemination, Communication & Policy Engagement" and in particular Task 7.4 Industry Clustering & Policy Engagement, in cooperation with WP7 will

identify contact details, for example in the form of lobbyist organisations and patient coalitions and contact our stakeholders in an effort to validate our solution.

1.3 Document Structure

The deliverable at hand is structured as follows:

- **Section 2** presents the value chain and the stakeholders who could be interested in FAITH solution from a commercial point of view.
- **Section 3** provides, for each identified market, a description of the market, market forecasts, market barriers, market opportunities and a description of the competitive landscape.
- **Section 4** presents the conclusions of the current deliverable.

2 FAITH Stakeholders

2.1 Value Chain

The ultimate direct potential user of the overall FAITH solution will be the cancer survivors, the caregivers and the clinicians. However, there are also several stakeholders' part of a value chain that will also indirectly benefit from FAITH outcomes.

An individual who is successfully discharged from cancer treatment goes back to their life and begins their post recovery journey, in principle by trying to find a new balance (i.e. a 'new normal'). At this point, the consultations with clinicians (be it oncologists, GPs, psychologist, or other) become less frequent compared to that experienced during cancer treatment period and occur on an ad-hoc basis. It has been shown that the transition from cancer treatment to survivorship is often poorly managed. Poor communication between patients, caregivers, and providers may lead to unmet needs and healthcare decisions that are inadequately informed by patients' preferences and data [12]. Challenges and unmet needs, which can negatively impact mental health can pass unnoticed when in the post treatment phase of a patient's recovery. The FAITH mobile app helps the individual to identify such needs and clinicians to act upon them if necessary. In case the individual is doing well, therefore, the automated monitoring and advice offered from the app allows them to carry on; when, on the other hand, the situation tends to deteriorate, the intervention of clinicians is possible. Similar benefits are offered to the unofficial caregiver of the individual (e.g. spouse, next of kin, help at home, etc.).

The FAITH concept map (**Figure 2**) provides a visual representation of the current vision of the concept.

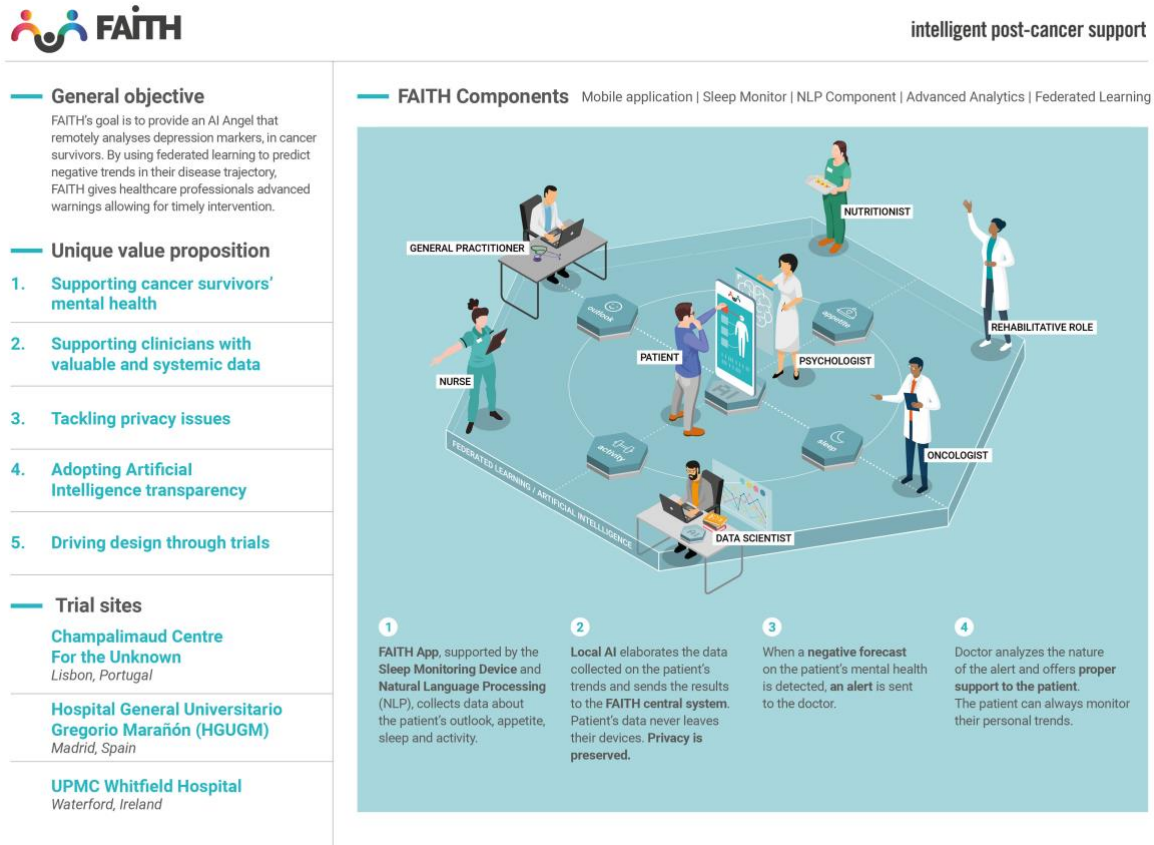

Figure 2 FAITH concept map [2]

For the clinicians and the hospitals, the benefits include the possibility to monitor a large number of cancer survivors at the same time, only focusing on those cases which tend to deteriorate and providing most of their efforts there. In addition, the constant flow of medical data contributes to more elaborate training of AI algorithms, which in turn tends to identify better the cases which might deteriorate, as well as propose more adequate intervention possibilities, by comparing with the results of similar interventions to patients with similar conditions in the past.

2.2 Stakeholders Involved and Relation to FAITH

The sections below identify the categories of stakeholders who could be interested in FAITH solution from a commercial point of view. In the context of WP7 "Dissemination, Communication & Policy Engagement" and in particular, Task 7.4 Industry Clustering & Policy Engagement, we will identify contact details, for example in the form of lobbyist organisations and patient coalitions and contact our stakeholders in an effort to validate our solution. FAITH as a RIA project, shall need a fair amount of effort in the post-project era to turn the direct outputs of the project into a market-ready product; as a result, the results of such engagement activities with interested contacts are expected to open markets already identified by FAITH in a more efficient manner.

2.2.1 Patients

Once they regain a certain degree of freedom, post-treatment cancer patients and their caregivers can struggle to maintain a steady follow-up process with their clinicians due to difficulties inherent to the lack of face-to-face consultations. This may hinder monitoring of patients' psychological well-being. Mental health may then deteriorate and lead to the occurrence of depressive symptoms, which can be undetected by medical professionals. Our solution will continuously monitor the well-being of the post-treatment cancer patient and will attempt to bridge the gap between medical staff and patients, therefore increasing the quality of life of cancer patients in their post treatment journey. This is thought to not only benefit the patients' well-being, but also easing the burden on their caregivers. Furthermore, it should help saving costs in the healthcare system by saving time and money incurred by unnecessary medical check-ups; by reducing hospital admissions (or at least lowering the risk of pain-related hospital admissions); and by providing care at an earlier stage of illness, if needed, due to early detection of symptoms. All of this without lessening the medical attention required by every patient.

2.2.2 Clinicians

Oncology professionals are part of a set of healthcare practitioners who follow the cancer patients' treatment and follow up. Because patients' mental health status has a strong influence on the effectiveness of treatment and the recovery of patients, the use of FAITH can contribute to the success of the oncological journey, avoiding costly reiteration of therapy, consultations, and medical care.

Psychologists collaborating in oncology have detected an incidence of depression and anxiety in cancer patients due to several causes, among them loss of resilience, deterioration of morale caused by emotional distress, and collateral effects from treatment. Adopting a solution like FAITH would allow psychologists to take patients into care at an earlier stage of distress, allowing shorter treatment cycles, which translates into less resources needed to provide the same level of effective care.

The FAITH project's solution could potentially bring a new opportunity for clinicians to verify the results of their diagnoses in a wider population of cancer survivors. Clinical decisions are becoming ever more evidence-based, relying on large quantities of research and clinical data. Today, doctors can make a diagnosis based on the data coming from a few cancer survivors. With FAITH, doctors' diagnoses results will be applicable and verifiable by a much larger cluster of cancer survivors in similar conditions, harnessing the potential of Big Data. Having access to data of a broader cancer patients' population will allow clinicians to convert data into relevant critical insights, helping make predictive use of healthcare analytics to prevent acute medical events and deterioration of patient's conditions.

2.2.3 Healthcare Providers / Healthcare Organisations

Healthcare providers and organisations spend a great deal of resources on cancer treatment. From physicians, nurses and technicians to equipment, the resources allocated to cancer-related medical purposes are often huge and competition is building in the cancer-care field. Hospitals and health systems are establishing new cancer centres in response to the projected increase in cancer diagnoses. As providers compete for patients, they also face the challenge of effectively marketing their cancer services to distinguish them from their competitors in terms of quality. FAITH will allow healthcare companies to improve aftercare analysis using new, efficient monitoring strategies which use the latest advanced AI and Machine Learning technologies. It opens a completely new window for hospital aftercare with respect to post cancer treatment and therefore helps them to gain market competitiveness.

2.2.4 ICT industry

IT equipment manufacturers in the IoT domain, for example sensor developers (e.g., sleep tracking sensors, activity tracking sensors/smartwatches/wristbands) can connect their sensors to FAITH (or can keep FAITH functionality in mind when developing new sensors). Interoperability is inherent in the FAITH framework, i.e., by the use of FHIR[1] standard when storing and exchanging medical data (health records) or by the publication of the interoperable component of the platform. Addressing interoperability engagement to enable different platforms and tools to communicate with the FAITH technology at semantic level will strengthen the outcomes of the project.

IT services providers in the field of eHealth could exploit FAITH functionality to detect depression signals and/or monitor the Well-being index of the patient and add it to their offering (for example by coming to a commercial agreement with FAITH consortium).

SMEs and the research community who specialise in AI and Big Data could be interested to see the results of ML algorithms applied in the case of FAITH framework or study the advancements in the NLP domain. Or even come to a commercial or research agreement with FAITH consortium to embed and test their own ideas in the FAITH AI component. Similarly, innovative SMEs and start-ups focusing on the hot topic of AI explainability might be interested in reviewing and tackling the challenge of feeding AI related results in such a complex domain such as healthcare.

[1] https://www.hl7.org/fhir/

3 Market Analysis

3.1 Scope of the Analysis

The FAITH goal is to create an innovative solution that uses Artificial Intelligence, based technologies to track targeted depression markers in cancer survivors to be able to monitor downward trajectories in these markers. Such mental health monitoring shall enhance patients' awareness of their own physio-psychological status and inform their point of care (formal or informal) of possible deterioration. By doing this, cancer survivors who begin to experience such declines get the chance to be more aware of their mental health situation, receive as early as possible intelligent post-cancer support, and therefore, in the end, improve their quality of life.

The main potential users of FAITH overall solution will be the cancer survivors, their caregivers and the clinicians. The patients are provided with mobile apps and sensors, the logic of which is linked to clinicians and health care organisations who are responsible for receiving patient info and, together with the help of data scientists, apply and optimise AI based algorithms on the collected data. The markers included in the mental health monitoring models cover four areas: outlook, sleep, activity and nutrition, and come in the form of data collected both directly from the mobile app without user intervention and from the patient herself in the form of replies to medical questionnaires.

Therefore, in the current section we present details not only for post-cancer treatment solutions and mental health support solutions, which would naturally be the among the first identified by our project as interesting market sectors with potential competitors or collaborators; but also for activity tracking, nutrition tracking, sleep tracking and natural language processing markets. We understand that the envisaged FAITH solution is not highly likely to stand up as a direct competitor in the activity tracking market, both because it shall have less features than, for example, MyFitnessPal and because its end goal would be very different than MyFitnessPal's goal. However, we believe that the exploration of such markets could give us a sense of what features their users are valuing the most and which are the main opportunities arising. Furthermore, well-established players in tangential markets could extend their offering to other sectors or applications.

The reader will also find a paragraph with an overview of the healthcare markets of today, as well as the outlook and expected evolution in the next years, mainly focused on Europe. It is foreseen that healthcare organisations shall incrementally evolve towards a loosely coupled architecture that will leverage the value of patient data across systems and to rapidly develop, change, and deploy patient-centric clinical and administrative workflows. The market for healthcare technologies is foreseen to grow and provide opportunities with significant changes and disruptions for the digital-service-enabled health, becoming more patient-centric, with AI-powered tools and virtual interactions between patients and care providers. Data-driven interoperability and personalised diagnostics will accelerate the delivery of predictive-analysis-driven precision care, paving the way for better and more efficient decision making for the patient and the providers. It is also foreseen that there will be a rise in investments related to health data integration, clinical software and applications, patient remote monitoring, patient digital experience, confirming a trend toward the acceleration of patient engagement plans, digital patient experience, and clinical efficiency across the healthcare ecosystem.

We believe, therefore, that through this market analysis exercise we can merge learnings from all markets presented in the following subsections towards positioning a solution and defining an exploitation strategy based on the combination of AI based technologies and mental health monitoring, which does not yet exist in the market in its full envisaged potential, in an effort to fulfil the innovation potential of this project.

3.2 Overview and Evolution of Healthcare Markets

Healthcare is in transition in Europe and worldwide; healthcare providers are working to fundamentally reform healthcare delivery models while having patients in the centre; their intention is to allow secure interaction anytime and anywhere, however in the context of value-based healthcare.

In this context, Europe is undergoing a major challenge in an effort to secure the financial sustainability of their health systems without undermining the values of universal coverage, solidarity in financing, equity of access and the provision of high-quality health care[2]; such a challenge, amongst other reasons, arising as a consequence of demographic change and increased longevity, which also have increased the prevalence of chronic conditions [2]. Furthermore, the importance of a robust health system in ensuring the well-being of EU citizens, is extended by the importance of healthcare as a key economic sector and a major employer in Europe. The healthcare sector directly spent in 2018 EUR 190 billion (or 1.3% of European GDP) on healthcare, another EUR 170 billion (or 1.2% of European GDP) is on social security programmes, while a further EUR 240 billion (or 1.6% of European GDP) is caused by indirect costs in the labour market, driven by lower employment rates and reduced productivity due to mental illness [3]. As for 2020, the share of GDP ranges from over 11% of GDP in some countries to less than 6% in others in the EU in 2020, but expected to increase due to the COVID-19 pandemic, while also accounting for 8% of the total European workforce [3].

In this context, since 2016 the EU recognised the need to reform health systems, while at the same time ensuring universal access to high quality healthcare including medicines; thus, to set actions to strengthen effective, accessible and resilient health systems[3] to provide high quality care while remaining cost-effective and fiscally sustainable. These needs have been recognised by policy makers [4] [5], such as the Economic Policy Committee, which have proposed a set of reform measures to address policy challenges in health and long-term care systems, including: strengthening health promotion and disease prevention; moving healthcare out of the hospital sector towards more cost-effective primary and ambulatory care services; and promoting integrated care. This is particularly important in the area of chronic diseases and also diseases as cancer, as areas of home care and residential care can act in a coordinated way with the aim to ensure cost-effectiveness and improve quality outcomes in long-term care situations.

In addition, the acceleration of medical innovations have increased demand for state-of-the-art treatments and more efficiency in healthcare from cost reduction terms to the notion of value-based healthcare; promoting a more holistic, person-centred or patient-centered care understanding of value [6]; also supporting patients and citizens to spend in good health those extra years of life gained through increased longevity (healthy life years is considered as an important measure of health and quality of life of populations).

These approaches are fundamentally reforming the healthcare delivery towards a patient-centric approach, enabling innovation in healthcare delivery, prevention and disease/post-disease management, integrating new services, transforming the patient experience, optimizing the operating models, integrating outcome-based care models that promote social and financial inclusion, as well as orchestrating internal and external resources to improve patient outcomes.

[2] Council of the European Union, 2006

[3] COM(2014) 215 final, https://ec.europa.eu/health/sites/health/files/systems_performance_assessment/docs/com2014_215_final_en.pdf

According to Market & Market research firm, the global healthcare IT market has been estimated to grow by CAGR of 15.8% from 2019 to 2024, reaching €324 billion by 2024[4]; the healthcare provider solutions segment being the one with highest expected CAGR growth in the forecast period. Tractica market intelligence firm, forecasted that global software revenue for healthcare AI use cases will surpass €7 billion annually by 2025[5] approximately 7% of the overall global AI market (estimated in €106 billion), although AI has been pushed back due to the privacy and ethical concerns. According to Grand View Research, the global Internet of Things (or IoT) healthcare market comprising wearables medical devices (e.g. blood pressure monitors) and in-hospital asset tracking (e.g. wheelchairs) will reach approximately €450 billion by 2025[6]. According to IDC market research intelligence firm, also opportunities in the market are driven by the following predicted trends[7]:

- In 2021, Real World Data (RWD) will support quantifying existing best practices and value in the life sciences, resulting in 50% of strategic insights; while the percentage of health organisations that will leverage technology to integrate all dimensions of health to deliver personalised care and demonstrate improved outcomes will grow by 50%.
- By 2022 it is expected that: 30% of pharma companies and 40% of healthcare providers will offer smartphone or smartwatch apps to improve medication adherence and patient engagement; about 20% of healthcare and 30% of life sciences organisations will support human-machine collaboration with AI and analytics.
- By 2023, clinical and business decisions will be supported by AI insights in 30% of health and life sciences organisations and human-machine collaboration and AI-driven interfaces will have driven disruption in the healthcare domain.
- By 2025, 40% of hyperconnected innovation will be driven by large-scale social, health, and environmental goals.

3.2.1 After Care and Home Care Market

The after-care market comprises the technologies and services of care that may continue after patients have been discharged of the hospital; thus, it is a temporary care to help patients back to normal and stay independent. This temporary care is also called intermediate care, reablement or aftercare. Most people receive this type of care in average for 1 or 2 weeks, although it can be provided for up to 6 weeks. When the after care is provided at home, it is so called home care.

According to the World Health Organisation (WHO) the home care aims at "*satisfying people's health and social needs while in their home by providing appropriate and high-quality home-based healthcare and social services, by formal and informal caregivers, with the use of technology when appropriate, within a balanced and affordable continuum of care [7]*". Like in healthcare, the demand and supply of home care demand and provision in Europe is influenced by the demographic, social, technological, epidemiological and political pressures. The demographic shifts in the population structure within the EU countries are increasingly demanding more home care services, while

[4] Markets and Markets, https://www.marketsandmarkets.com/Market-Reports/healthcare-it-252.html
[5] https://www.businesswire.com/news/home/20200106005317/en/Artificial-Intelligence-Software-Market-to-Reach-126.0-Billion-in-Annual-Worldwide-Revenue-by-2025-According-to-Tractica
[6] Grand View Research, https://www.grandviewresearch.com/industry-analysis/internet-of-things-iot-healthcare-market
[7] IDC Healthcare Predictions for 2019, https://www.idc.com/getdoc.jsp?containerId=prCHE47274521

the increasing proportion of old and very old people also impacts the tax base for funding public services and the available pool of formal and informal carers [8]. Due to these changes in ages and social structure it is foreseen that the demand for home care will increase, although it is required at a later stage of life than before, due to improvements in the quality of life, driven by improved lifestyle, food, personal hygiene and housing. Traditionally, home care provision across all European countries has relied historically on informal care (primarily family) mainly shifting to large-scale institutions and hospitals as providers, driven by changes in social attitudes, values and behaviours. For example, the fragmentation of the traditional large family group into small family units in an urbanised contexts reduce the number of people who can provide care to dependent family members; also greater internal mobility across Europe at all points during the course of life (working and retirement age) can create distances among family members and widen the care gap.

Home care is a labour-intensive activity that comprises a mix of professional and non-professional personnel, including nurses, therapists (physical, occupational and speech), home care assistants, social workers, physicians, dietitians, homemakers, companions, volunteers and others. Nurses represent the largest group of professional home care employees but in 2019 the services in EU were limited by a shortage of trained nurses.

In this context, Western Europe had the largest share of the global home healthcare and residential nursing care services market (43%) in 2020; higher than North America (33%). According to European Commission 2018 Ageing Report, public spending (on healthcare, long-term care, pension, etc.) the homecare market is expected to increase 1.7% to 26.7% of GDP from 2016 to 2070 [9] respectively. According to Grand View Research firm, the European home care market size was surpassed €70 billion in 2019 with a compound annual growth rate (CAGR) of 7.6% to 2027[8], driven by the aging population trend, the increasing incidence of chronic diseases including those with difficulty in mobility, dependent children with severe health problems or people with mental disorders. According to Market and Market the global home healthcare market size is projected to grow at a CAGR of 8.6% by 2025[9]. Main segments of this market comprise Home Care Testing, Monitoring and Screening, Home Healthcare Therapeutic Equipment, Mobility Assist & Other Devices, Nutrition and Fitness.

When looking at the diseases the home care market is segmented into cancer, respiratory diseases, mobility disorders, cardiovascular diseases & hypertension, pregnancy, wound care, diabetes, hearing disorders, and other indications. The diabetes segment is expected have the highest growth. The cancer segment is expected to continue growing as supportive Global Cancer Supportive Care Market 2020-2024 is expected to grow by 4%[10]. Home-based cancer treatment programs are carving out important roles in healthcare systems, supporting patients' outcomes and cost reductions.

The advancements in medical devices, pharmaceuticals, and services and innovations in technology are also making home care solutions affordable for people that are homebound and prefer medical care in the comfort of their homes, untapping the potential not only for the overall healthcare system but also to support the community-based independence for the individuals and patients. The increasing integration technologies (e.g. cameras, sensors, or other devices embedded in the residential infrastructure), both active (needed to be operated by individuals) or passive (not needed to be operated by an individual) are increasingly supporting the smart home care domain through monitoring

[8] Grand View Research, https://www.grandviewresearch.com/industry-analysis/europe-home-care-market
[9] Markets and Markets, https://www.marketsandmarkets.com/Market-Reports/home-healthcare-equipment-market-696.html
[10] https://www.businesswire.com/news/home/20200306005099/en/Global-Cancer-Supportive-Care-Market-2020-2024-Evolving-Opportunities-With-Amgen-Inc.-and-Baxter-International-Inc.-Technavio

and the provision of assistance in home care, such as physiological monitoring (active: devices can capture vital signs, weight, or symptoms and report them to a remote provider; or passive: home telemonitoring such as bed sensors that capture restlessness, sleep interruptions, or pulse and respiration during sleep), fall monitoring and emergency detection (e.g. active: devices that can detect falls and emergency buttons ; or passive: smart floors or carpets and can detect falls or near falls).

In this context, according to the Research and Markets firm[11], the Smart Home Healthcare Market is expected to register a CAGR of 26.5% over the forecast period 2020 - 2025. The increasing adoption of IoT devices is driving this market, growing the potential for healthcare services to be provided in a smart home. The smart devices were projected to reach 200 billion by 2020, according to Intel; connected homes can also help hospitals increase efficiency, prioritizing cases based on urgency and freeing-up beds. The AI and technology make advances, such as videoconferencing doctors, remote patient monitoring, potentially enabling smart homes as part of the primary care in the near future.

3.3 IT Solutions for Post-Cancer Treatment Market

The number of persons who are living beyond cancer diagnosis and treatment (also known as cancer survivors) is increasing each year as a result of the growth and aging of the population, as well as increases in survival rates due to changes in early-detection practices and treatment advances [10]. Cancer, therefore, is increasingly being regarded as a chronic disease due to the growing number of individuals who are living with cancer or surviving cancer with long-term symptoms and late effects of cancer treatment [11]. Cancer survivors develop increased physical, psychological and social issues. In addition to those, the transition from cancer treatment to survivorship is often poorly managed. Poor communication between patients, caregivers, and providers may lead to unmet needs and healthcare decisions that are inadequately informed by patients' preferences and data [12]. It has been identified that digital technologies can help. Several studies indicate the potential for smartphone apps to benefit cancer survivors [13]. In addition to that, there is growing political and clinical interest in using digital technologies to deliver efficient, high-quality care for cancer survivors and to empower patients to perform self-management activities.

In a review of 151 publicly available apps published in *BMJ Open* [11], the authors have characterised the apps based on their components, aims and technological features, helping to categorise and organise the apps in a way that clinicians, app developers and policy-makers can make sense of the current international app market. We believe the findings of this scoping review draw a rather good picture of the different segments of apps in the post-cancer treatment market. Therefore, we decided to share its key points in the present deliverable.

The apps offered contents that could be summarised under five main segments: (1) communicating information about cancer; (2) planning and organising cancer care; (3) interacting with others (including others affected by cancer and healthcare professionals); (4) enacting management strategies and adjusting to life with or beyond cancer and (5) getting feedback about cancer management.

[11] https://www.globenewswire.com/news-release/2021/01/06/2154442/0/en/Global-Smart-Home-Healthcare-Market-2020-to-2025-Growth-Trends-and-Forecasts.html

Communicating information about cancer

Over half the apps (53.6%) stated in their description that they provided information or educational material about cancer; for example, the nature of cancer, aspects of terminology related to cancer and cancer treatments. The apps presented this in various ways, including factsheets/written information, news feeds and updates, questions and answers, and videos. Some apps provided personalised information based on user-reported characteristics, including treatments received or disease subtype. Almost all apps claimed against being a medical device and suggested to their users to consult any results directly with their clinician.

Planning and organising cancer care

16.6% of the apps allowed users to enter and store records relating to their cancer care, such as results or diaries of treatments they had received. Apps also allowed users to keep a calendar of appointments, to keep lists and scheduling of medications.

Interacting with others

Being part of an on-line social network of individuals with cancer, healthcare professionals who answer questions, access to personalised information can greatly help in strengthening the individual's will and improve day to day life, therefore making this an important feature of apps related to cancer survivorship. 16.6% of the apps offered access to an on-line community (social network) of other individuals with cancer, promoting these networks as sources of support and information. Some of them advertised a matching service in which users could be matched with other users or groups based on characteristics such as cancer type, stage, treatments and interests. Apps also offered the ability to message or ask questions to professionals who were linked to the app platform.

Enacting management strategies and adjusting to life with or beyond cancer

19.2% of the apps allowed users to track their symptoms: mainly fatigue, pain, mood changes, nausea and sleep problems. Some suggested monitoring physical or physiological parameters, including pulse, blood pressure and weight, and some allowed customisation, letting the user decide which symptoms/parameters to monitor. The recommended frequency of self-monitoring varied, with some promoting weekly input, some apps suggesting on-demand tracking when symptoms were experienced, and others not specifying particular intervals for self-monitoring. Apps used a number of rating scales, including touch-screen sliders. 9.9% of the apps gave advice about diet and/or exercise after a cancer diagnosis, with five allowing users to track their exercise or dietary activities. A few apps offered integration with wearable fitness trackers.

Getting feedback about cancer management

13.9% of the apps allowed users who had tracked symptoms to generate graphical summaries of their self-monitoring data for personal reflection (usually line graphs showing, for example, pain levels plotted against date/time), and to generate output reports from the data, usually by email. A central premise was that users would learn about patterns within their symptoms, and that sending their symptom reports to professionals could result in action by the professional to help with symptom management.

The specific app functions that support each of the above segments are summarised in **Figure 3** below.

Survivorship activity	App feature	No (%) apps which advertised this feature
Imparting information about cancer	Delivers information about the nature of cancer, cancer terminology, treatment approaches and services. Apps present information as text, news feeds/ updates, videos and question/answer formats.	81 (53.6)
	Gives dietary and/or exercise advice, targeting individuals living with and beyond cancer.	15 (9.9)
Planning and organising cancer care	Upload and store personal records, for example, diaries/journals, results.	25 (16.6)
	Keep a list of medications±their scheduling.	20 (13.3)
	Share uploaded personal records with others.	8 (5.3)
	Keep a calendar of appointments.	12 (8.0)
	Login to view or change clinical appointments.	4 (2.7)
	Login to remotely access clinical records or results.	3 (2.0)
	Create or view survivorship care plan.	2 (1.3)
	Lists available clinical trials.	9 (6.0)
	Clinical trials matching.	1 (0.7)
Interacting with others	Access to an on-line cancer community or social network (four offered a matching service).	25 (16.6)
	List of local (geographically limited) sources of peer support.	11 (7.3)
	Message a linked healthcare professional.	4 (2.7)
	Ask a professional within an on-line community.	3 (2.0)
Enacting management strategies and adjusting	Track and record-specific symptoms or physiological parameters.	29 (19.2)
	Provides symptom management tips and advice.	5 (3.3)
	Set alarms as reminders to take medication.	14 (9.3)
	Track fitness or diet (four apps offered integration with wearable fitness trackers).	5 (3.2)
	Delivers instructions on complementary and/or alternative therapies.	12 (7.9)
	Delivers psychological therapies.	3 (2.0)
	Offers spiritual support, for example, bible verses, prayers.	2 (1.4)
Getting feedback about cancer management	Generates graphical summaries of self-monitoring data for personal reflection and sharing with others (particularly clinicians).	21 (13.9)
	Generates or supports creation of question prompt lists (intended to be used during medical encounters).	13 (8.6)
	Allows video or audio recording of medical consultations.	4 (2.7)

Figure 3 App functions that support main segments [11]

3.3.1 Market Forecast

The growing adoption of mHealth apps for tracking health and vital signs is likely to drive the mHealth apps market in the years ahead. Additionally, the increasing penetration of mobile devices, such as tablets, smartphones and wireless network devices are anticipated to further boost the mHealth apps market in the future. According to a report

from Zion Market Research[12], the global mHealth apps market was valued at approximately USD 8.0 billion in 2018 and is expected to generate around USD 111.1 billion by 2025, at a CAGR of around 38.26% between 2019 and 2025.

mHealth or mobile health refers to the use of mobile devices for healthcare services. mHealth apps are installed on mobile devices, such as smartphones, tablets etc. and can be used for general health and fitness tracking, remote patient monitoring, consultations, disease management, etc. It is estimated that over 200 health apps are added daily to app stores [11].

According to the report, North America accounted for about 40% share of the global mHealth apps market in 2017 and was the largest market in terms of revenue share. This can be due to the increasing adoption of mHealth apps for tracking health parameters and government focus to cut on healthcare costs. Europe is the second largest regional mHealth apps market, owing to the increasing penetration of mobile devices, growing adoption of mHealth apps for tracking vital signs, developed healthcare infrastructure, and high focus on precision/personalised medicine production. The Asia Pacific mHealth apps market is likely to register the highest CAGR over the forecast period, owing to a high prevalence of chronic diseases and a large population base.

3.3.2 Market Barriers

The development of a mHealth app from a financial point of view does not pose a significant barrier for market entry; as long as the stakeholder has the means to hire a development team, the app can be created and pushed to the market. This explains why in the market we can find both apps created by large enterprises, as well as apps created by small independent groups. The low entry market barrier is further highlighted by the availability of a vast number of mHealth apps online and the fact that more are created every month.

One possible barrier for entering the mHealth apps market is related to the privacy of the medical data that the individual shares with a mHealth app. In general, people are hesitant to share their medical data with an app, especially if it comes free of charge. In this case, it is assumed that the revenue stream of the app developers comes from harvesting medical data. There is increasing evidence that sharing of user data is routine in medical apps [14] and that data harvesting for targeted advertising is an important source of revenue for many app developers [15]. Effort must be made to prove that the medical data are safe when using the mHealth app.

Another barrier is the lack of trust of the individual in the contents in the app and the advice produced by it. Apps that provide education, monitor health or well-being, and store or transmit data without change are not subject to the same regulatory procedures with apps classed as medical devices (used to diagnose, support diagnosis or clinical decision-making or make calculations to determine diagnosis or treatment) [11]. These types of apps can be developed quickly by anyone who wishes to, without specific regulatory requirements. Effort must be made to prove that the app has been evaluated and verified in a real environment, with the inclusion of clinicians and patients in the trials phase.

[12] https://www.zionmarketresearch.com/news/mhealth-apps-market

To summarise, mHealth apps domain is challenging in terms of judging app quality, effectiveness, clinical utility and data privacy. In [11], the authors propose the Four D's to discuss with patients if they are considering using a health app:

- Does something useful—does it solve a problem you are having?
- Design—are there screenshots that summarise the content and give you an impression of how you would use the app?
- Developer—do you recognise a credible organisation/source behind the app, and do links to the developer website work?
- Data—does the app ask you for personal information that you would prefer not to be shared with others or provide a transparent description of how data will be used, stored and shared?

3.3.3 Market Opportunities

The most obvious opportunity is the fact that several studies indeed indicated the potential for smartphone apps to benefit cancer survivors, particularly interventions reporting results of a specific smart phone app with a particular group of cancer survivors, from children through young adults to older adults [13].

Linked to the market barriers discussed in the above sub-section, market opportunities arise for FAITH platform. Due to its design and the thinking behind the whole concept as described already in the DoA [1], the personal data of the individual never leave the device in order to be processed centrally. The level of security, therefore, is elevated compared to solutions that collect personal data (for any purpose) in a central point (e.g. cloud space). The aforementioned underserved AI applications highlighted by Tractica and related concerns of trust (mHealth apps vs medical devices) and privacy represent significant opportunities for this novel approach.

FAITH mobile app is set to undergo rigorous design approaches and its trials include the assessment of its use with an appropriate sample size of the target cancer survivor population. Furthermore, the funding from the EC, the consortium involved in its development and its organisational affiliations shall be transparent to the potential users of the app.

3.3.4 Overview of Solutions in the Market

Name	Description	Area	Funding/ Owner
Belong.Life[13]	An 'information sharing platform' between users, healthcare stake holders and publicly available information, featuring an on-line social network of individuals with cancer, healthcare professionals who answer questions, access to personalised information and a clinical trial matching service.	Cancer support, Post-cancer support	Private company (USA)

[13] https://belong.life/

Name	Description	Area	Funding/ Owner
	According to the description in the Google Play store, features include: • Access to leading oncologists, radiologists, researchers & nurses who answer your questions. • Assistance, tips, and support from a vast social network of others with cancer. • The ability to organise and manage your records on your mobile device and share easily with family and medical professionals. • The ability to personalise information and notifications. • Access to a robust clinical trial matching service specific to your type of cancer.		
Cancer.net Mobile[14]	Provides a fully featured set of tools to help manage your cancer care, as well as trusted, oncologist-approved information from Cancer.Net. Features include (selection from cancer.net webpage): • Export and share tracked data with healthcare providers, caregivers, and others. • Note symptoms and side effects. • Track questions for your doctors and record their answers. • Take photos of medication labels and bottles. Input dosage, frequency, and prescribing provider. Set reminders and log when medications are taken. • Up-to-date guides on 120+ types of cancer, including treatment, managing side effects, cost of care, and living with cancer, as well as the latest videos, podcasts, and Cancer.Net Blog posts.	Cancer support, Post-cancer support	American Society of Clinical Oncology (ASCO)
My Cancer Coach[15]	Provides information about personalised cancer treatments to help manage your cancer's progression. Questions about your stage of cancer, information on radiation, chemotherapy, risk of metastasis. Covers breast, prostate, and colon cancer patients and their caregivers. According to the description in the Google Play store, features include:	Cancer support	Private Company (USA) in partnership with Breast cancer.org,

[14] https://www.cancer.net/navigating-cancer-care/managing-your-care/cancernet-mobile

[15] https://www.mycancercoachapp.org/

Name	Description	Area	Funding/ Owner
	• Questionnaire and personalised treatment report • Questions to ask your doctor • Videos and other helpful resources such as links to patient advocacy websites • Easy-to-update journal with photo and audio-recording entry options • Calendar to help keep track of doctor appointments, support group meetings, and other important dates • Glossary of common terms		Men's Health Network, and Fight Colorectal Cancer
Vinehealth[16]	A mobile app to support cancer patients and their loved ones through treatment by allowing them to easily track, manage and understand their care. It supports people to understand their symptoms and side effects, and helps them to communicate with their care team. Has been developed with the help of patients and NHS oncologists.	Cancer support	Private Company (UK)

Table 1 Overview of other solutions in mHealth apps market

3.3.4.1 EU-funded projects

Below we have included a list related #EU (#H2020) projects that address post-cancer support. They are considered as potential competitors or collaborators. Over the course of the project our consortium aims to engage with other projects and form a cooperative relationship with as many as possible of the following identified projects.

Name	Description	Area	Funding/ Owner
BOUNCE[17]	BOUNCE will bring together modelling, medical, and social sciences experts to advance current knowledge on the dynamic nature of resilience as it relates to efficient recovery from breast cancer. BOUNCE will take into consideration clinical, cancer-related biological, lifestyle, and psychosocial parameters in order to predict individual resilience trajectories throughout the cancer continuum and eventually increase resilience in breast cancer survivors and help them remain in the workforce and enjoy a better quality of life. BOUNCE will deliver a unified clinical model of modifiable factors	Cancer support, Post-cancer support	RIA projects funded by the European Union (on-going)

[16] https://www.vinehealth.ai/

[17] https://www.bounce-project.eu/

Name	Description	Area	Funding/ Owner
	associated with optimal disease outcomes and will deploy a prospective multi-centre clinical pilot at four major oncology centres across Europe.		
ONCORELIEF [18]	Advances in early diagnosis and cancer therapy have greatly improved chances of cancer survival. A big challenge is to ensure survivors have the best possible quality of life. The EU-funded ONCORELIEF project is bringing together the latest technological advances and occupational psychology/health sciences. It is developing a user-centred artificial intelligence (AI) system to create an intuitive smart digital assistant called Guardian Angel. Not only will it provide personalised support in post-treatment activities and tasks, it will also suggest actions regarding the patients' overall health-status, improved well-being and active health-care. Ultimately, the Guardian Angel will help the cancer survivor remain engaged on a wellness journey that will safeguard their health during the post-cancer treatment period.	Post-cancer support	RIA projects funded by the European Union (on-going) (in the same call as FAITH)
LifeChamps[19]	Geriatric oncology, concerned with the diagnosis and treatment of cancer in the elderly, is an important subtopic. Improving outcomes hinges on many different factors, including the quality of services received. The EU-funded LifeChamps project aims to provide support to middle aged and older (pre-frail and frail) cancer patients. It has developed a big data-driven solution with an artificial intelligence (AI) and analytics engine that can offer timely and accurate clinical decision support. Operating on both the cloud and at the mobile edge, this new tool can identify the factors that affect quality of life of a patient. Ultimately, this offers personalised healthcare services as regards symptoms monitoring, treatment and rehabilitation. The project will conduct multinational pilot use case scenarios.	Post-cancer support	RIA project funded by the European Union (on-going) (in the same call as FAITH)
ASCAPE[20]	Cancer is a serious illness. Recent technological advances in Big Data, artificial intelligence (AI) and machine learning can help improve the quality of life of patients. The EU-funded ASCAPE project will create an open AI infrastructure for health stakeholders	Post-cancer support	RIA project funded by the

[18] https://oncorelief.eu/

[19] https://lifechamps.eu/

[20] https://ascape-project.eu/

Name	Description	Area	Funding/ Owner
	such as hospitals. New knowledge produced by this process will be sent back to the open AI infrastructure to be shared among everyone while the medical data will still remain private. The services to be designed and deployed by the project will include intelligent interventions for physiological and psychological support, improved patient and family counselling and guidance, early diagnosis and forecasts of ill health, identification of disease trajectories and relapse, as well as improved health literacy.		European Union (on-going) (in the same call as FAITH)
PERSIST[21]	The transition from cancer patient to cancer survivor should be planned and coordinated to ensure patients receive high-quality, coordinated and personalised care. The EU-funded PERSIST project is developing a system that supports self-care and can identify outcomes that require professional intervention. Its system uses big data technology and novel analysis algorithms that can be easily integrated into electronic health records and other sources of clinical data. Overall, the project aims to improve the management, intervention and prevention strategies to reduce side effects and prevent secondary diseases. Its long-term goal is to reduce the socio-economic burden related to cancer survivors' care by creating a dynamic decision support system and making maximum use of predictive models.	Post-cancer support	RIA project funded by the European Union (on-going) (in the same call as FAITH)
CLARIFY[22]	The number of cancer survivors has increased in recent years due to advances in diagnoses and treatment. Ensuring post-treatment quality of life of survivors remains a challenge. The EU-funded CLARIFY project will identify the risk factors for deterioration in a patient at the end of oncological treatment. Specifically, it will collect data about survivors from breast, lung and lymphoma cancer (the most prevalent types) from hospitals in Spain. Using big data and artificial intelligence techniques, it will integrate all data with relevant publicly available biomedical information, as well as information from wearable devices used after the treatment. The data will be analysed to predict patient-specific risk of developing secondary effects and toxicities from their cancer treatments.	Post-cancer support	RIA project funded by the European Union (on-going) (in the same call as FAITH)

[21] https://cordis.europa.eu/project/id/875406

[22] https://www.clarify2020.eu/

Name	Description	Area	Funding/ Owner
QUALITOP[23]	Cancer immunotherapy has helped to significantly advance cancer treatment. However, there remain two main challenges that hinder the path to better health and quality of life for cancer patients after starting immunotherapy. There is a need for predictive markers for immunotherapy-related adverse events as well as information on such patients beyond randomised controlled trials. To address these problems, the EU-funded QUALITOP project aims to develop a European immunotherapy-specific open smart digital platform. The platform will help identify the determinants of patients' health status, define patient profiles in a real-world context, and provide real-time recommendations. The project will thus enable better monitoring of the health and quality of life of cancer patients who are undergoing immunotherapy.	Post-cancer support	RIA project funded by the European Union (on-going) (in the same call as FAITH)
CAPABLE[24]	Coping with cancer treatments is a daunting task. Despite their benefit, strong therapeutic regimens often cause toxicity, severely impairing the quality of life of cancer patients. Patients and their caregivers also develop emotional, educational and social needs. The EU-funded CAPABLE project aims to develop a cancer patient coaching system with the objective of facing these needs. CAPABLE identifies unexpected needs while providing patient-specific decision support. This feature, together with the chance of discovering unknown adverse effects of new treatments, makes CAPABLE more than a personalised tool for improving life quality. It marks a significant advance for the whole research community.	Post-cancer support	RIA project funded by the European Union (on-going) (in the same call as FAITH)
BD4QoL[25]	The number of treatment options available for head and neck cancer (HNC) has increased in the last decade thanks to advanced technologies. While current post-treatment care plans focus on functional and health conditions, there are socioeconomic determinants of quality of life that also need to be addressed. The EU-funded BD4QoL project aims to improve HNC survivors' quality of life by developing a person-centred monitoring and follow-up plan. It will use artificial intelligence and Big Data collected from	Post-cancer support	RIA project funded by the European Union

[23] https://h2020qualitop.liris.cnrs.fr/wordpress/index.php/project/

[24] https://capable-project.eu/

[25] https://www.bd4qol.eu/wps/portal/site/big-data-for-quality-of-life

Name	Description	Area	Funding/ Owner
	mobile devices, in combination with multi-source clinical and socioeconomic data and patients' reported outcomes. Analysis of the quality of life indicators collected over time will facilitate early detection of risks, prevent long-term effects of treatment, and inform patients and caregivers for personalised interventions.		(on-going) (in the same call as FAITH)

Table 2 Overview of EU-funded projects in post-cancer support area

3.4 IT Solutions for Mental Health Support Market

As a result of the work already performed by the consortium during the first year of the project related to the health and mHealth domain State of the Art [16], a set of data assets has been identified; amongst them one can find a set of mental health support applications for smartphones. The data assets are available as part of the project's website in the following URL: https://dashboard.h2020-faith.eu/. This is a dynamic dashboard which is expected to be further enriched as the project progresses.

The main segments of the mental health support smartphone apps market are the following:

Mood companion/logbook

The "mood swing" phenomenon is a common concept used to describe rapidly and intensely fluctuating emotions. People often describe mood swings as a "roller coaster" of feelings from happiness and contentment to anger, irritability, and even depression [17]. A person may recognise something that has triggered a shift in their mood, such as a stressful event at work. But it's also not uncommon for mood swings to occur without an obvious cause. People may even experience changes in mood if they have an underlying mental health issue.

A mood companion (mood logbook) app pings the user to record their mood at certain times within the day, and also add how they are feeling, what they have been doing, what was the weather like, etc. Some apps (e.g., "Cogito Companion"[26]) even allow the user to record audio diaries that analyse how s/he speaks (not what s/he says) to give real-time feedback on your mood. With a mood companion you can keep track of your mood at the time you feel it, view your mood scores over time to see how they have changed, or stabilised, create yearly reports, etc.

Mental health chatbot (stress, depression & anxiety therapy)

Chatbots are systems that are able to converse and interact with human users using spoken, written, and visual languages. Chatbots have the potential to be useful tools for individuals with mental disorders, especially those who are reluctant to seek mental health advice due to stigmatisation [18]. Various stakeholders have developed artificial intelligence applications for mobile phones that aim to be the first line of support for mental health patients yet

[26] https://apps.apple.com/us/app/cogito-companion/id1159040768

provide privacy and anonymity (e.g. "Woebot"[27]). These applications, targeted at individuals, were developed to proactively check on patients, be ready to listen and chat anytime, anywhere, and recommend activities that improve the users' well-being. It is common that such mental health chatbots, in their paid version, are offered by large enterprises to their employees as a first line of support for personal and professional struggles.

AI assisted mental health monitoring/therapy

Mental health app offers cognitive behavioural therapy interventions for mental disorders such as depression, anxiety, and others. One challenge for clinicians in making diagnoses is that patient interactions only offer a snapshot of an individual's mental state, yet mood disorders are dynamic in nature and fluctuate over time [19]. Mental health applications, assisted by AI, are used by clinicians as tool to monitor mental health and support the therapy of patients (e.g. "MindDoc"[33]). AI may be combined with sensors and smartphone applications to enable increased monitoring in the community. Several smartphone applications have been developed which aim to improve adherence by giving reminders and helping patients keep track of their medications. The use of machine learning may facilitate continual improvement of such applications, including tailoring to the individual, to maximise their effect on medication adherence.

Mindfulness (connect with the present moment)

Mindfulness is a type of meditation in which you focus on being intensely aware of what you're sensing and feeling in the moment, without interpretation or judgment. Practicing mindfulness involves breathing methods, guided imagery, and other practices to relax the body and mind and help reduce stress. Mindfulness meditation is understood to aid individuals in coping with everyday personal and professional struggles by helping them to calm down and put things in perception.

Several apps have been developed, partly due to large demand from the general public as mindfulness has seen a lot of publicity and success during last years (e.g. "Mindfulness Coach"[28]). Such apps offer personalised meditation options, reminders to keep oneself mindful throughout the day, and statistics to track in one's meditation journal.

3.4.1 Market Forecast

Mental health disorder is being considered as an important health condition by the World Health Organisation (WHO), hence, various mental health related campaigns and awareness campaigns are being held all across the globe, pushing the mental health apps market to gain a significant lift.

Another factor driving growth of the metal health apps market is the presence of social stigma in the societies related to visiting a psychiatrist for receiving mental health treatment. According to WHO statistics, one out of four people struggle with mental health issues and two-thirds of those affected do not seek help for their issues.

[27] https://woebothealth.com/

[28] https://apps.apple.com/us/app/mindfulness-coach/id804284729

According to a report from Absolute Markets Insights[29] the mental health apps market accounted for USD 587.9 million in 2018 and is expected to generate a revenue of USD 3.918 billion by 2027, at a CAGR of 23.7% from 2019 to 2027.

3.4.2 Market Barriers

The development of a mental health support app from a financial point of view does not pose a significant barrier for market entry; as long as the stakeholder has the means to hire a development team, the app can be created and pushed to the market. Furthermore, apps that provide education, monitor health or well-being, and store or transmit data without change are not subject to regulatory procedures. The low entry market barrier is highlighted by the availability of a vast number of mental health support apps online and the fact that more are created every month.

3.4.3 Market Opportunities

Since products in this this market and the previous mHealth apps market come in the form of smartphone apps, the market opportunities for FAITH platform are similar to those presented in section 3.3.3:

- Elevated level of security for medical data elevated compared to solutions that collect personal data (for any purpose) in a central point (e.g. cloud space),
- Trials including the assessment of its use with an appropriate sample size of the target cancer survivor population, and
- Transparent funding sources, consortium members and organisational affiliations to the potential users of the app.

3.4.4 Overview of Solutions in the Market

Name	Description	Area	Funding/ Owner
Mindstrong Health[30]	A smartphone app to collect measures of people's cognition and emotional health through the usage of their phones. It monitors how the people use their phones, e.g. the way the person types, taps, and scrolls while using other apps. Data collected is encrypted and analysed remotely using machine learning, and the results are shared with the patient and the patient's medical provider.	Mental Health Support	Private Company (USA)
MindShift[31]	Anxiety management app which uses scientifically proven strategies based on Cognitive Behavioural Therapy (CBT) to help	Mental Health	Private Company

[29] https://www.absolutemarketsinsights.com/reports/Mental-Health-Apps-Market-2019-2027-362

[30] https://mindstrong.com/

[31] https://www.anxietycanada.com/resources/mindshift-cbt/

Name	Description	Area	Funding/ Owner
	learn to relax, develop more effective ways of thinking, and use active steps to take charge of anxiety.	Support, Anxiety	(Anxiety Canada)
IntelliCare[32]	Is a mental health app platform with 14 apps that are elemental, simple and brief to use. It is a suite of applications that have in common help people with depression and anxiety like sleep problems, social isolation, lack of activity and obsessive thinking.	Mental Health Support, Depression, Anxiety, Insomnia	
MindDoc[33]	Developed by clinical psychologists in close collaboration with leading researchers for those who want to learn about emotional well-being or who suffer from mild-to-moderate mental illness including depression, anxiety, insomnia, and eating disorders.	Mental Health Support, Depression, Anxiety, Insomnia	Private Company (Germany)

Table 3 Overview of other solutions in Mental Health Support apps market

3.4.4.1 EU-funded projects

Below we have included a list related #EU (#H2020) projects that address mental health, depression and anxiety. Over the course of the project our consortium aims to engage with other projects and form a cooperative relationship with as many as possible of the following identified projects.

Name	Description	Area	Funding/ Owner
Nevermind[34]	It addresses people who suffer from symptoms of depression related to a serious somatic disease. Collects data about mental and physical health from a smartphone and a lightweight sensitised shirt, to then get effective feedback. Collected data is monitored by a real-time Decision Support System running locally on the patient's smartphone, predicting the severity and onset of depressive symptoms, by processing physiological data, body movement, speech, and the recurrence of social interactions. The data triggers a response encouraging the patient to conduct or alter	Mental Health Support	RIA project funded by the European Union (finished)

[32] https://www.intellicare.net.ph/

[33] https://www.minddoc.de/; https://mymoodpath.com/en/

[34] https://www.marketing-nevermind.eu/

Name	Description	Area	Funding/ Owner
	activities or lifestyle to reduce the occurrence and severity of depressive symptoms.		
MindCare[35]	A mHealth solution that addresses the current lack of a real-time heath status monitoring for mental disorder patients. MindCare is a smartphone App that: 1) passively gathers data through a wearable device about the patient; 2) transforms the data into interpretable information using Artificial Intelligence (AI) for doctors, patients and caregivers; and, 3) integrates and displays the patient information, providing personalised information so that doctors and caregivers can quickly change the patient treatment or intervene at the right time.	Mental Health Support	RIA project funded by the European Union (finished)
MENHIR[36]	The MENHIR project aims to research and develop conversational technologies to promote mental health and assist people with mental ill health (mild depression and anxiety) manage their conditions.	Mental Health Support, Depression, Anxiety	RISE project funded by the European Union (on-going)

Table 4 Overview of EU-funded projects in mental health support, depression & anxiety area

3.5 IT Solutions for Activity Tracking Market

According to WHO, physical inactivity is considered a leading risk factor for premature death [20] [21]. Recognizing this fact, United States and United Kingdom public health authorities recommend that adults engage in at least 150 min per week of moderate-to-vigorous physical activity (MVPA) [22]. Such recommendations have made their way in modern activity tracking apps, for example Google Fit guides and prompts the user to collect 150 "heart points" per week, with "heart points" complying to the recommendations of the American Heart Association[37], or Apple Healthkit motivates individuals to "close" activity circles, which correspond to at standing up for at least for 1 minute for 12 times within a day, walking a distance that consumes 400 calories and doing a workout of 30 mins per day.

Apart from their applicability for medical reasons, for example by persons who have had surgery, activity tracking apps are also popular among the general public of healthy people. Even though many people do not comply with physical activity recommendations as stated by public health authorities, a lot of people engage in using activity

[35] https://cordis.europa.eu/project/id/865620

[36] https://menhir-project.eu/

[37] https://www.heart.org/en/news/2018/08/21/google-just-launched-heart-points-here-are-5-things-you-need-to-know

tracking apps, for one reason because these apps employ behaviour change techniques, which techniques make the interventions more likely to be effective. The roots are found in health behaviour change theory [23] [24] [25]. According to a study [26], an activity tracking app employs from 2 to 8 behaviour change techniques, with the average being 5 techniques. Self-monitoring, providing feedback on performance and goal setting were used most frequently, whereas some techniques such as motivational interviewing, stress management, relapse prevention, self-talk, role models, and prompted barrier identification were not, mainly due to the nature of a smartphone app.

Activity tracking apps are also very popular because they are available everywhere and can be personalised by the users to their needs, e.g., provision of tailored feedback at the time of conducting activity is more likely to be effective than generic information about the benefits of physical activity. Furthermore, they are available from the two main app marketplaces (Google Play and App Store) for free or for a low price, heavily promoted and with a bunch of ever-increasing and improving features. People carry smartphones with them and can access data anywhere and anytime, some apps work even without input from the user (i.e., recording activity while the user passively carries the smartphone with them), or without internet (i.e. collecting activity data locally on the device and synchronising with the user's profile and previously collected data once the phone is connected again to the Internet).

One cannot look into the activity tracking market without mentioning wearable fitness trackers and body sensors which can have great impact on healthcare systems and the quality of life. The accuracy and precision are subject of studies, but the outlook is rather positive; it appears the average accuracy is reasonable and can indicate the average level of activity and thus average energy expenditure [27].

3.5.1 Market Forecast

According to a Grand View Research [38], the global fitness app market size was valued at USD 4.4 billion in 2020 and is expected to expand at a compound annual growth rate (CAGR) of 21.6% from 2021 to 2028. The curfews and social distancing norms posed after the explosion of COVID-19 pandemic is driving a transition from traditional (e.g., gyms) to virtual fitness. An increase in the downloads and usage of fitness apps has been observed, as much as up to 46%, according to an article published in the World Economic Forum in September 2020. Awareness regarding health and wellness and the increased usage such activity tracking apps are the current global market drivers.

3.5.2 Market Barriers

Engagement with activity tracking apps is one of the main considerations; users are more likely to use the apps when the information is recorded automatically. Unfortunately, seamless recording (and perhaps need to capture frequently the location of the smartphone) drains the battery and poses privacy questions.

User experience is key: it is important to develop the mHealth technologies in a user-friendly and easily accessible manner, in order to encourage participants to record their data. Reliable apps that track and motivate patients' physical activity could assist healthcare practitioners with what would be otherwise lack of follow-up related to the condition of a post-treatment patient who has been release by the hospital. The development teams of mHealth apps should

[38] Grand View Research, https://www.grandviewresearch.com/industry-analysis/fitness-app-market

avoid what Norman calls 'featuritis'; a temptation to add more features to a single app that will ultimately weaken the app's usability [28].

Accuracy appears to be discussable: in a study they found that the accuracy of activity tracking smartphone apps was considered unacceptable when compared to a handheld pedometer [29].

3.5.3 Market Opportunities

The main opportunity of using activity tracking in the eHealth domain is to help healthcare practitioners offer support in a data-led fashion, by providing them with data collected from the patients' activity-monitoring tools. It is exactly this possibility which has pushed the development of smartphone applications with technologies that can obtain richer and more objective physical activity profiles.

A smartphone app which collets everyday data related to the patient's physical activity could eventually be used to deliver timely interventions to patients. Even more so, as envisaged in the context of FAITH project, collecting everyday data related to patients could end up building predictive model which, in turn, could be used to predict downtrends in the paths of other, or future, patients and not only those taking part in the trials.

Other than that, opportunities related to mHealth apps stand for activity tracking domain as well (see section 3.3.3).

3.5.4 Overview of Solutions in the Market

Activity tracking apps and fitness apps market is very wide and includes a vast number of apps. Since the primary goal of FAITH mobile app is not activity tracking, we decided to include in the following table some very basic solutions in the field, as references for valued features and usage rates.

Name	Description	Area	Funding/ Owner
Google Fit[39]	Google Fit is a health-tracking platform developed by Google for the Android operating system, Wear OS and Apple Inc.'s iOS. It is a single set of APIs that blends data from multiple apps and devices.[5] Google Fit uses sensors in a user's activity tracker or mobile device to record physical fitness activities (such as walking, cycling, etc.), which are measured against the user's fitness goals to provide a comprehensive view of their fitness.	Activity Tracking, Fitness app	Private company (USA)
Apple Activity on Apple Watch[40]	The Activity app on your Apple Watch keeps track of your movement throughout the day and encourages you to meet your fitness goals. The app tracks how often you stand up, how much you move, and how many minutes of exercise you do.	Activity Tracking, Fitness app,	Private company (USA)

[39] https://www.google.com/fit/

[40] https://support.apple.com/en-us/HT204517

Name	Description	Area	Funding/ Owner
		Wearable device	
Runtastic[41]	adidas Runtastic, formerly Runtastic GmbH, is a digital health and fitness company that combines traditional fitness with mobile applications, social networking and elements of gamification as a logical reaction to the Quantified Self movement.	Activity Tracking, Fitness app, Social network	Private company (Austria)
Garmin.Connect [42]	On mobile or web, Garmin Connect is the tool for tracking, analysing and sharing health and fitness activities from your Garmin device.	Activity Tracking, Fitness app, Wearable device	Private company (USA)
Fitbit Coach[43]	Stream personalised video workouts on your phone or computer, or a launch a workout anytime right on your wrist, with Fitbit Coach.	Activity Tracking, Fitness app, Video workouts	Private company (USA)
Strava[44]	Strava is an internet service for tracking human exercise which incorporates social network features. It is mostly used for cycling and running using GPS data.	Activity Tracking, Fitness app, Social network	Private company (USA)

Table 5 Overview of main solutions in activity tracking/fitness apps market

[41] https://www.runtastic.com/
[42] https://connect.garmin.com/
[43] https://coach.fitbit.com/
[44] https://www.strava.com/

3.6 IT solutions for Sleep Tracking Market

Sleep is an important part of the living activity since humans need to engage that stage regularly in order to maintain health and well-being. The exact period a person must sleep each night varies with age and from person to person. In any case, to stay healthy a person needs to sleep from 6 to 10 hours an average, where the aging process reduces the number of hours needed. Sleep assessment thus becomes an important point to evaluate a person's well-being and, in conjunction with other parameters, sleep indicators become a valuable indicator for health professionals, in particular medical doctors, to evaluate the well-being of his patients. Sleep performance can be assessed in many ways, but generically it may result from self-expression (e.g. "last night it was quite difficult to fell asleep plus I awake too many times") or as a result of devices measuring different parameters. Many devices can be used to monitor sleep, weather wearables or fixed devices may determine sleep effectiveness and provide clues for the evaluation of sleep disorders. Sleep trackers are well present in the market and with the wide adoption of fitness devices and wearable gadgets it becomes common that people have some sort of sleep monitoring device. In what regards to the quality of data and the usefulness of the information provided by those devices, it becomes less relevant than it might appear at first. In fact, many of those devices, while accessing stages of sleep, the resulting values are not measured but depend on an algorithm that, for each unit of sleep decomposes the time in Light, Deep, Rem sleep plus the time a person is awake. In this sense the real measurement is, most of the times, only relevant to determine sleep and awake time, the other values are just a mathematical outcome.

3.6.1 Market Forecast

In line with the above mentioned, there is a market for both new devices that effectively measure raw sleep parameters, as well as services using measurements collected from existing devices which end up calculating sleep parameters or collecting evidence related to sleep stages beyond algorithm-based time decomposition. Another important market aspect is the growth of the section related to devices based on mattress or under-mattress measurements which are more reliable. The market is also growing fast in the wearables, mostly because of activity tracking and less because of sleep tracking which is not yet considered reliable.

According to Global Markets Insights[45], Sleep Tech Devices Market size exceeded USD 10.9 billion in 2019 and is poised to achieve over 16.6% CAGR between 2020 and 2026. There are many companies developing sleep-aid technologies at this time (see section 3.6.4). Such technologies are primarily used for enhanced patient care, specifically for individuals suffering from insomnia, narcolepsy, and sleep apnea. The category of sleep tech devices includes rings, wearable smart watches, wristbands and sleep pads.

[45] https://www.gminsights.com/industry-analysis/sleep-tech-devices-market#:~:text=Sleep%20Tech%20Devices%20Market%20size%20exceeded%20USD%2010.9%20billion%20in,to%20boost%20the%20market%20expansion.&text=Growth%20Drivers%3A,sleeping%20disorders%20across%20the%20globe

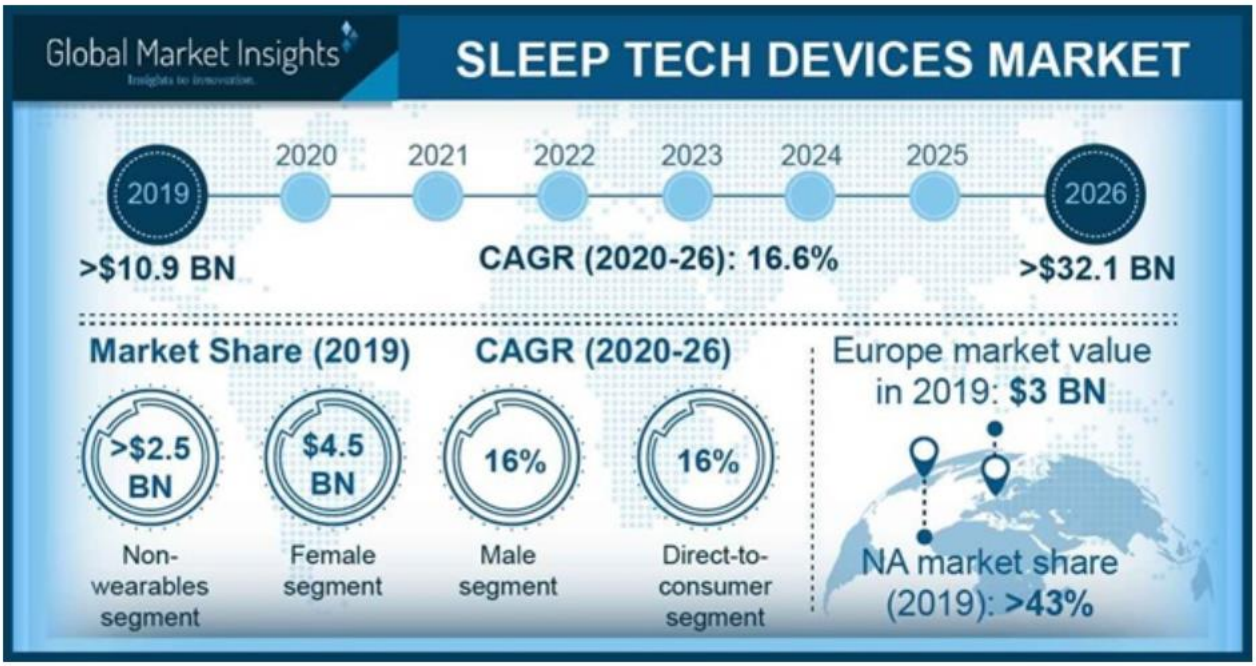

Figure 4 Sleep Tech Devices Market[45]

In particular related to hospitals, their market will expand at more than 17% CAGR through 2026 as hospitals are committed to provide state–of-the-art and affordable patient care for several sleep disorders with advancing treatment methods.

3.6.2 Market Barriers

Since there is a wide adoption of activity trackers, is not likely that people duplicate spending in devices just to monitor sleep. Adding to this, the mattress related devices are much more expensive, sometimes in the order of 10 times. Which is a barrier for such devices. The other barrier is privacy, while the manufacturers ensure that only anonymised data is used and aiming to improve the devices' effectiveness, the market does not trust blindly in such information mostly due to several data breaches that undermined the trust in devices and platforms.

3.6.3 Market Opportunities

In face of this scenario, clear market opportunities arise for services that gather data from existing devices but provide better insights about sleep performance, including a better usage and correlation of data collected from different sensors in the same device. On the other hand, the adoption of services that ensure edge computing at the devices, ensuring no communication of data to the manufacturer can become a new paradigm that becomes a market opportunity, as long as some provider releases enough insurance for data privacy. Finally, there is the opportunity for new competitive devices that accurately track parameters of sleep and provide to the user the best information on sleep disorders.

3.6.4 Overview of Solutions in the Market

The evaluation of quality of sleep aims to measure several parameters that will provide information about how valuable sleep is to a person's health and wellbeing. There are measurements to be performed at hospitals that use polysomnography devices to perform sleep measurements, which are out of scope of the present deliverable.

Recently there are several devices that aim to measure sleep parameters at home. Those can be grouped in two main categories; first there are specifically designed devices embedded in pillows, in mattresses or put under the mattress or over the bedside table. Second, the other category which is not so specific consists of fitness devices and wearables, either fitness bands or smartwatches that have sensors used for several analytics being sleep one of those.

Considering the first category, several devices exist in the market. Their price is not tangible as, in most of the cases, there is a service associated. The device can be included in the service, as a rent, or become a lesser parcel compared with a monthly payment. In the next table, a list of those devices is presented with their main features.

Product name	Development company/organization	Static Location	Distinguish between two people in bed	Dependencies	Communications	API	Sleep Cycles
Circadia	Circadia	Bedside table	Yes	Mobile app	Wi-Fi	No	Wake, Light, Deep, REM
S+	ResMed	Bedside table	Yes	Smartphone with Bluetooth, ResMed mobile application	Bluetooth	No	Wakefulness, Light, Deep, REM
Beddit v3.5	Apple	Under the sheet	Yes	Mobile app (only iOS)	Bluetooth	No	Awake, Light, deep, restless
SleepScore Max	Sleepscore Labs	Bedside table	Yes	Mobile phone	Bluetooth	No	Light, Deep, REM
Emfit QS	Emfit	Under the mattress	Yes	No	Wi-Fi	Yes	Light, Deep, REM
Sleep Tracking Mat	Withings/Nokia	Under the mattress	Yes	Mobile app	Bluetooth (setup) Wi-Fi	Yes	Light, Deep, REM
Beautyrest Sleep Tracker	Beautyrest	Under the matress	Yes	Mobile app	Wi-Fi	No	Awake, REM, Light, deep,
Zeeq Smart Pillow	Remfit	Pillow	yes	Mobile app	BLE	No	Light, Deep
Dreem	Dreem	Headband	Yes	Mobile app	No	No	Light, Deep, REM
Eight Sleep Tracker	Eight Sleep	Mattress cover	Yes	Mobile app	Wi-Fi	No	Light, Deep, REM
Sleep Number 360 Smart Bed	Sleep Number	Inside matterss	Yes	Mobile app	Wi-Fi	No	Restfull, restless, Sleep Score

Table 6 Overview of specifically designed sleep tracking devices [30]

Considering the second category, there are devices associated with sports and wellbeing. The next table presents a list of smartwatches in the market with the most relevant characteristics.

Product Name	Compatibility	GPS	Heart Rate Monitor	Sleep Tracker	Battery Life	Price (€)
Apple Watch Series 6[46]	iOS	Yes	Yes	Yes	Up to18 hours	439

[46] https://www.apple.com/pt/watch

Product Name	Compatibility	GPS	Heart Rate Monitor	Sleep Tracker	Battery Life	Price (€)
Garmin Vivoactive 4s[47]	Android, iOS	Yes	Yes	Yes	Smartwatch mode: Up to 7 days GPS mode: Up to 5 hours	303
Polar Grit X[48]	Android, iOS	Yes	Yes	Yes	Watch mode (with heart rate): Up to 7 days GPS mode: Up to 40 hours	430
Fitbit Sense[49]	Android, iOS	Yes	Yes	Yes	Up to 6 days	330
Casio GSW-H1000-1ER[50]	Android, iOS	Yes	Yes	-	Up to 1 day and half	400
Suunto 9[51]	Android, iOS	Yes	Yes	Yes	Smartwatch mode: Up to 14 days GPS mode: Up to 25 hours	500
Oppo Watch[52]	Android	Yes	Yes	Yes	Smartwatch mode: Up to 36 hours	230
Withings ScanWatch[53]	Android, iOS	No	Yes	Yes	Up to 30 days	280
Huawei Watch GT 2 Pro[54]	Android, iOS	Yes	Yes	Yes	Up to 14 days	300

Table 7 Overview of smartwatches with sleep tracking capabilities

Finally, the next table presents fitness bands that can be used also for sleep tracking and which are, in most of the cases, the less expensive options.

Product Name	Compatibility	GPS	Heart Rate Monitor	Sleep Tracker	Battery Life	Price (€)
Fitbit Inspire 2[55]	Android, iOS	No	Yes	Yes	Up to 10 days	100

[47] https://buy.garmin.com/en-GB/GB/p/643399
[48] https://www.polar.com/en/grit-x
[49] https://www.fitbit.com/global/eu/products/smartwatches/sense?sku=512BKBK
[50] https://www.casio-europe.com/pt/produtos/relogios/g-shock/gsw-h1000-1er
[51] https://www.suunto.com/suunto-collections/suunto-9
[52] https://www.oppo.com/en/accessory-oppo-watch
[53] https://www.withings.com/pt/en/scanwatch
[54] https://consumer.huawei.com/en/wearables/watch-gt2-pro
[55] https://www.fitbit.com/global/eu/products/trackers/inspire2?sku=418BKBK

Product Name	Compatibility	GPS	Heart Rate Monitor	Sleep Tracker	Battery Life	Price (€)
Xiaomi Mi Band 5[56]	Android, iOS	No	Yes	Yes	Up to 14 days	40
Samsung Galaxy Fit2[57]	Android, iOS	No	Yes	Yes	Up to 21 hours	50
Oppo Band[58]	Android	No	Yes	Yes	Up to 12 days	160
Honor Band 6[59]	Android, iOS	No	Yes	Yes	Up to 14 days	50
Huawei Band 4[60]	Android, iOS	No	Yes	Sleep	Up to 6 days	40
Garmin VivoSmart 4 HR[61]	Android, iOS	No	Yes	Yes	24h	125

Table 8 Overview of wristbands with sleep tracking capabilities

3.7 IT solutions for Nutrition Tracking Market

Being a cancer survivor (a person in the period after the completion of treatment and being cancer free), has many implications (physical, psychological, social and economic) for a person's quality of life. In this context nutrition has been identified in epidemiologic studies as one of the important determinants of health and quality of life, which together with physical activity and energy balance have been associated with cancer recurrence and as a modifiable risk factor, although still their effects are not clearly understood. Currently there is evidence from the last decade regarding dietary patterns, as well as the consumption of specific food-nutrients with respect to cancer incidence, recurrence and survival; especially for breast cancer. Data from the published literature suggest that a healthy dietary pattern characterised by high intake of unrefined cereals, vegetables, fruit, nuts and olive oil, and a moderate/low consumption of saturated fatty acids and red meat, might improve overall survival after diagnosis of cancer. Moreover, this is also evidenced for mental health; a healthy dietary approach (which shall include type of nutrients, food intake, health weight, etc.), usually combined with lifestyle; has a high potential in the prevention, management and treatment of mental health.

In this context, for example the intake of carbohydrates shall trigger the production of brain chemicals, serotonin and tryptophan, which promote feelings of well-being. Proteins are made up of amino acids; the neurotransmitter dopamine is made from the amino acid tyrosine and the neurotransmitter serotonin is made from tryptophan. If any of these two amino acids is missing, there will be insufficient synthesis of the respective neurotransmitters, which is associated with low mood and aggression in patients. Likewise, research of other nutrients in this context include for

[56] https://www.mi.com/global/mi-smart-band-5

[57] https://www.samsung.com/pt/watches/galaxy-fit/galaxy-fit2-black-sm-r220nzkaeub

[58] https://www.oppo.com/en/accessories/oppo-band

[59] https://www.hihonor.com/global/products/wearables/honor-band-6

[60] https://consumer.huawei.com/en/wearables/band4

[61] https://buy.garmin.com/en-US/US/p/605739/pn/010-01995-10

example the B6 vitamins (essential for the production of neurotransmitters, such as serotonin), Omega-3 fatty acids (hypothesized that enough long-chain polyunsaturated fatty acids could potentially decrease the development of depression), iron (which could be necessary for the synthesis of neurotransmitters) or selenium (which could potentially improve mood and reduce anxiety).

Moreover, depression is frequently also discussed to be associated with overeating and with a preference for certain foods (people with depression indicated an increase in food consumption in times of sadness, changes in food consumption in times of nervousness and happiness, and night eating: also, the daily consumption of fruits, vegetables, and fish, tends to be lower in the group of people with depression [31]), which can lead to weight gain. In addition, cancer survivals that might be prone to some food allergies (there are 17 million Europeans suffer from food reactions such as allergies to cow's milk, egg, wheat, soy, peanut, tree nuts, fish and shellfish), intolerances (e.g., gluten intolerance) or eating disorders (e.g. anorexia nervosa or bulimia).

Linked to this nutrition elements, technological innovation supporting the nutrition and appetite comprise by self-monitoring or interventional nutrition trackers and/or diet trackers, usually coupled to physical activity monitoring applications that are conveniently integrated in handheld devices; also technology that tracks what is in our food, what we should eat based on our genetic background or support the process of bringing specific food to the menus to support food allergies, intolerances or eating disorders and/or improve quality of life. In this context we can find:

- Devices such as smart utensils that help to track and monitor and track the eating habits (e.g. eating fast).
- Food scanners, which aim at helping to uncover some uncertainties around eating such as what people eats (ingredients, e.g., gluten sensor) or where food comes from or was packaged; thus informing users about specific ingredients, macronutrients and source of food.
- Food or nutrition tracking and healthy eating: nutritional trackers are associated with weight management (loss, increase, etc.), muscle reinforcement management or foster eating habits. Mobile devices allow real-time decision or support or reporting, by enabling users to check the caloric value of foods, caloric values of food intake and track of energy balance in real time. The technology usually provides a graphical user interface where users select the meals or foods they have ingested from predefined lists or images and receive feedback on their food intake; also, in some cases from predefined finite list of meals, the user can describe the ingests in many different ways that must be translated by the system into a tractable semantic representation from which to derive the nutritional aspects of interest. Further some developments cover nutrigenomics (e.g., guide in food that could be eaten based on genetics and what it should avoid at all costs), calorie counters or food chatbots (acting as coaches at a supermarket level to find specific or needed products).

3.7.1 Market Forecast

The mobile health applications (mHealth apps) are the umbrella market for the nutrition apps segment, supporting the overall view of tracking people`s health and well-being, analysing the different quality of life and lifestyle segments or contributing activities/processes. As detailed in the mHealth apps market forecast in section 3.3.1, the growing promotion of mHealth apps is a fact; and drives the growth in the diet, nutritional, calories and related apps global market; which is expected to gain strong market growth in the forecast period of 2020 to 2027. According to Data Bridge Market Research the diet and nutrition apps are expected to grow at a CAGR of 20.9% from 2020 to

2027, reaching a global market estimated in USD 8,5 million by 2027. The diet and nutrition apps market is segmented into nutrition tracking app, activity tracking app, social platform apps, wager apps and others. Nutrition tracking app is dominating the market as major customer base is using the app for monitoring the calories content in food.

Also, according to the Databridgemarketresearch.com report "Global Fitness App Market" Size, Share & Trends Analysis Report By 2027, the Global Fitness App Market (Workout App + Nutrition App) is expected to grow at a CAGR 21.30%; however, it is seen as highly fragmented and the major players have used various strategies such as new product launches, expansions, agreements, joint ventures, partnerships, acquisitions, and others to increase their footprint in this market.

In order to exemplify this market, we can point that in 2017, a total of 325,000 mobile health (mHealth) apps were available in major app stores[62], which aim at tracking of health-related behaviours and weight management. Within this group of apps, diet-tracking apps have been very popular, with some downloaded as much as 50 million times, tracking the consumption of certain foods and drinks may potentially help individuals achieve an improved understanding of their dietary patterns. However, it remains unclear how many of the current diet-tracking apps employ such features that are consistent with behaviour change theory.

In this context, according to the Reports and Data, the global Personalised Nutrition market is expected to reach USD 11.35 billion by the year 2026, at a CAGR of 9.3%; under an era of customisation, changing the ways of consuming food. Personalised nutrition and diet fit in perfectly with people's individual health goals. A personalised nutrition approach is based on the idea that customizing nutrition advice or making dietary changes would significantly improve our health and lower the risk of conditions[63].

3.7.2 Market Barriers

Although, there is a wide adoption of nutrition, calories, lifestyle, diet or food trackers there are several barriers. Barriers related to GDPR and privacy management have been discussed in section 3.3.2. Tracking nutrition and food could be impacted by resisting to provide some of the consumer buying lifestyle or performance data patterns; as now locations on the value or supply chain part of the tracking for supporting traceability of food origin or we ask about type of food, allergies, and times of food intake or tracking where people exercise. This information could also provide some hints regarding identifying the user or some location visited that shall be maintained as anonymous. Also, in many cases the device manufacturers ensure that only anonymised data is used and aiming to improve the devices' effectiveness, the market does not trust blindly in such information mostly due to several data breaches that undermined the trust in devices and platforms.

Furthermore, in the case of nutrition, interaction with user is needed to revise and advise on food intake, its frequency or type or food; so in many cases digital devices, food trackers, calorie counters, etc. cannot offer alone, a long-term, comprehensive solutions for supporting eating healthily and reduce the harm we do through food to our bodies; these applications need to link to other quality of life aspects such as physical activity and/or energy balance. Moreover, availability of cheap-alternative applications that provide similar functionality restricts the market growth for apps

[62] https://research2guidance.com/325000-mobile-health-apps-available-in-2017
[63] Reports and Data, https://www.reportsanddata.com/report-detail/personalised-nutrition-market

entering in the market. The app competition in marketplaces is enormous requiring a remarkably high amount of capital to get new apps to be seen by anyone. During 2020, consumers downloaded a total of 218 billion mobile apps of which 98% were estimated to be free, reaching 5.22 billion unique mobile phone users worldwide[64].

3.7.3 Market Opportunities

Increasing focus of individuals to maintain a healthier lifestyle, higher rate of adoption for smart devices such as smartphones and smart watches for fitness-related activities and increasing market adoption of the digital devices by consumers is augmenting this segment growth. The market growth provides an opportunity for FAITH developments; moreover, as most of the nutritional apps are theory deficient and provide general dietary or calorie tracking information/assistance. An opportunity exists for health behaviour change experts to partner with app developers to incorporate health behaviour theories into the development of individually tailored apps [32]. In addition, the domains of cancer, depression and nutrition offer new opportunities driven by the following trends.

In the context of cancer, the number of cancer survivors is growing steadily and increasingly; moreover, the cancer survivors are now living longer giving rise to a new concept, so called chronic cancer as survivors, as many continue to face long-term consequences of cancer and its treatment; for these survivors the quality of life becomes a vital consideration in understanding their survivorship and the long-term impact of cancer and its treatment. In addition, the concept of palliative care has evolved to include all aspects of cancer survivorship and not just end of life care; coupling nutrition and cancer as an important factor in both quality of life and in the pathophysiology of cancer; this is driven by the growing need of considering how diet and nutrition approaches can impact not only quality of life but overall health outcomes and perhaps even positively affect cancer recurrence and progression. In this area the nutrition, physical activity, and energy balance are important determinants for maintenance of "healthy weight[65]." In addition, data from the published literature suggest that a healthy dietary pattern characterised by high intake of unrefined cereals, vegetables, fruit, nuts and olive oil, and a moderate/low consumption of saturated fatty acids and red meat, might improve overall survival after diagnosis of cancer, more specifically breast cancer [33]. Also, the ingestion of macronutrients, shall be associated with better cancer survival, while with regard to micronutrients, could be linked with reduced the risk of cancer recurrence.

Moreover, the importance of various nutrients in mental health is discussed, with particular relevance to depression, as commented above (Vitamins of the B complex -especially B2 and B6- improve mood, iron is necessary for the synthesis of neurotransmitters, selenium improves mood and reduces anxiety, etc.). Furthermore, coming trends of integrative oncology[66] brings in addition to the front a patient-centered, evidence-informed field of cancer care that utilises mind and body practices, natural products, and/or lifestyle modifications from different traditions alongside conventional cancer treatments and cancer survivors experience.

[64] https://financesonline.com/number-of-mobile-app-downloads/#:~:text=As%20of%20the%20fourth%20quarter,from%20204%20billion%20in%202019
[65] https://www.nhs.uk/live-well/healthy-weight/
[66] https://integrativeonc.org/

3.7.4 Overview of Solutions in the Market

Most nutrition-related applications are developed for health management and not exclusively for dietary guidance. Although the basic principles of energy balance are used, its nutritional functionality was relatively limited and not individualised [34]. Most of the applications in the market are focussed on diet plans, prospective registry of food intake and a mix with physical activity; with just a few with customised nutritional recommendations [35]. Most of the applications are useful for nutritional guidance, but most of them are not based on reliable sources of information, theory based or with a trial experiment behind (in-person intervention). Most apps are theory deficient and provided just general information/assistance. In this context, a benchmark analysis has been developed over the 35 nutrition apps, most found downloaded at least 1000 times and available to be used (as of March 1st, 2021), searching in the web and marketplaces (Criteria of multiplatform apps, with a minimum of 1000 installation supporting nutrition, nutrition cancer, nutrition disorders, nutrition mental health, nutrition depression). The following tables provides categories of nutrition apps, as well as different features and characteristics appealing to the FAITH project.

App Name	Version (Android/ iOS)	Min OS required	Target user	Categories	Languages Supported	Price
MyFitnessPal[67]	Depends de-vice/ 20.24.7	Android (not specified) / iOS 13.0 + watchOS 2.0	General	Calorie counter; diet tracker	20	Free & Premium
Fitbit[68]	Depends de-vice/ 3.36.1	Android (not specified) / iOS 12.2	General	Calorie counter; activity tracker	17	Free & Premium
Lose It![69]	Depends de-vice/13.1.0 01	Android (not specified) / iOS 12.0 + watchOS 4.3	General	Calorie counter; food & weight tracker	31	Free & Premium
FatSecret[70]	Depends on device/ 8.15	Android (not specified) / iOS 11.0 + wearOS 3.0	General	Calorie counter; food & weight tracker; diet & fitness tracker	19	Free & Premium
Lifesum[71]	Depends on device/ 12.06	Android (not specified) / iOS 11.2 + watchOS 7.0	General	Diet tracker; Macro counter	11	Premium
Yazio[72]	Depends on device/ 7.1.8	Android (not specified) / iOS 12.2 + watchOS 7.0	General	Calorie counter; diet diary	20	Free & Premium
MyNetDiary[73]	7.5.5 / 8.5	Android 6.0 / iOS 13.0 + watchOS 3.0	General	Calorie counter; food diary nutrition tracker	1	Free & Premium

[67] https://www.myfitnesspal.com/
[68] https://play.google.com/store/apps/details?id=com.fitbit.FitbitMobile&hl=es&gl=US; https://apps.apple.com/es/app/fitbit/id462638897
[69] https://www.loseit.com/
[70] https://www.fatsecret.com/
[71] https://lifesum.com/es/
[72] https://www.yazio.com
[73] https://www.mynetdiary.com/

App Name	Version (Android/ iOS)	Min OS required	Target user	Categories	Languages Supported	Price
MyPlate[74]	3.5.3(54)/ 5.30.1	Android 4.1 / iOS 13.0 + watchOS 4.0	General	Calorie counter; calories, macros & workout	2	Free & Gold
EasyFit [75]	3.8 / 1.9	Android 4.4 / iOS 12.0	General	Calorie counter; Weight loss; diet;	20	Free
Cronometer[76]	3.5.9 / 3.5.9	Android 5.0 / iOS 11.0	General	Nutrition tracker	1	Free & Gold
Carbs&Cals[77]	2.13.0 / 4.0.8	Android 4.0 / iOS 8.0	General	Carb & Calorie counter; Diet, weight loss and Diabetes	1	€4.99
Waterminder[78]	2.11.1/ 4.2.6	Android 5.0 / iOS 12.2 + watchOS 4.2	General	Daily water tracker & reminder	16	Free / €5.49 (iOS)
Fooducate[79]	Depends on device / 6.58	Android (not specified) / iOS 11.0	General	Nutrition & Diet Tracker	1	Free
ShopWell[80]	6.0.29 / 6.0.29	Android 5.0 / iOS 12.0	General	Nutrition label Diabetes; Food goals intollerances;	1	Free
Food Intolerances[81]	2.7 / 4.7	Android 4.2/ iOS 10.0	General	Restricted diet helper	4	€6.99 (Android)/ €8.99 (iOS)
Noom[82]	8.37.0 /9.1.0	Android 6.0 / iOS 12.4	General	Health diet & weightloss	5	Free and Pro
Yuka[83]	3.40 / 3.37	Android 5.0 / iOS 10.0	General	Products label scanner	5	Free and Premium
Eaterpad[84]	2.3.7/ 2.3.7	Android 5.0 / iOS 9.0	General	Nutrition tracker	1	Free + Premium
MyRealFood[85]	3.0.0 / 3.0.0	Android 4.4 / iOS 9.0	General	Recipes; Nutritional tracker	1	Free + plan

[74] https://www.livestrong.com/myplate/
[75] https://easyfit-caloriecounter.de/
[76] https://cronometer.com/
[77] https://www.carbsandcals.com/app/app
[78] https://waterminder.com/
[79] https://www.fooducate.com/
[80] http://www.shopwell.com/nutrition
[81] https://www.baliza.de/en/apps/histamine.html
[82] https://www.noom.com/#/
[83] https://yuka.io/en/
[84] https://www.eaterpad.com/
[85] https://play.google.com/store/apps/details?id=es.myrealfood.myrealfood; https://apps.apple.com/es/app/myrealfood-recetas-y-alimentos/id1458031749

App Name	Version (Android/ iOS)	Min OS required	Target user	Categories	Languages Supported	Price
Eat this much – meal planner[86]	Depends on device / 1.160.1	Android (not specified) / iOS 11.0	General	Meal planner; Recipes; Macros; Grocery list	1	Free + subscription
DietSensor[87]	2.7.4 / 3.8.0	Android 7.0 / iOS 12.0	General	Calorie counter; diet macro tracker; weight loss	5	Free + Premium
Ate Food Diary[88]	Depends / 2.1.6	Android (not specified) / iOS 10.0 + watchOS 4.0	General	Mindful eating; photo meal journal	1	Free + Premium
FITIA[89]	7.2.2 / 6.2	Android 7.0 / iOS 11.0	General	Nutrition & Diet tracker; weight loss; gain muscle	2	Free + Premium
Nutritionix App[90]	1.4.1 / 1.42	Android 4.4 / iOS 11.0	General	Calorie counter: food tracker	1	Free + Track pro
Macros[91]	1.9.4 / 1.9.5	Android 4.4/OS 10.0	General	Calorie counter;	6	Free + plus
Nooddle[92]	1.14.1 / 1.14.1	Android 5.0 / iOS 10.0	General	Nutrition tracker; Tips & personalised nutritional plans	2	Free + nutritional plan
chemoWave[93]	1.6.1 / 2.8.4	Android 5.0 / iOS 13.0	Cancer patients; chemo	Cancer patients tracker	4	Free+ premium
8fit[94]	21.01.0 / 21.01.0	Android 6.0 / iOS 11.0	General	Fitness & nutrition tracker	6	Free + Premium
CalorieKing[95]	1.0.2 / 1.7.8	Android 4.1 / iOS 11.0	General	Food database	1	Free
Recovery Record: Eating Dis. Mgmt[96]	5.6.8 / 8.9.9	Android 5.0 / iOS 11.0 + watchOS 3.0	Eating disorders	Recovery records; Eating disorders	3	Free

[86] https://play.google.com/store/apps/details?id=com.eatthismuch; https://apps.apple.com/ca/app/eat-this-much-meal-planner/id981637806
[87] https://play.google.com/store/apps/details?id=com.dietsensor.dietsensor; https://apps.apple.com/us/app/dietsensor-diet-macro-tracker/id1101290388;
[88] https://play.google.com/store/apps/details?id=com.youate.android; https://apps.apple.com/us/app/ate-food-diary-easy-mindful/id1164976477
[89] https://play.google.com/store/apps/details?id=com.nutrition.technologies.Fitia; https://apps.apple.com/es/app/fitia/id1448277011?l=en
[90] https://www.nutritionix.com/app
[91] https://play.google.com/store/apps/details?id=com.josmantek.macros; https://apps.apple.com/es/app/macros-calorie-counter/id1216666985?l=en
[92] https://play.google.com/store/apps/details?id=es.nooddle&hl=es&gl=US; https://apps.apple.com/es/app/nooddle-recetas-sanas-f%C3%A1ciles/id1329457709
[93] https://play.google.com/store/apps/details?id=com.chemowave.android; https://apps.apple.com/us/app/chemowave-cancer-health-app/id1199851760
[94] https://play.google.com/store/apps/details?id=com.eightfit.app; https://apps.apple.com/us/app/8fit-workouts-meal-planner/id866617777
[95] https://play.google.com/store/apps/details?id=com.calorieking.calorieking_mobile; https://apps.apple.com/us/app/calorieking-food-search/id454930992
[96] http://recoveryrecord.com

App Name	Version (Android/ iOS)	Min OS required	Target user	Categories	Languages Supported	Price
Recovery Record for Clinicians[97]	1.7.4 / 2.5.8	Android 5.0 / iOS 11.00	Clinician	Eating disorder professional	3	Free + Premium
Rise Up + Recover[98]	1.2 / 1.4.0	Android 4.0 / iOS 7.0	Eating disorders	Eating disorders; monitoring & management tool	3	Free
Nourishly[99]	1.2.3 / 1.3.3	Android 7.0 / iOS 11.0 + watchOS 3.0	Dietary changes	Nutrition & Diet; dietary management	3	Free
deVicer: 90-Day Binge EDT[100]	1.4.6 / 1.3.16	Android 7.0 / iOS 10.0	Eating disorders	Binge Eating Disorder Therapy	1	Free + Premium
Brighter Bite - ED Recovery[101]	1.1.2 / 1.1.2	Android 4.0 / iOS 10.3	Eating disorders	Eating Disorders Recovery	1	Free

Table 9 Overview of other solutions in nutrition tracking apps market

[97] https://play.google.com/store/apps/details?id=com.recoveryrecord.clinician; https://apps.apple.com/us/app/recovery-record-for-clinicians/id657266479
[98] https://www.recoverywarriors.com/
[99] https://play.google.com/store/apps/details?id=com.nourishly&hl=en_419&gl=US; https://apps.apple.com/us/app/nourishly-nutrition-diet/id1182819968
[100] https://play.google.com/store/apps/details?id=life.devicer.devicer; https://apps.apple.com/us/app/devicer/id1454867798
[101] https://play.google.com/store/apps/details?id=com.brighterbite.brighterbite; https://apps.apple.com/us/app/brighter-bite-ed-recovery/id1513041355

These applications also were assessed from a features perspective also:

App Name	Calorie Tracker	Activity Tracker	Nutrition Tracker	Water tracker	Mood & feeling tracker	Weight Control	Fitness/ Healthy	Includes diet types	Food Intolerances &	Disease/Disorder /Other	Selection by images	Customizable	Macros information	Food composition/Nutritional info	Nutrition database	BarCode Scanner	Image recognition
MyFitnessPal	x	x	x	x		x	x					x	x	x	x	x	x
Fitbit	x	x	x	x		x	x					x		x	x	x	
Lose It!	x	x	x			x	x					x	x	x	x	x	
FatSecret	x	x	x	x		x	x					x	x	x	x	x	x
Lifesum	x		x			x	x					x	x	x		x	
Yazio	x	x	x	x		x	x					x	x	x	x	x	
MyNetDiary	x	x	x	x		x	x			x		x	x	x	x	x	
MyPlate	x	x	x	x		x	x					x	x	x	x	x	
EasyFit	x	x	x	x		x	x				x	x	x		x		
Cronometer	x		x	x		x	x					x	x	x	x	x	
Carbs&Cals	x	x	x			x	x			x	x	x	x	x	x		
Waterminder				x			x					x					
Fooducate	x	x	x			x	x	x	x	x		x	x	x	x	x	
ShopWell							x	x	x	x							
Food Intolerances									x			x	x	x	x		
Noom				x		x	x					x			x	x	
Yuka							x						x	x	x	x	
Eaterpad			x			x	x					x	x	x	x	x	
MyRealFood							x	x				x	x	x	x	x	
Eat this much – meal planner							x					x	x	x	x		

App Name	Calorie Tracker	Activity Tracker	Nutrition Tracker	Water tracker	Mood & feeling tracker	Weight Control	Fitness/ Healthy	Includes diet types	Food Intolerances &	Disease/Disorder /Other	Selection by images	Customizable	Macros information	Food composition/Nutritional info	Nutrition database	BarCode Scanner	Image recognition
DietSensor	x		x			x	x	x				x	x	x	x	x	
Ate Food Diary		x	x	x	x		x				x	x					
FITIA	x		x			x	x				x	x	x	x	x		
Nutritionix App	x	x	x	x		x	x					x	x	x	x	x	
Macros	x		x			x	x	x				x	x	x	x	x	
Nooddle			x				x	x	x			x	x	x	x		
chemoWave		x	x	x	x					x		x					
8fit		x	x			x	x	x	x			x			x		
CalorieKing			x			x	x					x	x	x	x		
Recovery Record: Eating Disorder Management										x		x					
Recovery Record for Clinicians						x				x			x				
Rise Up + Recover										x		x					
Nourishly		x	x		x		x			x		x					
deVicer: 90-Day Binge Eating Disorder Therapy										x		x					
Brighter Bite - ED Recovery			x		x					x	x	x					

Table 10 Comparison of nutrition tracking apps based on offered features

The apps' design mostly ensure interconnectivity for monitoring and tracking physical activity, caloric intake, diet and nutrition; and some of them also provide reminders and allows users to set physical activity goals. Currently, in mobile health there are some apps providing the detection of nutrient intake using pictures, and the detection of eating episodes and/or caloric intake using sensed wrist devices. Pictures are either taken by the participant on a smartphone or uploaded to a server manually. There are only a few dedicated to cancer prevention and cancer survivors, for example, chemoWAVE.

3.8 IT solutions for Natural Language Processing

The prevalence of big data, while offering much opportunity for Industry, has also presented challenges in terms of the large-scale processing needed to deliver useful insights and support decision making. The evolution of Natural Language Processing as an efficient way of understanding, organising and responding to image, text and speech data at scale is witnessing acceleration and adoption in a number of key sectors. Consumers are increasingly engaging with chatbots to resolve queries via both online and telephone channels. Marketing companies increasingly monitor attitudes towards brands or promotional campaigns through sentiment analysis which is derived from automatic parsing of text and speech responses. Virtual assistants like Cortana, Siri and Alexa are increasingly commonplace.

FAITH proposes to develop a voice / NLP interface that can assist in determining a user's mental health outlook. NLP is making significant inroads in Healthcare; for example, to drive operational improvements as with Nuance Communications product 'Dragon Medical One' which transcribes clinician's words into Electronic Health Records or IQVIA's platform which can use both unstructured data sources and medical documents to analyse compliance. NLP-based technologies are also gaining traction as a diagnostic aid. Start-ups in this area include Ada which offers a symptom assessment app and Conversa which offers a virtual care and triage platform based on patient generated data as well as biometrics. There is less evidence in the market of NLP being used as a diagnostic tool to detect mental health. As such, the market analysis at this stage looks at the broad NLP market and will refer to the use of NLP in sentiment analysis in other domains such as Marketing.

3.8.1 Market Forecast

The NLP market is predicted to be worth up to $41bn by 2025, reflecting a CAGR of approximately 23%[102]. Some more cautious estimates put the value at a still impressive $34.8bn[103]. There are several domains leading the adoption of NLP application including Retail. Healthcare is also one of the leading domains for NLP application. NLP is of course a branch of Artificial Intelligence. Cautious estimates of market worth for AI applications within healthcare predict a value of $6bn by 2022 [36]. Frost & Sullivan classify AI application in healthcare into Clinical, Operational and Financial categories.

[102] https://www.globenewswire.com/news-release/2020/07/10/2060472/0/en/Natural-Language-Processing-NLP-Market-to-reach-US-41-billion-by-2025-Global-Insights-on-Trends-Leading-Players-Value-Chain-Analysis-Strategic-Initiatives-and-Key-Growth-Opportunit.html

[103] https://www.mordorintelligence.com/industry-reports/natural-language-processing-market

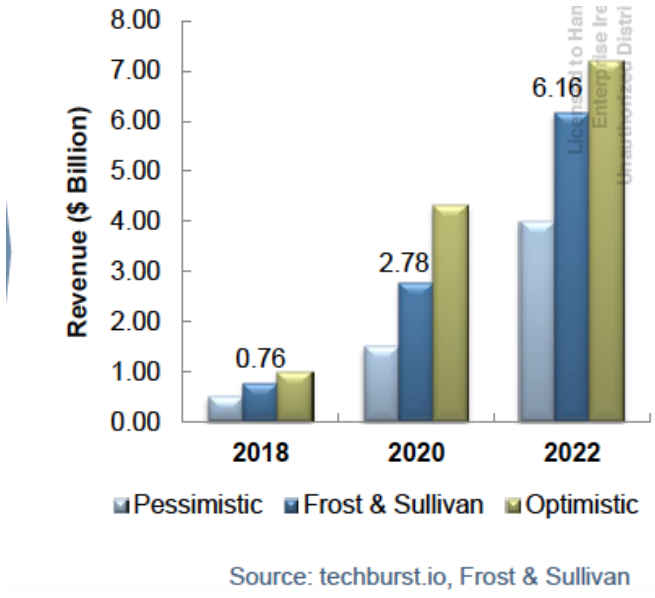

Figure 5 AI Market for Healthcare IT – Global Forecast Scenarios Analysis

Within healthcare, there are many applications of NLP and the focus of investment can vary depending on the setting (hospital, physician practises and payers (e.g. insurance providers, employers)). Frost research from 2018 summarises the situation as below:

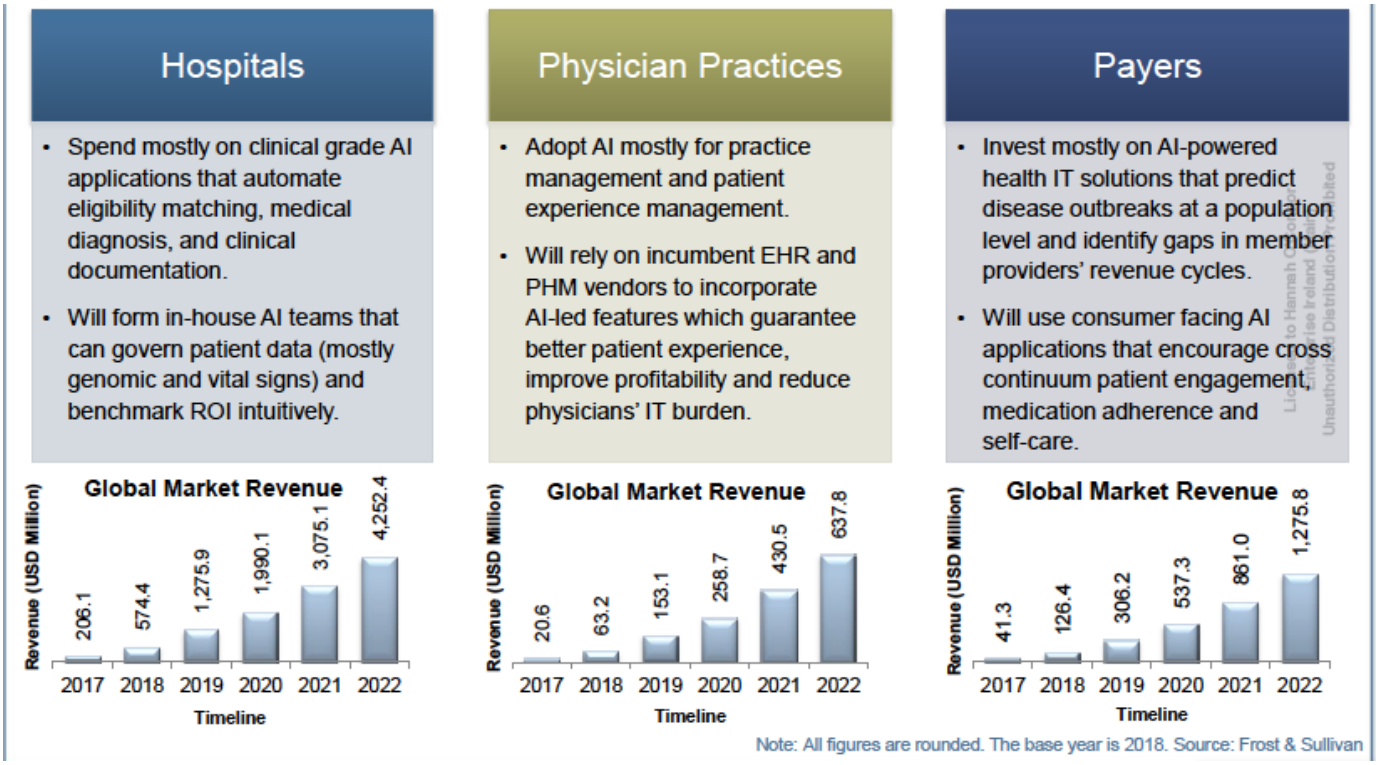

Figure 6 AI Market for Healthcare IT – Global Market Assessment of Key End Users in 2018

While one of the key takeaways from Frost research is that clinical grade AI applications (including NLP) will be accelerated to help optimise patient outcomes, it should be noted that much of the focus is currently on genomics and other physiological aspects. However, the use of AI to improve patient experience and results, for example post discharge engagement to check medication adherence or to ensure compliance with physical therapy and the emergence of start-ups such as Ada and Conversa (see section 3.8.4) indicate that the market opportunity for interventions such as that proposed by FAITH shows promise. Of the three Frost categories (Clinical, Operational, Financial), it is Clinical application that accounts for 50% of the revenue contribution of AI implementations and Frost analysts cite the prevention of adverse effects as well as the management of outcomes as immediate opportunity areas.

3.8.2 Market Barriers

While there is a strong appetite for AI led solutions in Healthcare, any market entry is not without is challenges, some of which are listed below:

- Health data is sensitive personal information. From a regulatory and ethical perspectives, very high standards of data governance must be demonstrated. Data subjects must be convinced that their data will be managed securely and that their privacy will be respected. Even if this is the situation, data owners may be reluctant to share their data due to its sensitive nature or because they are not convinced of the value that will be delivered to them in exchange. The data issue becomes even more complex when issues of interoperability are considered.
- The use of AI to analyse data and make related decisions can be viewed with mistrust. AI can be seen as something of a 'black box' with the inner workings not fully transparent or understood. In order for AI-led solutions to be accepted and fully adopted it is critical that to adopt an 'Explainable AI' approach. Gartner sums up the issue succinctly in its 2019 research "Understand the Value of AI for Healthcare Delivery Organisations" [37].
- Medical regulation can be a minefield. Regarding AI, regulation is continuously evolving to ensure responsible use. The FDA's definition of AI has been coined in such a way that implies that AI-reliant devices or applications need FDA approval for use ("a device or product that can imitate intelligent behaviour or mimics human learning or reasoning" Gartner, 2019). In addition, it recognises the difference between locked and adaptive algorithms. Traditional FDA approval pathways are suited to the former while the agency is evolving to consider the adaptive algorithms.
- The primary AI focus in healthcare has been on physiological analysis and application, for example oncology, diabetes and heart disease. Regarding mental health markers more work and proof points are needed. Evidence-based decision making must rely on proven algorithms and analysis. This necessitates robust testing on extensive data sets.

3.8.3 Market Opportunities

There are many market drivers that favour NLP applications in the healthcare setting:

- As previously mentioned, a large amount of healthcare data is generated every day with Dell indicating that healthcare organisations have seen an increase of 878% since 2016[104]. In a setting that is already under-resourced the appetite for better ways to understand, process and analyse this information is massive. There is a strong opportunity for AI technologies that can support clinicians, better enable evidence-based decisions and reduce staff burden.
- There is increasing acceptance of the value of AI in improving clinical decision making and precision medicine approaches with many successful applications. This should serve as a strong basis to extend the application of AI to Mental Health interventions.
- A US 2020 survey by Deloitte[105] confirmed that consumers are increasingly willing to use technology to measure and manage their health and that also they are more engaged in health management. Engagement can take the form of collecting and using health data and challenging clinicians.
- The funding landscape is positive with incubation & acceleration programmes, VCs and Angel investors are very favourable towards innovation in healthcare AI.

3.8.4 Overview of Solutions in the Market

There are some well-established examples of companies leveraging NLP and speech analytics technologies to deliver services to a variety of industry sectors. The emotional insights enabled by these technologies support applications in a variety of areas including market research, driver safety, insurance risk assessment, customer service and online retail. The presence of leading NLP / Speech analytics-based solutions in the healthcare market (Mental Health Analytics) is less evident. This section will provide a summary of companies that currently target other sectors but could realistically evolve their offering and orient their solutions towards the healthcare vertical. While many well-established companies like MindMeld use NLP to enable applications such as conversational platforms, the analysis will only primarily look at those that place some emphasis on emotion detection / mental state awareness. Additionally, some NLP based start-ups are included that offer some triage / diagnostic tools which could potentially evolve. their offering to additionally look at non-physiological indicators. This initial review of solutions in the marketplace will be a living market watch record. There is currently much activity in this dynamic, evolving area and it will be important to regularly review the competitive landscape.

Entity / Location	Solution Overview	Application Areas	Product Name / status
Affectiva, US	Uses computer vision & speech analytics to analyse 'human states in context'	Automotive AI (driver state, no of occupants, etc.)	Affectiva Automotive AI[106] *Doesn't seem to be commercialised yet*

[104] https://hitinfrastructure.com/news/organisations-see-878-health-data-growth-rate-since-2016

[105] https://www2.deloitte.com/us/en/insights/industry/health-care/consumer-health-trends.html

[106] https://go.affectiva.com/auto

Entity / Location	Solution Overview	Application Areas	Product Name / status
		Media analytics / measure response to ads Various including Gaming, Health (Autism, Stroke rehabilitation)	Affectiva Media Analytics[107] *Used by 25% of Fortune 500 companies* In-Lab Biometric solution *Both Facial and **vocal expression analysis** - partner iMotions integrates Affectiva with other biometric sensors*
Sestek, Dubai & Europe	Conversational AI, analytics and biometrics using speech recognition, TTS, NLP and AI	Financial Services Contact centre Retail Telecom	Conversational AI[108] *includes emotion detection*
Nemesysco, Israel	Voice analysis technologies for emotion detection, personality and risk assessment – can be used in real-time or offline (using recordings)	Recruitment Call centre Insurance Security	LVA[109] (layered voice analysis) technology seems well advanced and protected by patents – looks at vocal measurements, parameters and functions. Nemesysco uses its emotional diamond to visualise the human emotional reaction identified through LVA
Health Fidelity, US	Lumanent Insights - NLP to perform analysis on patient health records and perform risk adjustment +Other Risk Adjustment technologies	Health Insurance	LUMANENT[110] Insights *Strong market traction* *Continuous collaboration with Scientists (Columbia) to refine NLP tech*

[107] https://go.affectiva.com/affdex-for-market-research

[108] https://www.sestek.com/conversational-ai/

[109] https://www.nemesysco.com/lva-technology/

[110] https://healthfidelity.com/lumanent/

Entity / Location	Solution Overview	Application Areas	Product Name / status
Ada, Europe	Symptom assessment app, optimised by doctors	Healthcare	Ada[111] Used in some primary care settings in UK / NHS
Conversa, US	Virtual Care & Triage Platform – conversational AI platform to improve outcomes in situations such as post-acute outcome improvement, chronic care and procedural and surgical support	Healthcare – Providers Pharma Health Tech companies Payers	Conversa Well established with high profile clients

Table 11 Overview of other solutions in NLP & NLP apps market

[111] https://ada.com/app/

4 Conclusions & Next Steps

The purpose of this deliverable D8.1 has been to present the results of the market analysis, performed in the context of WP8 "Exploitation, Business Modelling & Sustainability".

First, we described in general the evolution of healthcare markets in our time and how this is expected to turn out in the near future; in particular, we showed extra interest towards after care market and home care market. Such markets are considered "umbrella markets" and could include anything, together with mobile apps (or, in general, IT solutions). In particular for mobile apps, we have identified six market sectors which could be of interest to FAITH to exploit commercially. These are the **mHealth apps** and the **mental health support apps**, which would naturally be among the first identified by our project as interesting market sectors with potential competitors or collaborators.

Furthermore, we have searched **activity tracking apps** market, **sleep tracking apps** market and **nutrition tracking apps** as extensions of the mHealth apps market, as well as **the sector of Natural Language Processing** as a whole (and not in particular related to the eHealth domain). For each of those markets, a description of the market was given, as well as a forecast of the market evolution for the next 3-5 years.

Then for each market, market barriers and market opportunities were identified, and the competitive landscape was explored, be it other EU or publicly funded projects, or private companies and solutions. We trust that the current deliverable can offer insights to be discussed and presented in the coming group workshops focused on business modelling, feeding directly into assets definition, individual exploitation routes and competitors analysis tasks. An iterative and collaborative approach can enable niche positioning for FAITH's outputs to be obtained in the course of the project.

4.1 Market Analysis Key Takeaways

Looking at the high-level forecasts of market evolution for each market, collected by various market research firms online, it is evident that those markets identified in this deliverable are in a growing trajectory, which makes them appealing for offering new products to their users, but also prospective users which are expected to be attracted in the near future. The demand for technologies and services of care that are necessary after patients have been discharged of the hospital, in a temporary care to help them get back to normal and stay independent, shall grow.

It is also important to note that the very design of the FAITH project takes into consideration the most important barriers identified in those markets and turns them into opportunities to differentiate and/or ease the worries related to those barriers. In particular, due to its design and the thinking behind the whole concept, the personal data of the individual never leave the device in order to be processed centrally. The level of security, therefore, is elevated compared to solutions that collect personal data (for any purpose) in a central point (e.g., cloud space). Furthermore, the FAITH mobile app shall be assessed using an appropriate sample size of the target cancer survivor population, keeping the users in central focus in its design. Finally, the source of funding for this project (the EC), the consortium members involved, and their organisational affiliations shall be transparent to the potential users of the app, easing worries on possible misuse of any kind.

Combined with the key takeaways above, FAITH aspires to lay the ground for a product based on the intersection of AI based technologies and mental health monitoring, which does not exist in the market in its full envisaged potential. The key takeaways, as well as the lessons learnt from the market analysis in the present deliverable, will be used in order to define an appropriate exploitation methodology for a novel solution. It needs to be noted, that as FAITH is

a RIA project, a substantial amount of effort would be necessary in the post-project era to turn the direct outputs of the project into a market-ready product that shall be in a position to compete with the other solutions that exist.

4.2 Next Steps

The present deliverable is expected to act as input for the next WP8 deliverables, namely D8.2 and D8.3, the two versions of "Business & Exploitation Plan".

In D8.2, as a first step a list of exploitable FAITH assets per partner shall be identified, together with individual exploitation routes for those, defined by each contributing partner. Furthermore, possible exploitation strategies for the project as a whole shall be sketched. Finally, initial considerations about business model definition will come in D8.2. As part of the business modelling tasks and aided by contacts with related organisations (e.g. patient coalitions, lobbyists, etc.), a more elaborate stakeholder definition and segmentation is expected to emerge.

In D8.3, as a second step, joint exploitation routes shall be identified, if applicable, the list of individual FAITH assets shall be further fleshed out and a more mature business plan and go-to market strategy shall be presented.

Bibliography

[1] FAITH Consortium, Description of Action, 2020

[2] European Observatory on Health Systems and Policies, Financing Health Care in the European Union: Challenges and Policy Responses, 2009, online https://www.euro.who.int/__data/assets/pdf_file/0009/98307/E92469.pdf?ua=1, accessed March 2021

[3] OECD/European Union (2020), Health at a Glance: Europe 2020: State of Health in the EU Cycle, OECD Publishing, Paris, https://doi.org/10.1787/82129230-en. online https://www.oecd.org/els/health-systems/health-at-a-glance-europe-23056088.htm, accessed March 2021

[4] Council Conclusions: Towards modern, responsive and sustainable health systems, OJ C 202, 8.7.2011, p. 10–12

[5] Ministerial Statement, OECD Health Ministerial Meeting, "The next generation of health reforms", 2017, online http://www.oecd.org/health/ministerial/ministerial-statement-2017.pdf, accessed February 2021

[6] Giuseppe Paparella, Person-centred care in Europe: a cross-country comparison of health system performance, strategies and structures, Picker Institute Europe, 2016, online https://www.picker.org/wp-content/uploads/2016/02/12-02-16-Policy-briefing-on-patient-centred-care-in-Europe.pdf, accessed February 2021

[7] Home-based and long-term care: home care issues and evidence. Geneva, World Health Organisation, 1999, online http://www.who.int/chp/knowledge/publications/Chronic_conditions/en/index.html, accessed January 2021

[8] Community home-based care in resource-limited settings: a framework for action. Geneva, World Health Organisation, 2002, online http://www.who.int/chp/knowledge/publications/Chronic_conditions/en/index.html, accessed January 2021

[9] European Commission, Economic and Financial Affairs, The 2018 Ageing Report: Economic and Budgetary Projections for the EU Member States (2016-2070), 2018, online https://ec.europa.eu/info/publications/economy-finance/2018-ageing-report-economic-and-budgetary-projections-eu-member-states-2016-2070_en, accessed January 2021

[10] American Cancer Society. Cancer Treatment & Survivorship Facts & Figures 2019-2021. Atlanta: American Cancer Society; 2019, online https://www.cancer.org/content/dam/cancer-org/research/cancer-facts-and-statistics/cancer-treatment-and-survivorship-facts-and-figures/cancer-treatment-and-survivorship-facts-and-figures-2019-2021.pdf, accessed November 2020

[11] Adam R, McMichael D, Powell D, et al. Publicly available apps for cancer survivors: a scoping review BMJ Open 2019;9:e032510. doi: 10.1136/bmjopen-2019-032510

[12] Davis, Sharon & Oakley-Girvan, Ingrid. (2017). Achieving value in mobile health applications for cancer survivors. Journal of Cancer Survivorship. 11. 1-7. 10.1007/s11764-017-0608-1

[13] Davis SW, Oakley-Girvan I. mHealth education applications along the cancer continuum. J Cancer Educ. 2015;30(2):388–94. doi:10. 1007/s13187-014-0761-4

[14] Grundy Q, Chiu K, Held F, et al. Data sharing practices of medicines related apps and the mobile ecosystem: traffic, content, and network analysis. BMJ 2019;364:l920

[15] Wyatt JC. How can clinicians, specialty societies and others evaluate and improve the quality of apps for patient use? BMC Med 2018;16:225

[16] FAITH Consortium, D2.1 Domain SotA & Data Assets, 2020

[17] Balbuena L, Bowen R, Baetz M, Marwaha S. Mood instability and irritability as core symptoms of major depression: An exploration using Rasch Analysis. Front Psychiatry. 2016;7:174. doi:10.3389/fpsyt.2016.00174

[18] Alaa A. Abd-alrazaq, Mohannad Alajlani, Ali Abdallah Alalwan, Bridgette M. Bewick, Peter Gardner, Mowafa Househ, An overview of the features of chatbots in mental health: A scoping review, International Journal of Medical Informatics, Volume 132, 2019, 103978, ISSN 1386-5056, https://doi.org/10.1016/j.ijmedinf.2019.103978

[19] Lovejoy, Chris & Buch, Varun & Maruthappu, Mahiben. (2019). Technology and mental health: The role of artificial intelligence. European Psychiatry. 55. 1-3. 10.1016/j.eurpsy.2018.08.004

[20] World Health Organisation: Physical Inactivity: A Global Public Health Problem. [http://www.who.int/mediacentre/factsheets/fs385/en/]

[21] World Health Organisation: Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. [http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf]

[22] Department of Health. Physical Activity Guidelines for Adults (19-64 Years). In: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/213740/dh_128145.pdf Accessed March 2021

[23] Webb TL, Joseph J, Yardley L, Michie S: Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. J Med Internet Res 2010, 12:e4

[24] Noar SM, Mehrotra P: Toward a new methodological paradigm for testing theories of health behavior and health behavior change. Patient Educ Couns 2011, 82:468–474

[25] Foster C, Richards J, Thorogood M, Hillsdon M: Remote and web 2.0 interventions for promoting physical activity. Cochrane Database Syst Rev 2013, 9:CD010395

[26] Middelweerd, A., Mollee, J.S., van der Wal, C.N. et al. Apps to promote physical activity among adults: a review and content analysis. Int J Behav Nutr Phys Act 11, 97 (2014). https://doi.org/10.1186/s12966-014-0097-9

[27] ElAmrawy, Fatema & Nounou, Mohamed. (2015). Are Currently Available Wearable Devices for Activity Tracking and Heart Rate Monitoring Accurate, Precise, and Medically Beneficial?. Healthcare Informatics Research. 21. 315. 10.4258/hir.2015.21.4.315

[28] Norman D. The design of everyday things. New York: Basic Books; 2013

[29] Orr K, Howe HS, Omran J, Smith KA, Palmateer TM, Ma AE, et al. Validity of smartphone pedometer applications. BMC Res Notes. 2015;8(1):733

[30] F. Luís-Ferreira, J. Gião, J. Sarraipa, R. Jardim-Goncalves, G. McManus, P. O'Brien, " Sleeping Movement Detection Towards Mental Health Indicators - A Review" in proceedings of ICE2020 International Conference for Concurrent Enterprising, Cardiff, UK, (2020)

[31] Gülşah Kaner, Meltem Soylu, Nimet Yüksel, Neriman Inanç, Dilek Ongan, Eda Başmısırlı, "Evaluation of Nutritional Status of Patients with Depression", BioMed Research International, vol. 2015, Article ID 521481, 9 pages, 2015. https://doi.org/10.1155/2015/521481

[32] West, Joshua & Hall, P. & Arredondo, Victor & Berrett, Brian & Guerra, Brittany & Farrell, Jaleen. (2013). Health Behavior Theories in Diet Apps. Journal of Consumer Health On the Internet. 17. 10-24. 10.1080/15398285.2013.756343.

[33] De Cicco P, Catani MV, Gasperi V, Sibilano M, Quaglietta M, Savini I. Nutrition and Breast Cancer: A Literature Review on Prevention, Treatment and Recurrence. Nutrients. 2019;11(7):1514. Published 2019 Jul 3. doi:10.3390/nu11071514

[34] Li Y, Ding J, Wang Y, Tang C, Zhang P. Nutrition-Related Mobile Apps in the China App Store: Assessment of Functionality and Quality. JMIR Mhealth Uhealth. 2019;7(7):e13261. Published 2019 Jul 30. doi:10.2196/13261

[35] Franco RZ, Fallaize R, Lovegrove JA, Hwang F. Popular Nutrition-Related Mobile Apps: A Feature Assessment. JMIR Mhealth Uhealth. 2016;4(3):e85. Published 2016 Aug 1. doi:10.2196/mhealth.5846

[36] Frost & Sullivan, 2018, Artificial Intelligence Market – Key Application Areas for growth in Healthcare IT, Forecast to 2022

[37] Understand the Value of AI for Healthcare Delivery Organisations, Laura Craft, Gartner, August 2019, online https://www.gartner.com/en/documents/3869974/understand-the-value-of-ai-for-healthcare-delivery-organ0, accessed January 2021