DR 6.14: PAL System impact valorization and future perspectives

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Publishable executive summary

PAL developed a Personal Assistant for healthy Lifestyle (PAL), a system that will assist the child, health professional and parent to advance the self-management of children with type 1 diabetes aged 7 - 14, so that an adequate shared patient-caregiver responsibility for child's diabetes regimen is established before adolescence.

The incidence of childhood type 1 diabetes mellitus (T1DM) is rising rapidly, with the number of reported cases doubling every 20 years. It is estimated that diabetic care (T1 and T2) costs 110 billion Euro, and that T1 patients incur higher mean treatment costs than T2 patients.

PAL responds to the fact that :

- There is a lack of knowledge and attitude with children for daily Type 1 Diabetes Management (T1DM). Consequently, the children are not prepared to handle the problems when they reach puberty;
- The parents also lack diabetes knowledge and lack insight in children's related competencies;
- The Health-Care Professionals (HCPs) have limited time to teach and coach the children and parents;
- Acquiring the required knowledge and attitude is difficult with the available tools for children.

Besides that there is a lack of an explicit univocal specification of the core concepts for behaviour change that an agent-based eHealth systems can apply. Currently, this knowledge is tacit and mainly applied (implicitly) by the HCPs.

Children need to be involved in the design of digital support systems for them. However, there is a lack of a coherent methodology (1) to acquire the support needs of children and (2) to create the corresponding design solutions.

The MyPAL service provides a combination of situated support functions to advance children's knowledge and attitude for their diabetes self-management over a long period of time: A conversational agent that builds a relationship with the children, timeline, educational activities with gamification, knowledge-base and reasoning engine, and dashboards.

Potential exploitable results of the project were identified and characterized by represented consortium partners and an expert at different planned Business Development sessions. First a longlist of exploitable results was produced and, subsequently, assessed. Next the list was shortened and condensed, resulting in a shortlist of 3 Key Exploitable Results (KERs). They are summarized in Table 1 below. Initiatives to work-out these KER in deployment plans have been started: The implementation of the *MyPalApp* agent-based game-framework in different web-based software environments, the re-use of the *Ontology-and-Reasoning* models to establish personalization and meaningful dialogues in near-future eHealth systems, and the *C4 suite* for providing services to structurally involve children in co-design (and evaluation) activities of eHealth systems). For education in particular, the impact of PAL relates to primary and secondary schools (e.g., "robot in the class" projects), and the university by providing the students the new knowledge and practices for agent-based educational software for advancing childs' self-management. Taken together, PAL entails an *evolving* type of *hybrid* care system that integrates a combination of (care) technology (e.g., robotics, artificial intelligence, mobile gaming) with human care (health care professionals and parents); subsequent steps are the (partial) implementation of the MyPalApp software framework, the re-use of the ontology-and-reasoning models and the provision of co-design and evaluation services based on the C4 suite.

Table 1 Key Exploitable Results in the PAL project

No.	Key Exploitable Result	Lead partner	Other project partners participating	Who will exploit it	What will be exploited	Potential way of exploitation
1	**MyPALApp**	**MXL**	Mixel, TNO, DFKI, FCSR, IMP	MXL	App	The agent-based game-framework can be used in different web-based software environments.
2	**Ontology and Reasoning**	**TNO**	TNO, TUD, DFKI	TNO	Know-how	The generic part of the ontology will be reused in future developments of educational software with conversational agents to establish personalization and meaningful human-agent dialogues. Two options are possible: (a) Starting joint projects in which the models are instantiated for specific applications, and (b) entering multi-party contracts for sharing and using the current and future versions of the models (incl. the running costs of the software). To initiate and support these exploitations, the ontologies will be made accessible via the PAL-space of the Socio-Cognitive Engineering Tool (SCET).
3	**C4 Suite**	**FCSR**	FCSR, TNO	FCSR	Web-based tool	The C4 suite is used to provide services to structurally involve children in co-design (and evaluation) activities of eHealth systems).

1. Introduction

1.1 PAL Objective

The overall aim of the PAL project is to develop a Personal Assistant for healthy Lifestyle (PAL), a system that will assist the child, health professional and parent to advance the self-management of children with type 1 diabetes (T1DM) aged 7 - 14, so that an adequate shared patient-caregiver responsibility for child's diabetes regimen is established before adolescence. PAL will be composed of a social robot, its (mobile) avatar, and an extendable set of (mobile) health-education applications, which connect to a set of (selectable) self-management objectives, an ontological knowledge-base and reasoning mechanisms. In this way, PAL supports its primary end-users, the children with T1DM, at the hospital and at home as a new type of situated "blended" care.

To advance the self-management, the PAL support focuses on the three human basic needs of the Self-Determination Theory (SDT): The needs for *competence*, *autonomy* and *relatedness* (see Ryan and Deci, 2017). These high-level support needs have been further decomposed in the PAL Objective Model (POM) ontology and PAL claims, as recorded in the Socio-Cognitive Engineering Tool[1].

It should be noted that the PAL objective matches well with the "*Global Action Plan for the Prevention and Control of NCDs 2013-2020"* of the World Health Organization (WHO). Particularly, the third, fourth and fifth objective are of relevance to the concepts of prevention, education and people-centered health-promoting actions, which are some of the key drivers of PAL:

- to reduce modifiable risk factors for noncommunicable diseases and underlying social determinants through creation of health-promoting environments

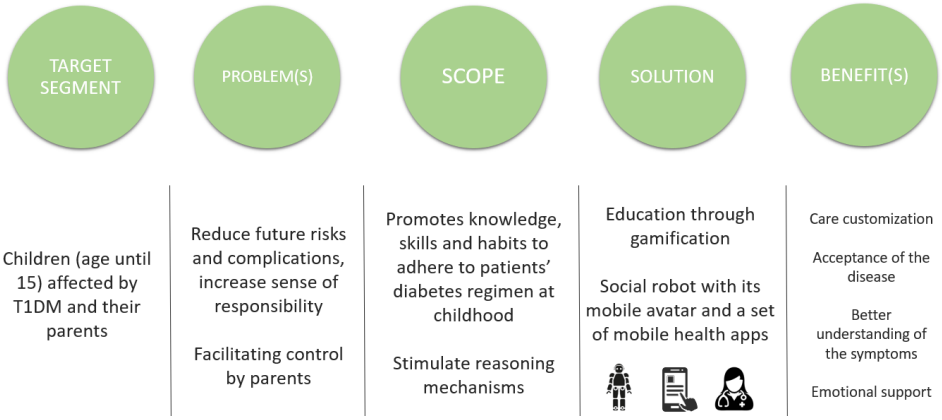
- to strengthen and orient health systems to address the prevention and control of noncommunicable diseases and the underlying social determinants through people-centred primary health care and universal health coverage

- to promote and support national capacity for high-quality research and development for the prevention and control of noncommunicable diseases

[1] https://confluence.ewi.tudelft.nl/display/PALsCE/Home+page+PAL+Socio-Cognitive+Engineering

1.2 PAL consortium and stakeholders

This 4 year project involved the *research partners* TNO (NL), DFKI (GER), FCSR (IT), Imperial (UK) and Delft University of Technology (NL), the *hospitals* Gelderse Vallei and Meander Medical Center (NL), the *Diabetics Associations* of Netherlands and Italy, and *SME's* Mixel (IT) and Produxi (NL). Stakeholders are also the PAL consortium itself and its users (children, parents and healthcare professionals). The partners analyzed why customers (users) should choose PAL. Below is a picture that shows the target segment, problems, scope, solution and benefits.



In the case of PAL, the service is characterized by a huge intangible value (education, autonomy, self-monitoring). This represents a challenge in communicating the offered value, because there are no objective measures that allow you to understand how much benefits are achieved. A simplification of this process occurs through reputation and brand awareness, whose construction is possible through agreements with public health institutions. Another solution is to offer to customer a trial period, during which he/she can test the interaction with the robot and use the mobile app. This can help to overcome parents' possible distrust in new technologies and in their therapeutic power.

Other stakeholders identified by the partners during the consortium are in the following main categories: healthcare, service providers, competitors and extra categories. All partners were asked to fill in a questionnaire. The aim of this questionnaire was to identify real life representatives of stakeholders in relation to PAL4U from the partner's country or relation network. A stakeholder is defined as: any group or individual who can affect or is affected by the development of PAL4U. In the healthcare stakeholders category, the following list of stakeholders was gathered:

- Financing / re-imbursement
    - Fundraising institutions
- Diabetes health organisations
    - Regional partnership of hospitals for child diabetes care
    - Specialized treatment center for children with T1DM
    - Education / training / knowledge

    - First Association of Diabetes Nurses
- Patient interest groups
    - Diabetes foundation by and for youth with T1DM
    - Friends of "the hospital" foundations
- Referring health professionals
    - National Association of General Practitioners

For service providers the following were identified:

- Pharma Insulin providers
- Glycaemic control providers (producers, whole sale, re-sellers)
- Self-management program providers
- Life style program providers (Lifescan – SweetBee)
- Robot providers (Wittyworx, developer of ixi-Play)
- Information Management providers (Netbasics, integrating information systems)

Competitor mentioned was: Jerry the bear. And in extra we identified: Pharmacy: Mediq, who is a home supply provider of tests, needles and insulin.

1.3 Exploration of PAL Exploitable Results

Potential exploitable results of the project were discussed between represented consortium partners and an expert at different planned Business Development sessions. The report provided by the expert with all the outcomes can be found in Appendix A Business Plan Development report. This provided a longlist of exploitable results produced. The consortium had produced a list of 17 KERs prior to the first workshop with the expert. After discussion 2 of the KERs were removed from the list. It was decided to cluster the remaining 15 KERs into 3 groups: Design; Content & Models; Software & Methods/Methodologies.

1.4 Consortium decisions on exploitation foci

This list of 15 KERs were discussed prior to the second session and discussed at the seminar. There this was shortened to a shortlist of 3 Key Exploitable Results (KERs). Two KERs from Software & Methodologies and one KER from Content & Model category:

- Co-Design tools (FCSR)
    - A set of co-design methods for children, aged 7-14: Image-theatre, draw-write-and-tell, storytelling, photo-elicitation and user journey maps. They provide a rich set of user requirements and use cases for pervasive, personalized and

situated support that are expected to improve children's daily self-management.

- Ontology models and reasoning rules (TNO)
    - Self-management support for Lifestyle related diseases; consist of : PAL Objective Model, User Model, Emotion Model, Episodic Memory Model, Feedback and Advice Model, Policies and working agreements for personalized safe information sharing.
- MyPAL app suite (Mixel)
    - MyPAL App is a mobile application that provides specific support to children affected by Type 2 Diabetes. Its main features are: education, training, entertaining, day-by-day assistance, diary, progress and goals tracking. It also allows remote monitoring over the child by parents, caregivers and doctors.

These three KERs were further characterized, see Chapter 2.

2. Three Key Exploitable Results

This chapter describes the further characterization of the three KERs.

2.1 co-Design tools

In researches where innovative technologies are developed for different classes of users, it is of key importance to understand the real needs and expectations of the ecosystem of end-users and to investigate the corresponding dynamics[2]. This guarantees the effectiveness of the solution developed, the respect of the interaction end-users will have with the system according to their existing behaviors, motivations and social/cultural background and prevent researchers from creating a product that reflects their preconceptions[3]. Therefore, in order to develop PAL, a "Socio-Cognitive Engineering" (SCE) approach has been exerted in order to: *(i)* understand the end-users (i.e. children, their families and Healthcare Professionals) determinants and values; *(ii)* possibly meet needs and desiderata, *(iii)* as well as address renown behavioral models, technology-related constraints and challenges[4]. All of these factors has been taken into account through the project lifetime in order to create a motivational and engaging robotic enhanced platform for T1DM educational and self-management support. To this extent, PAL

[2] Reed W a. User-centered design: a guide to ROI with ISO 9241-210. Texology Sci 2014
[3] Chesbrough HW. Open Innovation: The New Imperative for Creating and Profiting from Technology. Press, Harvard Businness School; 2003
[4] Blanson Henkemans, O.A., Bierman, B.P.B., Janssen, J., Neerincx, M.A., Looije, R., Van der Bosch, H., Van der Giessen, J. A.M. (2013). Using a robot to personalise health education for children with diabetes type 1: A pilot study. PEC, 92, 174 – 181.

has been developed, in all its preliminary studies and three cyclical releases, together with children and other relevant users in a process of "pervasive" *co-design*, i.e. embedded within "real life" situations and environments.

The PAL ***4C suite*** is a set of **co-design methods** specifically developed **for children**, aged 7 to 14 years old, embracing: interactive user journey maps, photo-elicitation, role-play and a selection of creative methods (i.e. draw-write-tell, storytelling and image theatre) to explore children's values, needs and their daily experiences on T1DM and to stimulate creativity, reflection and iteration (Figure 1). Through settings with representations of the envisioned technological solution (e.g., social robots, mock-up of MyPAL app or its beta versions), these tools are meant to provide a wide-range of user requirements and use cases for PAL development and validation. It is worth noting that the methods composing the suite have been designed by a multi-disciplinary team, involving robotics researchers, service designers, psychologists and ethicist, in order to take advantage from the different expertise and provide therefore investigation tools capable to be really engaging, respectful of the different values and tuned on the developmental phases of the users involved.

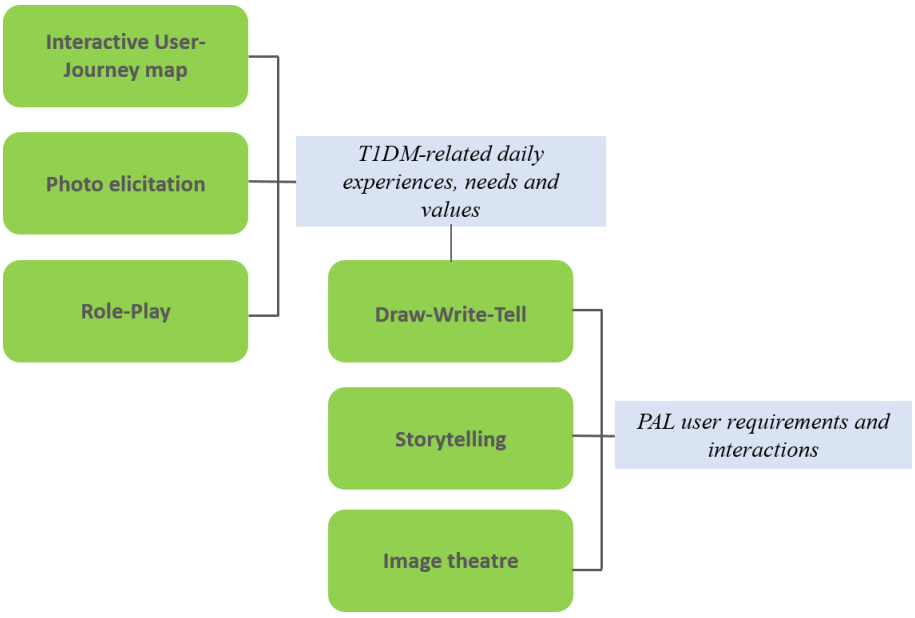


Figure 1: 4C suite framework

4C suite rationale

Nowadays, Non Communicable Diseases (NCDs), such as diabetes, are responsible of the death 41 million people yearly, equivalent to 71% of all deaths in the world (see Table 2). They tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behavioural factors[5]. Among the possible physiological factors, specific metabolic conditions, i.e.

[5] https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases

overweight/obesity, hyperglycemia, hyperlipidemia and high blood pressure, are directly correlated with an increase of NCDs risk. The same happens for modifiable behaviours, such as tobacco use, physical inactivity, unhealthy diet and the harmful use of alcohol.

Table 2: Disease burden and deaths from NCDs in the WHO European Region. As a measure of the disease burden is reported the DALY, which is the disability-adjusted life year; one DALY equals one year of healthy life lost (WHO 2005[6]) [Adapted from Singh 2008[7]]

Groups of causes	**Disease burden**		Deaths	
	DALYs (millions)	**Proportion from all causes (%)**	Number (millions)	Proportion from all causes (%)
Selected noncommunicable diseases				
Cardiovascular diseases	**34.42**	**23**	5.07	52
Neuropsychiatric conditions	**29.37**	**20**	0.26	3
Cancer (malignant neoplasms)	**17.03**	**11**	1.86	19
Digestive diseases	**7.12**	**5**	0.39	4
Respiratory diseases	**6.84**	**5**	0.42	4
Sense organ diseases	**6.34**	**4**	0	0
Musculoskeletal diseases	**5.75**	**4**	0.03	0
Diabetes mellitus	**2.32**	**2**	**0.15**	**2**
Oral conditions	**1.02**	**1**	0	2
All noncommunicable diseases	**115.34**	**77**	8.21	86
All causes	**150.32**	**100**	9.56	100

On the basis of these evidences, the prevention and control of NCDs became of utmost importance for the global health, that WHO has established a dedicated "*Global Action Plan for the Prevention and Control of NCDs 2013-2020"*[8]. And, among its objectives, three are strictly related to the concepts of prevention, education and people-centered health-promoting actions, which are some of the key drivers of PAL:

- **Obj. 3**: TO REDUCE MODIFIABLE RISK FACTORS FOR NONCOMMUNICABLE DISEASES AND UNDERLYING SOCIAL DETERMINANTS THROUGH CREATION OF HEALTH-PROMOTING ENVIRONMENTS

- **Obj. 4**: TO STRENGTHEN AND ORIENT HEALTH SYSTEMS TO ADDRESS THE PREVENTION AND CONTROL OF

[6] https://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/
[7] Singh, D. (2008). How can chronic disease management programmes operate across care settings and providers ?
[8] https://apps.who.int/iris/bitstream/handle/10665/94384/9789241506236_eng.pdf;jsessionid=8813C42CB56729C9114671891DCE8FC5?sequence=1

NONCOMMUNICABLE DISEASES AND THE UNDERLYING SOCIAL DETERMINANTS THROUGH PEOPLE-CENTRED PRIMARY HEALTH CARE AND UNIVERSAL HEALTH COVERAGE

- **Obj. 5**: TO PROMOTE AND SUPPORT NATIONAL CAPACITY FOR HIGH-QUALITY RESEARCH AND DEVELOPMENT FOR THE PREVENTION AND CONTROL OF NONCOMMUNICABLE DISEASES

In such a scenario, there is a growing international agreement on the conviction that introducing modern ICT-enhanced health supporting interventions (i.e. eHealth technologies) may lead to: (i) a more effective use of resources, (ii) an improvement in the quality of care, and (iii) greater attention paid to the needs and wishes of patients. Currently, many governments have started to support holistic information and communications systems strategies such as e-health platforms and electronic health records. This would possibly lay to: (i) an improved access to integrated data sets, (ii) an increased patients' participation and awareness in their process of care, (iii) an improved efficiency of delivery of prevention, education and care and (iv) a choral coordination among the different actors of the healthcare ecosystem, e.g. doctors, patients, hospital workers, pharmacists, care workers, health insurers and public administrators.

However, despite this growing evidence and the variety of possibilities to develop eHealth products, one of the key issues found in the creation of such services/products is to be able to include the end users in the process of designing, implementing and testing them[11] , as well as to rely on a coherent methodology for this purpose

PAL 4C suite market segmentation

The market we are addressing with PAL Co-design tools is the eHealth market, "*an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology*"[9].

In recent years, the number of web-based applications in healthcare (e.g. monitoring/diagnosis services, home care support systems) has increased exponentially, and the main factors responsible for this growth are, among others,

[9] **Gunther Eysenbach** speech delivered at UNESCO (Paris), June 2001, Conference of the International Council for Global Health Progress: Global health equity - Medical progress & quality of life in the XXIst century.

the rising Internet of Things (IoT), the flourish of wearable devices, self-servicing kiosk, mobile technology and mobile apps, cloud-based systems, and the increasing demand for a wider health self-management. Regarding this last point, infact, with the help of recent internet,-based solutions healthcare professionals can deliver *trusted health information* to health consumers more conveniently and in less time. According to Grand View Research[10], the global eHealth market was worth USD 159,371.4 million in 2017 and it is expected to reach USD 308,002.9 million in 2022 growing at a compound annual growth rate (CAGR) of 15.8% over the forecast (see Figure 2).

Figure 2: e-health market growth rate by region[11]

***Services And Products Overview*[12]**

Based on services, the eHealth market is segmented into (see Figure 3):

- monitoring (include vital signs, adherence monitoring, specialty services, and accessories);
- diagnostics (patience aid in the diagnosis of diseases and other issues);
- healthcare strengthening systems.

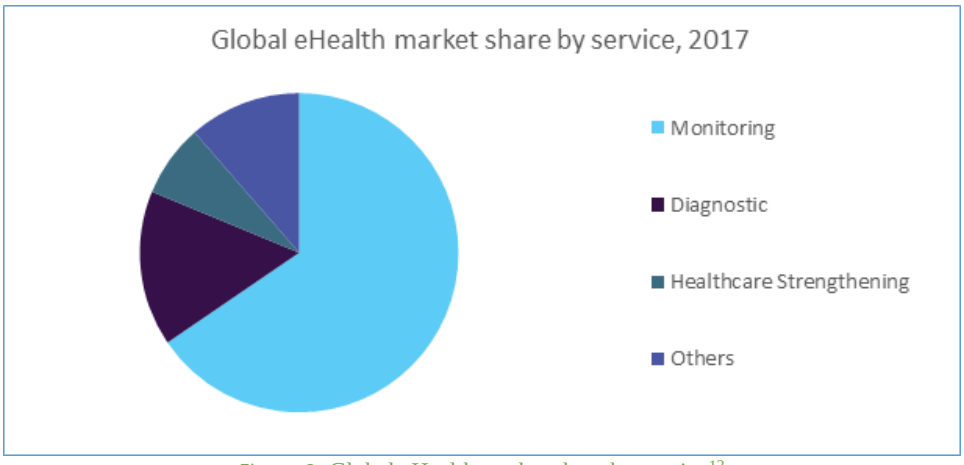


Figure 3: Global eHealth market share by service[13]

[10] https://www.grandviewresearch.com/
[11] e-health market- growth, trends, and forecast (2019 - 2024), published: Feb 2019 – Mordor Intelligence
[12] https://www.healthworkscollective.com/what-are-the-factors-influencing-ehealth-market-growth/
[13] Image Source: www.grandviewresearch.com

The corresponding product segments include:

- electronic health record (EHR),
- e-prescribing,
- clinical decision support,
- consumer health information,
- telemedicine,
- m-health,
- health management,
- healthcare information system.

***Market Players*:**
Some of the key players in Digital Health market include: Allscripts Healthcare Solutions Inc, GE Healthcare, Truven Health Analytics, Agfa-Gevaert N.V., McKesson Corp, Qualcomm Inc., Cisco Systems Inc., Philips Healthcare, Epic Systems Corp, Cerner Corp., Siemens Healthineers, AT&T Inc., Alcatel-Lucent Corporation, AirStrip Technologies LP, Aruba Networks, Inc. athenahealth Inc., Boston Scientific Corporation, Cerner Corporation, CompuMed Inc., IBM,, Medisafe, SetPoint Medical, McKinsey & Company, Proteus Digital Health, Telecare Corporation.

Target Segments

1. *Healthcare providers* specialized in chronic diseases, such as diabetes.
2. *Professionals dealing with lifestyle-associated disorders*, such as hypertension, cardiovascular disorder and obesity.
3. *Public healt*h, hospitals, ambulatory, high-tech healthcare infrastructure, insurance companies, medical informatics referring to health services (Beghelli, Almaviva, Telbios).

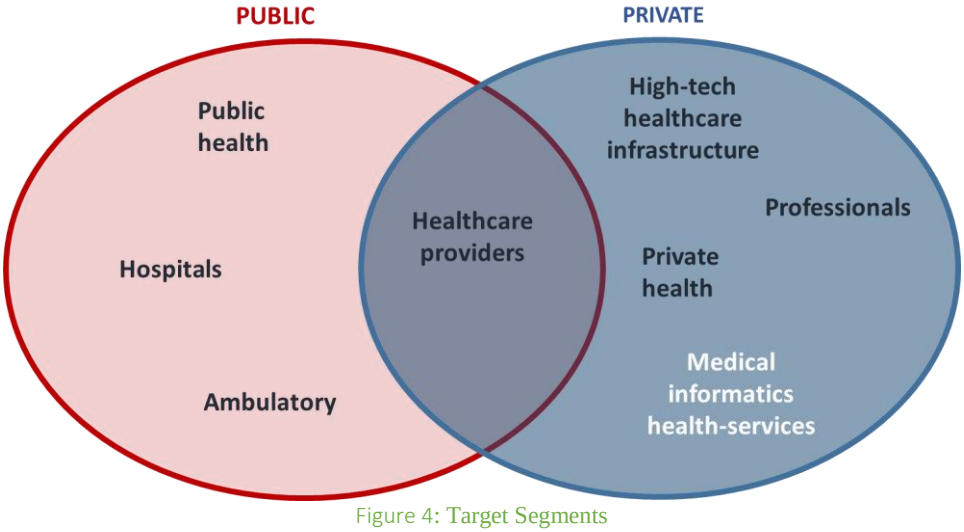


Figure 4: Target Segments

The first step before defining the marketing strategy is to select the target segments that have more potential based on some criteria, such as:

- they are sizeable enough to be profitable given our operating cost,
- they are growing and not already swamped by competitors,
- they are accessible

- we have the resources to compete in it

Medical IT health companies/service providers are the PAL 4C suite elective targets. Like for example, software companies that develop behavior change support systems for children with chronic diseases (or in general for wellbeing), who has no access or have limited resources for R&D (in terms of investments and/or resources).

PAL 4C suite unique value proposition and SWOT

As previously mentioned, the PAL 4C suite is a set of co-design methods for children, aged 7-14, providing a rich set of *methods and best practices for user requirements elicitation and use cases definition for the development of a pervasive, personalized and situated eHealth educational support*, which is expected to improve children's daily T1DM self-management. In particular, it is meant to be a set of complementary techniques to acquire insight in the contexts, desired functionalities and solutions for agent-based (e,g., robot, avatar) behaviour-change support for children

Moreover, to productively adopt a user-centered approach in the design and development of a product/service, one of the pillars is to rely on an ecosystem where insights, ideas and feedbacks are generated involving the possible users in a process of open innovation. To this extent, *the PAL 4C suite has been deployed in a living-lab based cross-disciplinary and countries environment*, where patients, caregivers, technicians, developers, researchers and domain experts where easily accessible and involved in the project lifetime. This has been possible thanks to: (i) TNO research network of contacts, spreading from hospitals in the Netherlands and patients' associations, and (ii) San Raffaele Hospital City of the future living lab[14].

PAL 4C suite business strategy

In the perspective of a concrete exploitation strategy for the PAL 4C suite, the first strategy explored is the one of a **consultancy service for eHealth-based innovative technologies/services for children with T1DM and/or chronic diseases,** offering to the interested customers a specific and contextualized user-requirements analysis, thanks to the use of the 4C suite methods and best practices as well as a trusted and easy access of a pool of linked stakeholders to also (possibly) testing the solution developed.

We started with the exploitation as a consultancy service, using the available content, tools and instruction material developed within the project. PAL provides the needed foundation to initiate this new service, for which we will collaborate with TNO. Actually, the 4C-suite environment (in Confluence, see Deliverable

[14] Vicini, S., Bellini, S., Sanna, A.: The city of the future living lab. Int. J. Autom. Smart Technol. **2**(3), 201–208 (2012)

6.13 “Co-creation online tool) will be used to maintain and share the experiences that FCSR and TNO will develop in Italy and Netherlands, respectively.

Here it follows an example description of a possible related marketing strategy abstract:

- *Early adopters/ First costumers*: ICT small/medium companies providing educational services/products in the healthcare sector for children with T1DM or chronic diseases, healthcare service organizations.
- *Services:* understand the ecosystem of end users needed for a specific product, engage them through the living-lab based network, define the corresponding needs/determinants/values to be formalized into functional user requirements in order to drive the technical implementation to obtain the best solution for the intended purpose.
- *Channels to inform and recruit customers*:
    - Website: create a dedicated web site where upload all information, benefit and service description, convey traffic and collect contacts;
    - Press releases and ADV
    - Social Media strategy
        - LinkedIn: the world’s largest professional social media network, ideal for salespeople to connect with prospects and for marketers to run Lead generation campaigns;
        - Twitter: the social media for people and companies that have to communicate the results of a research, share resources, promote events and publications, build online communities, connect with people and communicate with followers;
        - Facebook (page/groups): ideal to communicate and get in contact with communities;
        - Youtube: ideal to show product demos;
    - *Lead Generation*: to find and contact prospects;
    - *Participation to exhibitions and trade fairs*

In the following instead, is reported a tentative overview of the possible costs of the PAL 4C-suite consultancy exploitation service. Basically, we took into account the costs coming from the personnel voices, i.e. Marketing & Sales to identify potential customers, Service Designers/researchers for the 4C methodology application, Field Experts in the healthcare domain in order to provide trusted knowledge during the investigation activities.

Cost of employment					
	maximum number of consultancies (nominal)				
Fixed cost - yearly based	0	10	20	30	40
Marketing & Sales	€ 56.000	€ 56.000	€ 56.000	€ 56.000	€ 56.000
FTE - 1 day/week	20%	20%	20%	20%	20%
	€ 11.200	€ 11.200	€ 11.200	€ 11.200	€ 11.200
Service Designer Sr	€ 49.000	€ 49.000	€ 49.000	€ 49.000	€ 49.000
FTE - 1,5 day/week	30%	30%	30%	30%	30%
	1	1	1	1	1
	€ 14.700	€ 14.700	€ 14.700	€ 14.700	€ 14.700
Administration	€ 56.000	€ 56.000	€ 56.000	€ 56.000	€ 56.000
FTE - 0,5 day/week	10%	10%	10%	10%	10%
	€ 5.600	€ 5.600	€ 5.600	€ 5.600	€ 5.600
	€ 31.500	€ 31.500	€ 31.500	€ 31.500	€ 31.500

Variable cost - yearly based	0	10	20	30	40
Service Designer Jr	€ 35.000	€ 35.000	€ 35.000	€ 35.000	€ 35.000
minimum effort per consultancy - 100% = 1 year	20%	20%	20%	20%	20%
number of service designer involved	0,00	2,00	4,00	6,00	8,00
maximum number of consultancies (nominal)	0,00	10,00	20,00	30,00	40,00
	€ 0	€ 70.000	€ 140.000	€ 210.000	€ 280.000
Medical Doctor	€ 60.000	€ 60.000	€ 60.000	€ 60.000	€ 60.000
minimum effort per consultancy - 10% each	0%	20%	40%	60%	80%
	€ 0	€ 12.000	€ 24.000	€ 36.000	€ 48.000

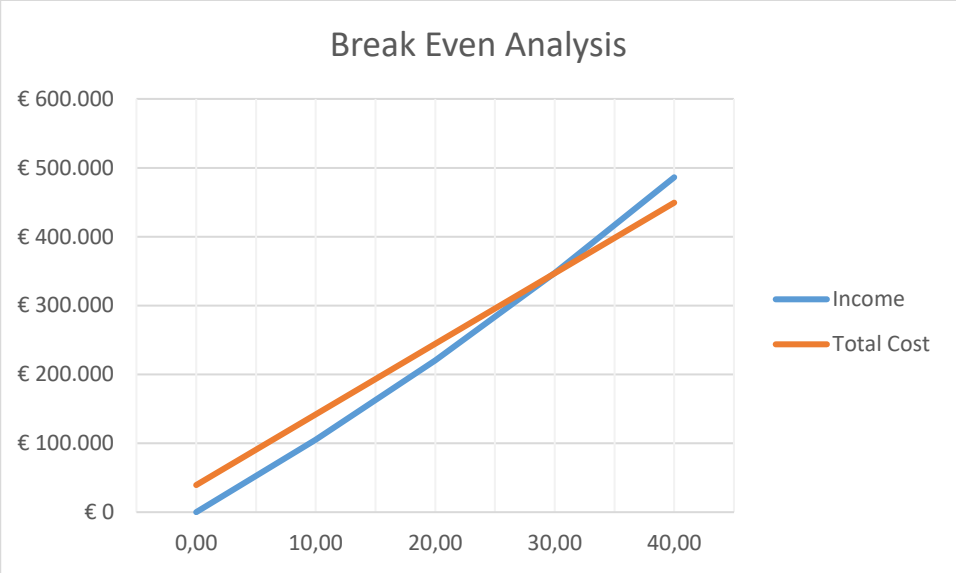
Direct personnel cost - yearly based	€ 31.500	€ 113.500	€ 195.500	€ 277.500	€ 359.500
Overheads (25% direct personnel cost)	€ 7.875	€ 28.375	€ 48.875	€ 69.375	€ 89.875
Total Cost of employment	**€ 39.375**	**€ 141.875**	**€ 244.375**	**€ 346.875**	**€ 449.375**

Overheads will take into account mainly travel and accommodation cost across nationwide.

From a revenue perspective, some considerations has to be made about the team productivity and the selling price of the service. As the number of consultancy services increases, the size of the team must increase and it is therefore reasonable to expect an increase in productivity. The sale price of the service was assumed based on the consultancy services we experienced in our activities: in a range between 10k€ and 50k€, we prudently chose 10k€.

Consultancies revenues					
maximum number of consultancies (nominal)	0,00	10	20	30	40
Productivity	0,00	1,05	1,10	1,16	1,22
number of consultancies (effective)	0,00	10,50	22,05	34,73	48,62
Consultancy service - each	€ 10.000	€ 10.000	€ 10.000	€ 10.000	€ 10.000
Income	**€ 0**	**€ 105.000**	**€ 220.500**	**€ 347.288**	**€ 486.203**

In this configuration, the break-even point could be reached in approximately 30 consultancies.



In addition to the revenues, this will provide further experiences with the usage and exploitation that will be fed into the manuals and expert guidance knowledge and skills. Subsequently, the online versions of the 4C suite methods will be made ready for usage by others, as a kind of "blended" service, leveraging on specific online versions of the instruments and including costs from the 4C-experts and IT personnel.

After these first experiences, we will explore possibilities to transfer it to a start-up, mostly to identify a proper cost-benefit model justifying the revenues and profit profile assumed.

Summary LEAN CANVAS

(1) Problem	**(4) Solutions**	**(3) Unique Value proposition**	**(6) Unfair Advantage**	**(2) Customer segment**
To manage a chronic disease is not at all trivial mainly because, when it occurs, it requires the involved people (both the young and the elderly) to acquire a series of information, learn specific competences and manage tasks which are not immediate. Most countries are experimenting innovative strategies for disease prevention and early detection, but they all require changes in professional routines, qualifications and care settings.	To provide the best answer to the user needs, it is possible to offer a consultancy service to provide user requirements by taking advantage from the use of cross-expertises environments and end-users' hubs like living labs. The PAL *4C suite* is a set of co-design methods specifically developed for children, aged 7 to 14 years old, embracing: interactive user journey maps, photo-elicitation, role-play and a selection of creative methods (i.e. draw-write-tell, storytelling and image theatre) to explore children's values, needs and their daily experiences on T1DM and to stimulate creativity, reflection and iteration.	PAL 4C suite provides a rich set of methods and best practices for user requirements elicitation and use cases definition for the development of a pervasive, personalized and situated eHealth educational support, which is expected to improve children's daily T1DM self-management. In particular, it is meant to be a set of complementary techniques to acquire insight in the contexts, desired functionalities and solutions for agent-based behaviour-change support for children. Moreover, to productively adopt an user-centered approach in the design and development of a product/service, one of the pillars is to rely on an ecosystem where insights, ideas and feedbacks are generated involving the possible users in a process of open innovation. To this extent, the PAL 4C		Service providers have the opportunity to carve out new market shares providing personalized services on users' needs • Healthcare providers specialized in chronic diseases, such as diabetes. • Professionals dealing with lifestyle-associated disorders, such as hypertension, cardiovascular disorder and obesity. • Public health, hospitals, ambulatory, high-tech healthcare infrastructure, insurance companies,

<table>
<tr><td>Modern ICT may lead to more effective use of resources, an improvement in quality of care, and greater attention paid to the needs and wishes of patients</td><td>(8) Key Metrics

Number of consultancies</td><td>suite has been deployed in a living-lab based cross-disciplinary and countries environment, where patients, caregivers, technicians, developers, researchers and domain experts where easily accessible and involved in the project lifetime.</td><td>(5) Channels

Early adopters/ First costumers

Services

Channels to inform and recruit customers:</td><td>medical informatics referring to health services</td></tr>
<tr><td colspan="3">(9) Cost structure

Basically costs coming from personnel involved, mainly Marketing & Sales to identify potential customers, and Service Designers for the methodology application.</td><td colspan="2">(7) Revenue Streams

Consultancies revenues</td></tr>
</table>

Looking over PAL: 4C suite for pediatric chronic disease and wellbeing and for other age-ranges

On the basis of the previous discussion, the Co-design suite of participative methods developed in PAL, could be also modified and improved in order to widen the range of services offered by a such consultancy service.

In fact, the same strengths characterizing the suite of best practices for children with T1DM could also be directed towards:

- The implementation of personalized and situated educational/supportive tools for children with other chronic diseases or for children in general, in order to create awareness and education towards correct health-related habits
- The implementation of the same services for different age-ranges (e.. adults or elderly); of course in this case the 4C suite would be strongly re-shaped in order to correctly tackle an audience with different behaviours and developmental phase.

2.2 Ontology models and reasoning rules

The first KER is the ontology model and reasoning rules of child diabetes self-management support. The PAL ontology consists of:

- PAL Objective Model (POM)
- Domain Model
- Episodic Memory Model
- Agreement Model
- Semantics Model
- Affect Model (emotion and sentiment)
- Feedback and Explanation Model
- Small Talk Model
- Task Model

The **problem** we address with the ontology model and reasoning rules is that there is a lack of an explicit univocal specification of the core concepts for behavior change that an agent-based eHealth systems can apply. An important growing societal and economic problem is the prevalence of lifestyle-related chronic diseases (e.g. see Table 2 in section 2.1). Interactive Artificial Intelligent technology provides new opportunities to help solve this problem, but current knowledge on disease management and behavior is for an important part tacit and mainly applied (implicitly) by the health care professionals without a complete "formalized correct logic". In the PAL project, the concept of human-agent *partnership* incorporates core behavior

change and disease management concepts that have been worked out and formalized in the concerning ontologies (with a consistent human-understandable logic). These ontologies incorporate expert knowledge *both* about diabetes management *and* about agent support for behavior change.

The **unique selling point** is the re-usable validated expert knowledge on personal behavior change, nutrition and diabetes, which (a) human can understand and uptake for behavior change, and (b) agent-based technology can use to provide their services. It is extensible and transferable to other lifestyle-related disease management domains.

When looking at the **product/ service market** we think it is mainly interesting for big companies that apply "hybrid AI" in the eHealth domain (for instance: Philips, Siemens, Google, IBM). Other interested are SME that apply "hybrid AI" for eHealth (e.g. organizations in Medical Delta, etc.). There is a *trend* towards "hybrid AI" (the 3rd wave): a combination of symbolic and sub-symbolic (machine learning) AI. These ontologies underpin the symbolic layer. So far competitors are only visible in the academic world (e.g. universities), but early adopters could be eHealth Developers or serious game developers. The product is actually ready at the end of the project, but cost of implementation should be kept in mind to include specific domain knowledge.

We will continue with the "Twin-Win Model" (Shneiderman, 2018) to both advance the ontologies and deploy them in collaboration by teams of researchers, academic leaders, business managers, and government funding policymakers. This problem-oriented approach to research are envisioned to provide the next validated solutions (after PAL), increasing the readiness for further (more widespread) development and implementation (i.e., the ontologies are the flywheel of PAL-based innovations). Here, the focus is educational software with conversational agents to establish personalization and meaningful human-agent dialogues. Two options are possible: (a) Starting joint projects in which the models are instantiated for specific applications, and (b) entering multi-party contracts for sharing and using the current and future versions of the models (incl. the running costs of the software). To initiate and support these exploitations, the ontologies will be made accessible for the participating organisations via the PAL-space of the Socio-Cognitive Engineering Tool (SCET).

Summary LEAN CANVAS

<table>
<tr>
<td rowspan="2">(1) Problem

Interactive Artificial Intelligent technology provides new opportunities to help the increasing number of persons with lifestyle-related chronic diseases, but current knowledge on disease management and behavior change is for an important part tacit and mainly applied (implicitly) by the health care professionals without a complete “formalized correct logic”.</td>
<td>(4) Solutions

The PAL ontologies entail personalized pervasive human-agent partnership interactions for behavior change and disease management concepts (with a consistent human-understandable logic). These ontologies incorporate expert knowledge both about diabetes management and about agent support for behavior change.</td>
<td rowspan="2">(3) Unique Value proposition

Based on cross-disciplinary and cross-border research, the ontologies provide sound re-usable validated expert knowledge on personal behavior change, nutrition and diabetes, which (a) human can understand and uptake for behavior change, and (b) agent-based technology can use to provide their services. It is extensible and transferable to other lifestyle-related disease management domains.</td>
<td>(6) Unfair Advantage</td>
<td rowspan="2">(2) Customer segment

Software companies and service providers have the opportunity to carve out new market shares providing personalized behavior change technology

• Healthcare providers specialized in chronic diseases, such as diabetes.
• Software companies with interests in the health domain.
• Public health, hospitals, ambulatory, high-tech healthcare infrastructure, insurance companies, medical informatics</td>
</tr>
<tr>
<td>(8) Key Metrics

Number of ontology users and implementations.

Number of applications that (a) incorporate or (b) query PAL ontologies.</td>
<td>(5) Channels

R&D communities/ eHealth platforms/ Hospital organizations</td>
</tr>
</table>

				referring to health services
(9) Cost structure Basically costs coming from personnel involved, mainly Marketing & Sales to identify potential customers, and Ontology Engineers to maintain, update and disseminate the ontologies.		**(7) Revenue Streams** R&D projects, consultancies revenues		

2.3 MyPAL app suite

Description

Within the PAL project architecture, the MyPAL app is a mobile application, strictly interacting with the PAL artificial intelligence engine and the cloud system, able to provide a set of useful services for the child and his parents. The application has been designed to be used on tablet devices based on the Android operating system, in version 4.2 or higher.

Some sections of the app can be separated from the system and go to form additional stand-alone apps. The main services can be summarized as follow :

- Provide a wide range of tools for information, education and learning
- Provide a variety of self-test instruments
- Provide a day by day management support mechanism (diary, timeline, data acquisition)
- Provide a set of long-term engagement mechanism in order to extend the use of the tools and consequently maximize their benefits.
- Offer a gaming platform
- Increase creativity and expand the child's social life

Therefore the use of the MyPAL app, together with the PAL control&inform and the NAO ('real' version and 'virtual' version), provides an answer to a series of needs clearly expressed by the end-users and actually not covered by the existing national health services and structures.

The final results of the PAL project described in PAL deliverable D1.5, offer a proof and a detailed description of how PAL provides positive results in terms of awareness, learning processes, knowledge acquisition and control of biological parameters. Based on these results it's possible to develop an exploitation plan of the MyPal app KER, eventually integrated with some additional features already analyzed within the PAL project.

Background

Among the most emerging needs in the context of the diagnosis and subsequent treatment of chronic diseases, the discomfort that can arise in the child when in contact with the hospital world is one of the most important situations to manage. The implementation of the PAL system and the NAO Robot help to create a friendly approach and help to increase the child's well-being during

the hours spent in the hospital. The use of entertainment systems for educational purposes can also help to manage waiting periods within hospitals.

The creation of games linked to the pathology of diabetes, but which may also be of interest regardless of the pathology, leads to reducing the social barriers that can be established between children with diabetes and peers. The use of the application helps the socialization among the various child users thanks to the gamification and challenge mode implemented within the system. The customization of the graphic aspects and the interactivity with the robot in some sections of the app such as the dance, helps the child to develop his own creativity.

The use of an avatar based on a real robot, capable of simultaneously reproducing the movements of the physical robot, is one of the strengths of the entire work. Through this feature, the child does not feel the gap between the interaction with the app in the hospital setting, which occurs through the physical and real robot, and the use of the app at home. The child is led to consider the virtual robot as a concrete transposition of the real robot he or she sees in the hospital.

The child tends to implement mechanisms of refusal towards authoritarian figures, such as parents and the doctor. The use of the NAO Robot helps to instill confidence in the child, so that he can teach and give advice in a non-authoritarian perspective. Moreover, children tend not to expose their hardships to their parents. A system based on interaction with a friendly figure can help young people get rid of some of the thoughts and discomforts they face.

The learning and long-term engagement mechanisms through play dynamics and the aggregation system aimed at children suffering from chronic diseases can be expanded within scenarios that involve patients in adulthood. In addition, both the definition of the knowledge needed by the patient and monitoring of nutrition, therapies and good practices bring benefits regardless of the patient's age

Market

The market we are addressing with myPAL app is the eHealth market, with particular reference to the following target :

- self-management of type 1 diabetes in children before puberty (age range from 7 to 14) - this is the most addressable sector, for which myPAL app was designed and created

This market can be enlarged by considering others adjoining markets segments with similar needs and similar potential benefits offered by the MyPal app services :

- self-management of type 2 diabetes in adults - this is the natural outcome of a prospective development process of myPAL app

- self-management of other chronic diseases - such as obesity, renal/hepatic impairment, hypertension and cardiovascular disorders - both for children and adults - this is a desirable outcome of a prospective development process of myPAL app

- healthcare infrastructure - hospitals, ambulatory, medical informatics and insurance companies

See Figure 4 of section 2.1 for an overview of the public and private market segments.

In order to define an adequate market strategy, it is necessary to select the target segments with greatest potential. The following criteria are used:

- scalability - taking into account the operating costs, market segments have to be sizeable enough to be profitable

- growth - market segments must be actively growing and not saturated

- accessibility

Chronic patients, healthcare providers and high-tech healthcare infrastructures are the myPAL app preferable targets.

Team, Management Structure and Business Overview

At a first analysis, considering the technical characteristics of the MyPal app, the overall services required by this specific market and based on similar experience providing these kind of services it's possible to estimate an operational team structured as follows:

- business team:
    - 1 Manager
    - 1 Secretary + Assistant (Administration)
    - 1 Sales Manager
    - 1 Product Manager (Sales Assistant)

- technical team:
    - 1 CTO
    - 2 Software developer
    - 1 Help Desk

The following table summarizes the cost structure.

team of 8 people = 8 **x** 40 k€/y	**320 000 €/y**
overheads 35%	**112 000 €/y**
external providers	**50 000 - 80 000 €/y**
TOT	**480 000 - 520 000 €/y**

The high number of shareholders potentially involved in the chain of diabetics services potentially offers more than a single business model to sustain an exploitation activity based on MyPal app.

To obtain a first estimation of the position of a break-even point we can consider a mixed revenue model based on :

- a fee covered by the hospitals who offer the MyPal services
- a fee covered by each family using the MyPal app services
- a fixed income coming from selected sponsors active in this specific market

Based on this assumptions we can consider the following numbers :

10 hospitals = 10 **x** 10 k€/y	**100 000 €/y**
30 patients each hospital = 30 **x** 10 **x** 1.2 k€/y	**360 000 €/y**
2 sponsors (pharma, insurance) = 2 **x** 20 - 50 k€/y	**40 000 - 100 000 €/y**
TOT	**500 000 - 560 000 €/y**

Based on this revenues hypothesis the break even point could be reached by implementing MyPAL app in a minimum of 10 hospitals with 30 patients each and by being supported by 2 sponsors (e.g., pharma, insurance companies).

The market size and his potential can be considerably increased considering the opportunities offered by the possibility of using the same approach for different diseases, different age segments and the integration with wearable sensors, like the glucometers for the diabetes patients.

EXPLOITABLE FOREGROUND

OVERVIEW TABLE WITH EXPLOITABLE FOREGROUND								
Type of Exploitable Foreground	Description of Exploitable Foreground	Confidential	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application	Timetable for commercial use or any other use	Patents or other IPR exploitation (licences)	Owner and Other Beneficiary(s) involved
Source code	Creates movements to be used on a NAO	Yes	??	BehaviorManager	NAO-Apps	Ongoing	No patents. Applied in products like Ziggi	Produxi
Source code	Creates movements on the NAO	Yes	??	NAOConnector	NAO-Apps	Ongoing	Noc patents. Applied in products like Ziggi	Produxi
General Advancement of Knowledge	Improved HFC reasoner, Software for specialized reasoning over time	No	None	HFC: can be exploited in other projects	M72 Scientific research and development M71.2 Technical	Available for commercial and academic use	CCv4	Owner: DFKI PAL partners Open Source

					testing and analysis			
General Advancement of Knowledge	Linguistic resources in Dutch, Italian, English	No	None	can be exploited for further research activities	M72 Scientific research and development	Available for academic use	None	Owner: DFKI PAL partners
General Advancement of Knowledge	VOnDA framework for reactive and adaptive Dialogue management	No	None	VOnDA: can be exploited in other projects	M72 Scientific research and development	Available for commercial and academic use	CCv4	Owner: DFKI PAL partners Open Source

3. Education opportunities

3.1 PAL as example for human-centered design

Several Master and PhD-students have been working on the PAL-project, learning and applying the human-centered design methods for human-agent partnerships (such as Socio-Cognitive Engineering, SCE). As such, PAL has been an interesting topic in guest lectures and PhD-schools. Furthermore, PAL, as a best practice of SCE, is part of the Master-course Intelligent User Experience Engineering, and the future Master-course Socio-Cognitive Engineering at the Delft University of Technology.

In Germany, the VOnDA will be used as a basis for teaching the creation of conversational systems at Saarland University, which DFKI cooperates with on a regular basis.

At Imperial College London, PAL is introduced as part of the "Human-Centered Robotics" course. This course is available to students from the Electrical Engineering department, as well as to those from the Design Engineering department. PAL is provided as one example of systems that involve robots and have a strong human-centred design aspect. Furthermore, students were given the opportunity to work on the PAL system as part of their coursework.

Since 2018 at the San Raffaele University (Università Vita e Salute San Raffaele http://www.unisr.it), the PAL project has been included as a case study in the course of Health Informatics for the Cognitive Psychologists students.

3.2 PAL for elementary schools

In the Netherlands, the *Dutch National Research Agenda* (NWA) describes broad, societal challenges that require a national research approach from which the knowledge economy and society at large can benefit. Twenty-five so-called "NWA routes" have been identified, for which the *Research along Routes by Consortia* (NWA-ORC) call aims to fund research and innovation projects. These projects will be designed and implemented by interdisciplinary consortia spanning the entire knowledge chain, in which relevant societal partners are also represented. TU Delft and TNO are involved in a project proposal for one of these routes: "Child and adolescent development, upbringing and education". This way, the relevant PAL models, methods and design patterns for robot-assisted education will be further developed and implemented at schools in the Netherlands.

At a Dutch *high school*, the Produxi-Performer and Produxi-Quizzer are applied in support of teaching French and German classes with a NAO-robot. These applications are developed based on experiences from the PAL project. Especially the form of the Quiz and usages of guidance to help the child execute the quiz is used.

3.3 PAL for future care

End-event. Presentation for the Executive Board of the ZGV hospital, … Create information…

4. Legacy & Other future plans

4.1 Single Partners' plans on the basis of the PAL legacy

ZGV

In collaboration with PROD, the ZGV hospital derived the Ziggi robot platform from the PAL concept, particularly building upon the quiz use case and a group presentation use case. Ziggi is being used at ZGV to assist children who are diagnosed with T1DM and are admitted to the hospital. First, these children play the quiz (a) to acquire basic diabetes knowledge, and (b), subsequently, to do a test if they did acquire this knowledge (which is needed to go home). Second, the children prepare a presentation for their school class with Ziggi (i.e. a presentation that they will give together with Ziggi). Subsequently, they take the robot to school and give the presentation with Ziggi. Furthermore, ZGV initiated a project proposal with TNO to develop a PAL system for children with asthma, starting with the Dutch hospitals ZGV and UMC.

MEA

The Meander hospital aims to join the Ziggi-activities of ZGV (see above). An important step is to harmonize the expectations of the medical professionals and managers concerning the functionalities and deployment of a robotic system like PAL, to the actual technical and operational opportunities. Together with TNO, the Meander project partners will produce educational material on the support of cloud-based social robots, like PAL, for young patients with a chronic diseases like diabetes.

FCSR

FCSR, alongside with San Raffaele hospital, aims at exploiting the PAL results according to a threefold strategy:

1. A stand-alone version of the PAL eHealth app-*games* (i.e. memory game and the break&sort one), developed by MIXEL and available on dedicated tablets, is going to be used as educational support by OSR healthcare professionals during their "in-ward" lessons for the *hospitalised* T1DM children and families at the onset or during their periodic checks. In this way, the educational team of the paediatric diabetology, composed by paediatricians and dietists/nutritionsits, will have at disposal an engaging tool to approach T1DM-related lessons and education with a gaming perspective and capable to reinforce some of the key notions they're conveying to families (especially on the nutritional and CHO counting topics);

2. The possibility to use the same version of the PAL *games* in OSR *paediatric diabetology clinics* is currently under discussion. The idea is to design and create an interactive corner with a game-station or "totem" in which children can play alone on in couple to the PAL games while they're waiting for their diabetological control;

3. Through the different PAL dissemination activities carried out through the project lifetime with schools, FCSR and OSR have developed an interactive format for *lessons* with the NAO robot and field experts (e.g. nutritionists). These lessons are provided to primary schools classes on relevant topics of nutrition and healthy lifestyles, both related to T1DM or not, according to the specific needs. Currently advanced discussions are taking place among OSR and schools of the Milan areas to cyclically deliver to students these formats.

DVN

The Dutch association for diabetes in the Netherlands (DVN) intends to disseminate the PAL-games via the website. The practicalities are currently explored with MXL, and further collaboration is being set-up with the Diabetes Funds Netherlands (DFN) and TNO.

SOStegno

Sostegno70 is intended to exploit the educative aspect of PAL in two ways:

1. Integrating the stand-alone version of the PAL app-games (i.e. memory game and the break&sort one) as interactive tools for the nutritional lessons which are held for the associate children with T1DM in specific occasions organised by the association like: yearly educative camps for children and pre-adolescents, informative T1DM-related meetings with children and families or congresses.

2. Making available on the association's website the PAL app-games. This plan has a longer perspectives as a deeper discussion has to be conducted on this regard with the rest of the project Consortium.

MXL

Mixel is a SME organization and has a strong interest in exploiting the assets and the results coming from the PAL Project. Several partners of the PAL consortium (Sostegno70, DVN, FCSR) have already expressed their intention to use some of the software modules developed by Mixel (in particular the educational games and the My Pal app) as stand-alone products. Therefore Mixel is evaluating the potential market.

The educational game formats designed within the PAL project can also be extensively used, either with additional new contents or applied as learning tool for other diseases or, with some adequate minor changes for other class of end-user (different ages, different formative context).

On top of this, Mixel has started with FCSR a joint activity to evaluate the feasibility of a real service, based on the PAL results and particularly the MyPal app, the "PAL Control&Inform" module and the NAO (real NAO and Virtual NAO).

Based on the result of this preliminary analysis it has been decided to further investigate the opportunity of developing a proposal for one of the next 'SME instruments' call for proposals. At this purpose, a deep analysis of intellectual property issues, market size and trends, potential business model, costs structure and potential revenues is currently in progress.

PROD

Based on the experiences from the PAL-project, Produxi started to build applications that facilitate usage of NAO's by children in various environments. The current available applications are (for examples, see www.roboduxi.nl):

- *Produxi-Quizzer*: an application with which professionals can create a database with questions and from there create sessions. Each session consists of a number of questions which the NAO and the child alternatingly ask and answer.
- *Produxi-Performer*: an application with which a person can make a presentation and present it together with a NAO. First the person creates a PowerPoint and then decides what the NAO and what the person is going to tell. Using the application the person creates the texts and the gestures used by the NAO and add steps to start the presentation and go to other slides. Or add steps to instruct the NAO to starts saying a text when a specific slide is shown on screen.

The applications can be bought separately as well as in combination with the necessary hardware like NAO, laptop, tablet, seesaw, transport case. The full package is called Ziggi.

The products are in use by a hospital, a school and a research institute. In the hospital (partner ZGV), it is used to test and help children during their first introduction to diabetes. At the school, it is used to support specific learning subjects, such as the French-language. The research institute (partner TNO) is applying the Produxi Performer to enable researchers and marketers to program the NAO for demonstrations on events.

Further improvements are being worked on as well as on facilitating applications of the NAO in other environments.

TNO

In coordination with the PAL partners, TNO has consolidated the PAL ontology and made it accessible for potentially interested parties. TNO will re-use the generic part of the ontology in future developments of educational software with conversational agents to establish personalization and meaningful human-agent dialogues. In the Research & Development processes, two options will be considered: (a) Starting joint projects in which the models are instantiated for specific applications, and (b) entering multi-party contracts for sharing and using the current and future versions of the models (incl. the running costs of the software).

In collaboration with the Dutch partners, TNO started initiatives to introduce PAL-technology at the "national level" for a broader spectrum of diseases, e.g. involving Netherlands Diabetes Federation (NDF), Netherlands Association of Hospitals (NVZ) and additional hospitals (VUmc, UMC, LUMC, PMC). One of the initiatives has been worked out in a proposal for a "PAL-system" for children with asthma, starting with the Dutch hospitals ZGV and UMC.

TNO has a recognized position in diabetes care, showing that life-style changes can have a major impact on patients' health risks and condition. Currently, the PAL-framework and models are being generalized and worked for the self-management of diabetes type 2 (risks). First tests with diabetes type 2 data-sets are being conducted.

DFKI

The DFKI Multilingual Technologies Group will continue research and development on the *n*-tuple repository HFC and the VOnDA (Versatile Ontology-based Dialogue and Agent Frame-work) ecosystem. The technology is already used in other German and international projects for

assisting rehabilitation patients by intuitive robotic systems, and human-robot disaster response scenarios. Many ideas and concepts started in PAL will receive further attention since they are directly linked to the conversational agent paradigm, such as the episodic memory, or knowledge-driven social talk.

VOnDA has already been used by another DFKI group to rapid prototype a dialogue system for research on dialogue strategies for automated shop assistants. It is also planned to use VOnDA as a basis for teaching the creation of conversational systems at Saarland University, which DFKI cooperates with on a regular basis.

The dialogue management framework VOnDA developed in WP4 can be used to explore a wide range of new research directions. This starts from research on extending its functionality to fuse specification and implementation of general artificial agents with dialogue specifications, and how these interact, to directly integrating probabilistic reasoning into the rule decision process.

Furthermore, VOnDA is already used in new industry projects to cover aspects of dialogue where it is easier or faster to specify the functionality by hand than to learn from data, or where the tolerance for errors is very low. In addition, several dialogue strategies in the PAL system can be used with minor modifications in new dialogue systems.

TUD

Two TUD-students are expected to receive their PhD degree, based on PAL-research (Frank Kaptein and Rifca Peters), and to provide their corresponding PhD-theses on social human-agent interaction for behavior change (focusing on children and chronic diseases like diabetes). In general, the Delft University of Technology will continue its structural collaboration with TNO on the further development and implementation of eHealth technology; concerning PAL, the focus will be on the ontology, the methods to attune robot behaviors and explanations to the situated (educational) objectives and the dashboards for children, professionals and parents.

The Interactive Intelligence group is aiming at follow-on collaborations with interested parties in the area , as member of the Medical Delta and the Delft Robotics Institute. Diabetes care and social robots are important themes in these partnerships. Furthermore, the II-group is participating in a national project on “robots in the class”, building on the PAL-research.

IMP

Imperial College London has exploited the outcomes in WP3 in several ways throughout the PAL project and will continue the exploitation beyond the end of the PAL project. The continued exploitation will be supported by funding that Imperial College has acquired in related areas. An overview of exploitable results within WP3 is as follows:

1. PAL's action selection module, HAMMER, has been open-sourced for the scientific community. The repository (https://github.com/Aneoshun/HAMMER) contains a lightweight, high performing implementation of the HAMMER architecture along with several examples for the architecture's usage. The architecture itself is generic and not tied to application within PAL.
2. The proposed knowledge level tracker, GPCF, has been published in the IEEE Transactions on Knowledge and Data Engineering. We are currently investigating to open-source the

underlying code and make it available to the scientific community. The code itself is not patentable.

3. The work within PAL has resulted in several gaze tracking modules. One of the modules, RT-GENE, is applicable in natural environments and can be run on any camera, including robot eye cameras. This work was performed in collaboration with Samsung and was subsequently open sourced for the research community at https://github.com/Tobias-Fischer/rt_gene (code) and https://zenodo.org/record/2529036 (dataset). While this work was only recently published in September 2018, the dataset has already been downloaded over 900 times.
4. Another outcome of the gaze tracking research was the PAL-M dataset. This dataset contains ground truth gaze data as well as interaction data of participants interacting with the PAL quiz on a tablet device. The PAL-M dataset was collected for research purposes only and no further exploitation is planned.
5. Another gaze tracking module was developed with the aim of estimating the mental state of the user. This line of work will be continued in several new research projects. Firstly, within a Multidisciplinary University Research Initiative (MURI) grant (collaboration between UK and USA universities), the mental state estimation using eye gaze will be applied in car driving scenarios. Secondly, an EPSRC project on perception-action-learning for robots will investigate the integration of eye gaze tracking with interactive robots. Finally, a 10-year Royal Academy of Engineering project will make use of the mental state estimation within the context of assistive robotics. The work performed in these projects might lead to patentable results. Yiannis Demiris' lab at Imperial College has prior experience in collaboration with industry. Past industrial partners include Samsung, BAE Systems and BBC R&D.

4.2 Re-engineering PAL

The re-usable PAL design and ontological models are maintained and accessible in the Socio-Cognitive Engineering Tool[15]. The PAL prototype version 3.5 provides an example implementation, which was developed for research & development purposes. A bench mark test shows the unique selling position of PAL: Integration on two aspects. Integration of technology to establish pervasive --personalized, intelligent and context-sensitive—support and integration into the multi-party care process (i.e., addressing children with their parents and health-care professionals). The final two times 3 months' evaluation showed the benefits and shortcomings to overcome.

Table 3. Components of the MyPAL application

Component	Description
Child-actor interaction	The PAL actor (robot or avatar) initiates, guides and closes interactions (e.g. greetings when logging in, feedback on progress) to inform and motivate the child. In addition, it can act as a play-fellow in the games.

[15] https://confluence.ewi.tudelft.nl/display/PALsCE/Home+page+PAL+Socio-Cognitive+Engineering

Quiz game	Children play against the NAO, alternating between asking and answering questions. Questions were validated by health care professionals.
Break&Sort game	Children and the avatar play this game together. Boxes appear on the screen, which need to be dragged and opened. These boxes contain types of food. Children need to sort these, based on either carbohydrates, order of frequency of consumption, or on which nutrients it contains.
Memory game	Children can play, alone, against the avatar, or with a friend. The cards contain different pictures: symptoms that have to be matched with hypo or hyper, foods that have to be matched to the correct amount of carbohydrates, and activities that have to be matched with blood glucose going up or down. Only the version with the correct amount of carbohydrates was included in version 3.0.
Timeline	A timeline in which information about blood glucose levels and insulin corrections, consumed food and carbohydrates, and activities and consequent emotional reactions can be entered.
Videos	The MyPAL app contains different types of videos children can watch, such as a video about a diabetes camp.
Dances	In this section, children can pick and combine dance moves which the robot will then execute. Dances can also be created for the physical NAO, which will do this dance the next time the children goes to the hospital.
Achievements	This section contains information on children's achievements, goals, and tasks. Completing these will earn children coins. Based on set achievements, the avatar also suggests relevant tasks that are necessary to complete goals and achievements.
Shop	Children can buy colors for the NAO, dance moves, floors, and backgrounds.

Table 3 provides an overview of the different components of the current PAL-prototype. The studies in the PAL-project show that children with T1DM and their parents need socio-cognitive support for child's diabetes management. As a first main contribution, PAL appears to support the learning process: the acquisition of *competencies* (knowledge and skills) for diabetes management, a crucial pre-requisite for *self*-management. Second, the studies showed that applying the desired personal diabetes regime routines in the dynamic daily contexts is a challenge in itself, also when the relevant competencies are available. There is a need to support the process of *autonomy* development, i.e., to establish a harmonious child-parent responsibility-sharing progress. The studies disclosed support requirements for the responsibility transfer that did not seem to be addressed by the current version of the PAL system. For a next version, the PAL Objective Model will be extended with explicit responsibility (learning) achievements, goals and tasks. Third, particularly the robot actor proved to be liked, as an indication of bonding ("*relatedness*"). In future applications, we will take care there are relatively more robot

experiences (e.g., the "Ziggi use case" already allows children to take the robot at home and to school).

Taken together, the technological and evaluation outcomes of the PAL-project provide a sound and promising foundation for re-engineering and actual deployment. The re-engineering entails consolidation and upscaling of the software capacities. A "Twin-Win Model" (Shneiderman, 2018) can be applied, involving multi-party contracts for sharing and using the current and future versions of the software (incl. the service costs). The initiative with the three KERs provide a first step in this direction. Four improvements could advance the cost-benefits of the PAL-implementation substantially: Integration of the speech technology (as demonstrated at the PAL end-event and review meeting), extending the content (particularly (a) for children above 10 years old and (b) covering objectives for responsibility transfer), increasing the interaction moments with the (physical) robot, and automating the data transfer from diabetes equipment (e.g. blood glucose meter) to the PAL system. It should be mentioned that we are scaling up by approaching more hospitals for further development, validation and implementation (i.e. the university hospitals VUmc, UMC, LUMC in the Netherlands).

In addition to these possibilities, and leveraging on the PAL-key components and relevant improvements highlighted above, the Consortium, headed by MIXEL, is working on an upcoming application (October 2019) to the next SME Instruments call for proposals, phase 2, with deadline for October 2019. The objective of the proposal will be an upgrade of PAL System from a research prototype to a competitive commercial products and also a possible extension of it's scope evaluating the use of the PAL method for different ages and differents diseases. If the application is going to be successful, and PAL will be re-engineered according to what previously said, there's going to be included also a plan for a further, more extended evaluation with children with T1DM. Paediatricians of OSR, in fact, expressed their willing to lead a new experimental evaluation of the final product, possibly in concert with the new medical Dutch centers contacted, with a greater number of children and more homogeneous inclusion criteria (e.g. therapy treatment and age-ranges) in order to see an effect on the clinical determinants of T1DM that in the current pilot-test campaign not emerged.

4.3 Extensibility of PAL:

Following the Socio-Cognitive Engineering method, the PAL system has been developed in a way that provides generic behaviour change support models and functions, which are instantiated and tested in the domain of paediatric T1DM disease management. Consequently, the "generic" part can be applied to related domains, which are being explored currently. This way, we are increasing the application scale. Specifically, consortia are being formed for the development of a "PAL" (a) for children with asthma (starting with the Dutch hospitals ZGV and UMC, TNO and Produxi), and (b) for patients with T2DM (starting in the Medical Delta with the LUMC hospital, TU Delft and TNO).

5. Conclusions and Discussion

Worldwide, there has been made substantial progress in technologies that provide new opportunities for personalized support of disease self-management, such as Artificial Intelligence, Robotics, Conversational Agents, Mobile Gaming, Virtual Reality and Cloud Computing. We combined these technologies to develop a "Personal Assistant for a healthy Lifestyle" (PAL), which

supports children (aged between 7-14 years) with their parents and health-care professionals to learn to self-manage diabetes type 1 (T1DM). The evaluations of the PAL prototype show promising results on knowledge gain and self-management behaviours (see PAL deliverable D1.6). The next valorisation step is to implement (parts of the) PAL system in the education and care processes of children with T1DM. Three key exploitable results (KERs) with corresponding KER-leaders have been identified: The *MyPAL app suite* (MXL), the *Ontology models & reasoning* rules (TNO), and the *C4 suite* (i.e., co-design tools, FCSR). Furthermore, each partner worked out its "own" additional plan for uptake, usage and/or dissemination of the PAL-results. At the European level, we will connect to the *Digital Innovation Hub network in Healthcare Robotics*, among other things to establish technology transfer experiments of the PAL system.

Concerning valorisation, it should be noted that "value" is insufficiently measured in current health care systems value, in general, because there is a lack of sound outcome and cost measurements (Porter, 2010). Future research should also involve measures beyond HbA1c, to assess different types or components of interventions (Feldman et al., 2018). Particularly, measurements are needed of *changes* in health conditions with the related circumstances, patient behaviours and intervention methods. Potentially, the PAL system collects such a rich longitudinal, *valuable*, data-set, supporting paediatric diabetes caregivers. It is crucial that these caregivers monitor key factors for adequate metabolic control of children, because metabolic control of T1DM during childhood predicts metabolic control in early adulthood (Samuelsson et al., 2014). For this, we need quality registries, such as the Swedish Pediatric Quality Registry (SPQR), which transcend national borders (e.g., see McKnight et al., 2015).

6. References

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Appendix A Business Plan Development report

Business Plan Development Service

for

Personal Assistant for healthy Lifestyle (PAL)

DATE

15 February 2018

Provided by:

DR TREVOR GREGORY

INDEX

1 Introduction

Appropriate exploitation leads to innovation (in different markets and societal contexts), new businesses and jobs, increased knowledge, and welfare. Exploitation thus contributes to the overall objectives of the investors European Union.

Exploitation has become a crucial element in FP7 and H2020 projects and is a mandatory activity and reporting item. In order to maximise the value added and impact of research projects, the Directorate-General for Research and Innovation offers on-demand services to interested projects – Common Exploitation Booster (CEB).

To move forward and improved the outcomes of PAL, Meta Group was appointed by the European Commission to help the partners in developing and reviewing the go to market strategy/plan for their exploitable results and to design a road map to implement the first steps, after the end of the EC grant. The services included a workshop, held at TNO in Leiden, The Netherlands, on Thursday 15 February 2018.

2 Participants in the Seminar

TNO: Mark Neerincx, Anita Weggemans, Nanja Smets, Steven Erpelinck (coordination and WPL WP1 and WP7)

Produxi: Bert Bierman (large involvement in WP5)

TUD: Joost Broekens, Joost Mathot (University – WPL WP2)

DFKI: Bernd Kiefer (WPL WP4)

FCSR: Eletta Oleara (WPL WP6)

ZGV: Angelique Groot (Hospital)

IMP: Antoine Cully (Univeristy – involved in WPL WP3)

MXL: Mario Fumagalli (WPL WP5)

3 Project main data

Title	Personal Assistant for healthy Lifestyle
Acronym	(PAL)
Contract N°	643783
Coordinator	NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK (TNO) Netherlands
Budget	EUR 4 515 460
Starting Date	01 March 2015
Duration	48 months

4 Project description

Abstract	The overall aim of the project is to develop a Personal Assistant for healthy Lifestyle (PAL), a system that will assist the child, health professional and parent to advance the self-management of children with type 1 diabetes aged 7 - 14, so that an adequate shared patient-caregiver responsibility for child's diabetes regimen is established before adolescence. PAL will be composed of a social robot, its (mobile) avatar, and an extendable set of (mobile) health-education applications, which connect to a set of (selectable) self-management objectives, an ontological knowledge-base and reasoning mechanisms. The overall project aim is being decomposed into the following sub-objectives: 1. To analyse child's, parent's and health-care professional's (HCP) roles in establishing child's self-management behaviour from childhood into early adolescence and the corresponding support needs of these three types of PAL users. 2. To develop an evolving transparent ontology for persistent knowledge-based multi-user self-management support for user-in-the-loop learning and reasoning, extracting and integrating semantics from available healthcare assets, and establishing a normative system with different (personalized) support roles for the child, professional and parent. 3. To develop an agent-based reasoning mechanism for the personalised setting of child's learning and behavioural goals, and engagement strategies.

	4. To develop support for the caregivers, i.e., (i) a module for the health professional to tailor the PAL support to the child by the selection of objectives, and to monitor and learn from child's progress, (ii) and a monitor and inform module for the parents to improve their knowledge and attitude on child self-management, without violating the child's values. 5. To develop a user model, and machine-learning and sentiment-mining methods that feed this model, for attuning the support to child's developmental and behavioural change stage, condition, preferences, knowledge, skills and experiences. 6. To develop consistent personalized multimodal natural interactions for the physical (robot) and virtual (avatar) embodied conversational agent (ECA), fostering long-term engagement in a range of educational or assisting (mobile) health applications, and across a range of situations and interaction devices. 7. To further develop and integrate (mobile) health applications into an open infrastructure for comprehensive knowledge-based self-management support of children with diabetes. 8. To determine the costs and profits for the proposed self-management support.
Key Exploitable Results	1. Situated Cognitive Engineering (sCE) method This is a method for the (incremental) development of interactive intelligent systems, focusing on the creation, specification and evaluation of the artefact with its design rationale. Due to the coherent documentation of the (theoretical and empirical) foundation and design decisions, the design solutions can be re-used for similar design problems in other development projects. 2. Situated Cognitive Engineering Tool (sCET) Web-based tool for establishing the foundation, specification and evaluation of the design (using Atlantis Confluence software) 3. CCCC - Co-Design for Child-Computer Companionship suite (method) A set of co-design methods for children, aged 7-14: Image-theatre, draw-write-and-tell, storytelling, photo-elicitation and user journey maps. They provide a rich set of user requirements and use cases for pervasive, personalized and situated support that are expected to improve children's daily self-management. 4. Sentiment and topic analysis software module Text mining module to estimate the sentiment and topic of text. 5. Ontological model and reasoning rules Self-management support for Lifestyle related deseases; consist of : - PAL Objective Model - User Model - Emotion Model - Episodic Memory Model - Feedback and Advice Model - Policies and working agreements for personalized safe information sharing 6. Educational activities for lifestyle related disease self-management Educational activities for life-style related disease: time-line, quiz, break and sort, memory, videos. 7. Dashboard

	Overview of Childs progress self managemnt for the Health Care Professional and Child" 8. PAL data set Data-set of PAL evaluations 9. Ziggi Have the Robot and children play a quiz. Let the Robot assist the child while delivering a presentation. ***NB. The KERs were discussed at length (and a number of additional KERs were identified) at the BDD Workshop and the outcomes of the discussions are outlined in Section 5.***
Exploitation model	As part of the evaluation of the most appropriate Business Model to exploit the outputs from the PAL project a study has been undertaken on 'Minor Theses EIT: Commercialising e-Health Apps without ethical circumstances: Developing a business case without compromising the users data'.

5 Review and fine tuning of the Exploitation plans

The BPD service provided to PAL was structured as follows:

1) Analysis of the state of the art (deliverables dealing with exploitation, reviewers report)
2) Animation of a workshop with partners to finalise the main KERs and to initiate a discussion on the lean canvas (including the possible business models).
3) Support in fine tuning available information and drafting the 'Exploitation Plan', and provision of final comments, after the workshop.

Analysis of the state of the art

The following documents were analysed to start the iterations with Anita Weggemans (Senior Project Assistant, Human behaviour & Organisational Innovations Coordinator and partners):

- Final_Proposal-643783-PAL
- Grant Agreement-643783-PAL
- PERIODIC TECHNICAL REPORT – PART B (30 August 2017)
- Minor Theses EIT: Commercialising e-Health Apps
- 2017 10 03 Exploration Impact Assessment
- 2017AprilMeeting valorisation

The following issues were discussed during the workshop:

KERs	The consortium had produced a list of 17 KERs prior to the workshop. After discussion 2 of the KERs were removed from the list. It was decided to cluster the remaining 15 KERs into 3 groups: Design; Content & Models; Software & Methods/Methodologies. The final list of KERs is shown in Annex I. The main KERs still have to be characterised and an example of one has been initiated in this document (including a risk analysis) – see ANNEX II.

IP situation	There appears to be no general issues with regards to IP ownership. However, the Consortium need to have further, more specific discussions about the release of information in relation to the 'open source' elements of the project.
Potential exploitation partners	In order to frame the project valorisation plan, interviews with insurance companies, hospital policy makers and business consultants have been held, and discussions with technological SMEs have been conducted.
What is the 'offer'?	The offer is focused around: - A social (learning support) robot; - Its mobile avatar; and - An extendable set of mobile health apps (e.g. diabetes diary, educational quizzes, sorting games). Other elements of the offer were discussed including: the capacity for using AI for self-learning; a self-management tool; increase in quality of life; and reduction in healthcare costs.
Target groups	These have only briefly been considered but include: healthcare companies who offer a glucometer as a product; health insurance companies; and medical devices SMEs. Another consideration is the formation of a company (of which the consortium members could have equity) to hold any generated revenue/royalty, and which could be used to fund future collaborative R&D activity.
USP	Not entirely clear what this is.

	A Lean Canvas for one of the KERs has been initiated and appears in ANNEX III.
Planning	One of the biggest risks associated with exploitation is the lack of a clear plan relating to which organisation(s) would be responsible for 'managing the PAL service offer post-project. This was very unclear and little thought had been given to this.

Workshop with partners to finalise the main KERs and to initiate a discussion on the lean canvas (which includes the possible business models

A workshop was held at TNO, Leiden, The Netherlands. During the workshop a brief introduction on lean canvas and how to pitch was given by the expert.

Timing*		
09.30 – 10.00	Welcome and refreshments	
10.00 – 10.15	Introduction to the day	*Dr Trevor Gregory (TG)*
10.15 – 10.45	Summary of Key Exploitable Results (KERs)	*Discussion led by TG*
10.45 – 11.15	Evaluation of KERs	*Discussion led by TG*
11.15 – 11.45	Business/Lean Canvas model – introduction	*TG*
11.45 – 12.30	Business/Lean Canvas model – discussion	*All (supported by TG)*

12.30 – 13.15	LUNCH	
13.15 – 14.00	Cont.	
14.00 – 14.30	Risk Analysis	*TG*
14.30 – 15.30	PESTLE Analysis	*TG* *All*
15.30 – 15.45	Legacy outcomes	*TG*
15.45 – 16.00	Summary	*TG* *Anita*

Comments on received materials have been discussed. Partners attending discussed the comments and agreed on further work on the following main exploitable results:

#	Exploitable Result	IP owner(s)/Partner(s)
5	**Ontological model and reasoning rules** Self-management support for Lifestyle related diseases consist of: - PAL Objective Model - User Model - Emotion Model - Episodic Memory Model - Feedback and Advice Model - Policies and working agreements for personalized safe information sharing	TNO/TUD/DFKI/FCSR
7	**Dashboard** Overview of Childs progress self-management for the Health Care Professional and Child	TNO/TUD/FCSR

9	**Ziggi** This comprises of both the software and the robot. The Robot and children play a quiz, and the Robot assists the child while delivering a presentation. Ziggi is outside of PAL - a 'spin-off' impact/benefit – and is being implemented 'in the field' (schools, hospitals) by June 2018.	Produxi
13	**3D Model NAO Avatar** The NAO Avatar is a 3D model of the real NAO robot, and is a very precise reproduction of it. The Avatar is built up using a virtual version of the robot junctions, so reproducing same movements. Therefore, the overall look and feel of the two objects is almost the same. The virtual Avatar is used to keep a connection between the different activities made at home or in hospital by the child.	IPR belongs to an external partner to the project but conversations need to be had between some of the partners about the best way forward on the IP situation (Mixel, Produxi, FCSR, TUD).
16	**MyPAL App** MyPAL App is a mobile application that provides specific support to children affected by Type 2 Diabetes. Its main features are: education, training, entertaining, day-by-day assistance, diary, progress and goals tracking. It also allows remote monitoring over the child by parents, caregivers and doctors. It has been designed and developed as part of the PAL project.	Mixel

The expert has offered post-workshop advice to the Project Coordinator on:

- Characterisation of the key KERs;
- Risk evaluation of the key KERs;
- Development of a Lean Canvas for one of the key KERs;
- Format and content of an Exploitation Plan;
- Analysis of added value impacts and benefits of the PAL project through a PESTLE Analysis; and
- Evaluation of Expected v. Actual outcomes for each consortium member (evidence of the value of collaborative activity.

6 Recommendations by the expert

Issues	Recommendations
Characterisation	Further work will need to be done to fully characterise the KERs that have been identified by the Consortium. The focus should be restricted to the 5 main KERs identified in the table above. These KERs represent the consolidation of multi-partner involvement and, in some cases, offer an opportunity to realise commercial value.
IP ownership	It is important that the IP ownership of each of the key KERs is fully clarified, and it may be necessary to construct an IP Supply Chain diagram. Contributed background IP has been reasonably well defined but will need to be evaluated for completeness.
USP	The overall aim of the project is to develop a Personal Assistant for healthy Lifestyle (PAL), a system that will assist the child, health professional and parent to advance the self-management of children with type 1 diabetes aged 7 - 14, so that an adequate shared patient-caregiver responsibility for child's diabetes regimen is established before adolescence. The involvement of all relevant and interested parties, and the learnings from their involvement in order to direct the treatment of the individual is unique in this field.
Business Model	A number of different models for exploitation are available to the consortium and were discussed at the workshop.

	One possibility that was discussed at the BPD Workshop was the possibility to establish a company that would hold the IP rights of the developed technologies, would manage the updating of the (My)PAL system, and would manage any commercial revenues generated from the products/services for benefit of the consortium members.
Planning	The consortium need to have a number of meetings to discuss the exploitation route for the different elements for potential exploitation. Ownership is key in those discussions but the appropriate business model still needs to be concluded.
Actions to be performed the first 6 months after the end of the project	1. The IP landscape needs to be investigated fully. 2. Access to finance for investment needs to be established. 3. Collaborations with hospitals to carry out further trials need to be secured. 4. The project has identified further opportunities for research activity – these will need to be crystallised and funding sought.

Annex I – Summary Table for KERs

KEY: D – Design; CM – Content & Models; SMM – Software & Methods/Methodologies

Num	Description	Exploitation champion	Comments	IP/knowledge owner(s)	Other partners with interest in exploitation
1 SMM	**Situated Cognitive Engineering (sCE) method** This is a method for the (incremental) development of interactive intelligent systems, focusing on the creation, specification and evaluation of the artefact with its design rationale. Due to the coherent documentation of the (theoretical and empirical) foundation and design decisions, the design solutions can be re-used for similar design problems in other development projects.	TNO	cluster with 2, 3 integrated kb system impact on the PAL system independent KER - can be used elsewhere already in public domain	TNO TUD	FCSR
2 SMM	**Situated Cognitive Engineering Tool (sCET)** Web-based tool for establishing the foundation,	TNO	clustered with 1 and 3 - can't be used without 1	TNO TUD	FCSR

	specification and evaluation of the design (using Atlantis Confluence software)				
3 SMM	**CCCC - Co-Design for Child-Computer Companionship suite (method)** A set of co-design methods for children, aged 7-14: Image-theatre, draw-write-and-tell, storytelling, photo-elicitation and user journey maps. They provide a rich set of user requirements and use cases for pervasive, personalized and situated support that are expected to improve children's daily self-management.	TNO FCSR	further enhancement	TNO FCSR	
4 CM	**Sentiment and topic analysis software module** Text mining module to estimate the sentiment and topic of text.	TNO	development of something which already existed and applied through enhancement	TNO	

5 CM	**Ontological model and reasoning rules** Self-management support for Lifestyle related deseases; consist of : - PAL Objective Model - User Model - Emotion Model - Episodic Memory Model - Feedback and Advice Model - Policies and working agreements for personalized safe information sharing	All partners	a KEY KER - input from ALL PARTNERS (some more than others) validated in the project can be used in a different, independent format than the robot, avatar … high level details have been published ('self-learning' may be developed next	TNO / TUD / DFKI / FCSR ?	
6 CM	**Educational activities for lifestyle related disease self-management** Educational activities for life-style related disease: time-line, quiz, break and sort, memory, videos.	TNO Mixel FCSR	content is specific for PAL (but the content can be modified to apply elsewhere) design is PAL specific, s/ware can be utilised in other contexts can it be clustered with 14	TNO Mixel	
7 D	**Dashboard** Overview of Childs progress self managemnt for the Health Care Professional and Child	TUD All partners	actual interface and how 'you' interact with it (relationship with KER#5)	TNO TUD FCSR	

8	**PAL data set** Data-set of PAL evaluations	All partners	database of data from children over the last 4 years - consent may be an issue outside of PAL may be not a KER derived models can be used but actual data not	All partners	All partners
9 D SM M	**Ziggi** Have the Robot and children play a quiz. Let the Robot assist the child while delivering a presentation.	Produxi	s/ware and a robot significant KER of PAL (Ziggi is outside of PAL - a 'spin-off' impact/benefit) being implemented 'in the field' (schools, hospitals) by June 2018		
10 C SM M	**Contextawareness** Calibration-free gaze tracker can be used to model user's behaviours while using a mobile device in a non-invasive manner. Gaze patterns are highly correlated with user's mental states such the level of domain knowledge, curiosity engagement. The system can be further	IMP	clustered with 11 and 12		

	personalised and adapted based on user's mental states. It has also implications on the design of the application interface and how the robot avatar should exhibit behaviours.				
11 SMM	**HAMMER-based action selection** The HAMMER architecture can be used to select or suggest activities to the users based on predictive models that monitor the influence of each action on the state of the users.	IMP			
12 CSMM	**Online Knowledge level tracker for personalized learning experience** Providing questions at an adequate level is a requirement to maximize the learning experience of the users. Here, with an online knowledge level tracker, the systems can personalize the difficulty of the questions based on the current, and future (thanks	IMP			

	for predictors), level of the user.				
13 SMM	**3D Model NAO Avatar** The NAO Avatar is a 3D model of the real NAO robot, and is a very precise reproduction of it. The Avatar is built up using a virtual version of the robot junctions, so reproducing same movements. Therefore, the overall look and feel if the two objects is almost the same. The virtual Avatar is used to keep a connection between the different activities made at home or in hospital by the child.	Mixel	can be used outside the PAL project - IPR belongs to an external partner to the project conversations need to be had between some of the partners about the best way forward on the IP situation (Mixel, Produxi, FCSR, TUD)		
14 DSMM	**Educational and Serious games** Two specific games for diabetics teaching purposes: - BREAK AND SORT: a speed game that allows the child to create simple associations about food in his brain.	Mixel	s/ware which underpins KER#6		Produxi

	- MEMORY GAME: a slow game to force the child to think the correct association based on food's detailed information.				
15 SMM	**RealTimeInstance PAL Agent** The RealTimeInstance allowed us to instantiate a different number of modules for each logged user (child). This set of modules are called “PAL Agent”, an AI software that can adapt itself to the child's moods and needs.	Mixel	specific s/ware module		
16 DSMM	**MyPAL App** MyPAL App is a mobile application that provides specific support to children affected by Type 2 Diabetes. Its main features are: education, training, entertaining, day-by-day assistance, diary, progress and goals tracking. It also allows remote monitoring over the child by parents, caregivers and doctors.	Mixel	can be used outside of the PAL project; developed specifically for PAL		

17	**NAME?** 1. Certified trustworthy contents; 2. Service design; 3. User cognitive ergonomy; 4. Specific methodology based on long-term experience.	OSR			

ANNEX II – Characterisation of KER#16 including the associated Risk Map

KER#16 MyPAL App	Complete the information in the cells below
Description of the Result	MyPAL App is a mobile application that provides specific support to children affected by Type 1 Diabetes. Its main features are: education, training, entertaining, day-by-day assistance, diary, progress and goals tracking. It also allows remote monitoring over the child by parents, caregivers and doctors.
Problems you are addressing and how your customers solve them so far	The app covers a wide range of daily problems which impact on children affected by Type 1 Diabetes and their parents. At the present day, when not assisted by the software tools, the children have to manually take care of all their needs, mostly assisted by their parents.
Unique Selling Point	We believe that the most unique features of MyPAL app, compared with the currently available solutions, are: 1. A strong scientific approach 2. An integrated solution addressing several different issues 3. A mood modulated interaction based on sophisticated AI technologies 4. Natural language availability
Product/Service Market Size	T1DM typically appears in early life and is one of the most pervasive conditions in childhood. Incidence for children aged 0-14 years has particularly high rates in Northern Europe - e.g. Finland 57.6 cases/100,000 per year, Sweden 43.1, Norway 27.9, United Kingdom 24.5, Denmark 22.2 and The Netherlands 18.6. It is estimated that diabetic care (T1 and T2) costs 110 billion Euro, and that T1 patients incur higher mean treatment costs than T2 patients.
Market Trends/Public Acceptance	The incidence of childhood T1 diabetes is rising rapidly in all populations, with a doubling factor of less than 20 years in Europe.
Product/Service Positioning	The main potential adopters of the App are insurance companies, hospitals and technological medical devices SMEs.
Legal or normative or ethical requirements (need for authorisations, compliance to standards, norms, etc.)	All work with children will be conducted under national and international rules and legislation, as well as European standards of research ethics.
Competitors/Incumbents	
Early Adopters - First Customers	Early adopters include: 1. FCSR, Italy in collaboration with OSR and Sostegno; and 2. Hospital Gelderse Vallei, Ede, Meander Medical Centre, Amersfoort and DVN in The Netherlands.

Cost of implementation - bringing product/service to the "market" (before Exploitation)	Not yet determined
Time to market (from the end of the project)	This is being trialled during 2018 (not sure about this??)
Foreseen Product/Service Price	As yet undefined
Adequateness of Consortium Staff	The consortium contains some of the leaders in this filed
External Experts/Partners to be involved	tbd
Status of IPR: Background (type and partner owner)	tbc
Status of IPR: Results/Foreground (type and partner owner)	tbc
Status of IPR: use the results from the Exploitation Form	Licensing of technology to Hospitals, Health Insurers and Medical Device SMEs.
Partner/s involved expectations	
Sources of financing foreseen after the end of the project	tbd

ANNEX III – Lean Canvas for KER#16

The canvas is a good way to display your exploitation model at a glance. The Lean business model canvas, by Ash Maurya, based on Problems and Customers is closer to R&D projects than the Business Model Canvas.

When approaching it have in mind 4 good questions:

1) Who is "my customer"?
2) What is "her/his" problem?
3) How does "She/he" solve the problem now?
4) Is our solution more efficient than the current one?

How to complete the template LEAN CANVAS

General aspects to consider: You are developing a Lean Canvas. The end goal of this canvas is that an unknowing third-party will be able to review your canvas from start to end and through this revision understand what your project is about. They will understand the problem in focus, the customer groups that you target, the solution you supply, why your solution differentiate from competitors, how you intend to create value, etc.

Due to this, it is very important that you keep in mind, that the use of highly technical language, abbreviations etc. can result in third-parties not understanding the nature of your project. Thus avoid extensive use of acronyms and technical argons.

Before starting, define who you are (manufacturer of the new product; service provider (training, advice), etc. Follow the steps as described below.

1) **PROBLEM** – describe the main problem(s) being addressed.

   Explain: ***What*** is the problem, ***who*** is it a problem for, and ***why*** is it a problem.

   Additionally, attempt to add numbers or quantifiable measures that will clearly highlight the scale of the problem.

   Describe EXISTING ALTERNATIVES - how is the problem currently being 'solved' (today's alternatives)

2) **CUSTOMER SEGMENT** - identify who has the problem, define target customers (do not confuse with users).

   Be clear on explaining the geographic location of your customers, the industry in which they are operating in, as well as connecting them to the problem in question.

   EARLY ADOPTERS - find a small niche that are likely to take the 'risk' of being early adopters of the proposed new solution.

   These will be the first customers for your solution; be sure to find as much information about these as possible. Explain the geographic location, connect them to the problem, explain exactly why these will be the first adopters, clarify your current connection to them etc.

3) **UNIQUE VALUE PROPOSITION** - Define your UVP based on the current alternatives; what makes your product more efficient for your customers, a single and compelling sentence that makes everybody understand why you are far better (your features need to be compelling to the customers' needs, otherwise are irrelevant to clients).

   Ensure that you clearly define how you differentiate from alternative solutions, and why the customer will come to you; Explain the ***uniqueness*** of your solution.

   Provide facts and data, explaining the performance of your product compared to alternative solutions (efficiency increase of 20%, decreased energy consumption of 10%, 30% less development costs etc.).

4) **SOLUTION** – outline the main features of your solution. When your features are similar to the ones of the competitors, this is an equality. What matters are the points of difference! What you do, that the others do not do, is what matters to the clients.

   Be sure to explain the format of your solution (is it a product, equipment, software, a service, a process, etc.), what it does, and how it does it.

5) **CHANNELS** – How will you reach your customers? What is your route to market?

   Be sure to investigate whether the chosen channels are suitable for your choice of customers and consider whether they will be enough to establish the needed reputation on the market.

6) **UNFAIR ADVANTAGE** – what is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought.

   This could be IPR, being first movers on new technology that takes years to develop etc. Be sure to explain, *why* the listed points provide you with an advantage. It can be difficult for third-parties to understand, if they do not have a wide array of knowledge regarding your industry.

7) **REVENUE STREAMS** - which will be the main revenue streams when the solution is ready for the market. Explain how each of them will generate revenue and how much you expect to generate from each stream.

   Estimate revenues after 6 months and after 3 years. Quantify amounts and prices by detailing, for example, the expected amount of services provided and paid, number of licenses sold at which prices etc.

8) **KEY METRICS** – key activities you will measure to track the success (e.g. units sold, users registered, retaining users, paying customers, number of complaints …)

9) **COST STRUCTURE** – which will be the main costs when the solution is ready for the market (e.g. manufacturing costs, customer acquisition costs, distribution costs, hosting, people etc). As with revenues, estimate the total costs issued after 6 months and 3 years along with the estimated cost of each "cost-entity". This will connect your revenues to your costs.

After you finish the exercise, test your hypothesis "out of the lab", with at least 2 to 3 real potential customers:

- Are the problems you assume really the ones? Is your solution solving their problem?
- Are the features your solution is offering the ones the market needs and looks for?
- Are the explanations provided in the canvas sufficient to provide the customer with an understanding of your project?

Write down the feedbacks and update, revise, iterate the CANVAS accordingly.

(1) Problem	(4) Solutions	(3) Unique Value proposition	(6) Unfair Advantage	(2) Customer segment
The incidence of childhood type 1 diabetes mellitus (T1DM) is rising rapidly, with the number of reported cases doubling every 20 years. T1DM is associated with serious complications, which may appear sooner or later, cause high morbidity and mortality, affect the quality of life, and increase health-care costs.	The overall aim of the project is to develop a Personal Assistant for healthy Lifestyle (PAL), a system that will assist the child, health professional and parent to advance the self-management of children with type 1 diabetes aged 7 - 14, so that an adequate shared patient-caregiver responsibility for child's diabetes regimen is established before adolescence. PAL will be composed of a social robot, its (mobile) avatar, and an extendable set of (mobile) health-education applications, which connect to a set of (selectable) self-management objectives, an ontological knowledge-base and reasoning mechanisms.	We believe that the most unique features of MyPAL app, compared with the currently available solutions, are: 1. A strong scientific approach 2. An integrated solution addressing several different issues 3. A mood modulated interaction based on sophisticated AI technologies 4. Natural language availability	What is it that gives you an advantage in front of the competition? Something that can't be easily copied or bought.	In Europe alone the care costs for diabetes is in the region of 110 billion Euro. There are associated well-being costs, and the costs to society as the condition will affect those that have the condition in later life.

	(8) Key Metrics The success of the App will be measured simply by the number of patients that are involved, and ultimately the impact that has on their ability to self-manage the condition.		**(5) Channels** The project is already working with some hospitals to trial the technology (in Italy and The Netherlands).	

(9) Cost structure There will be costs associated with maintenance of the App and, possibly, support and servicing costs (host server costs, online help, etc). These are yet to be determined.	**(7) Revenue Streams** Licensing of technology to Hospitals, Health Insurers and Medical Device SMEs.

When reviewing the canvas, the project partners should keep in mind that the goal of the canvas is to ensure that a third-party without any knowledge of the proposed opportunity and the related business/exploitation model can get an overall understanding of the opportunity you would like to exploit. Comments provided are connected to this.

Appendix B Valorisation PAL

Project

PAL

Activity

Benchmarking

State of art: applications and platforms that provide services to diabetes users and stakeholders

Authors

Francesco Sardu

Date

March 2019

MySugr: Diabetes Logbook: app (Android e iOS) e platform web.

Link: https://mysugr.com/

Video: https://vimeo.com/85338614

Factory:

-mySugr GmbH (Austria)

Cost:

free, pro version 28€ for month or 140€ forever

Released:

2011, last version October 2015.

Target:

Child diabetes type 1

The same factory created "my academy" app for the therapy management training of users with type 2 diabetes.

Technical features:

Data profile:

- Name,
- Surname
- e-mail,
- Gender,
- Date of birth

Therapy data:

- Diabetes type,
- Onset date,
- Device (pen, insulin pump),
- glycaemia (mg/dl o mmol/l),
- Carb (gr o bred unit),
- Insulin (typology),
- Drugs
- Range - Parameters of hypoglycaemia and hyperglycaemia
- Body weight,
- Blood pressure,

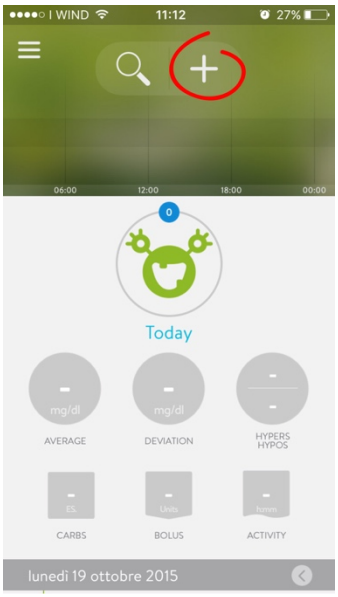
- Haemoglobin A1C,
- Pedometers (daily goal).

Setting:

- Glucometer synchronization
- Insulin pump synchronization,
- Health app synchronization,
- Newsletter.

Functionalities:

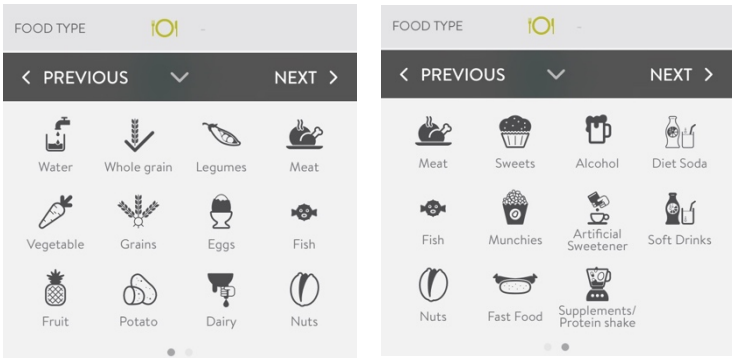
This app basically provides a glycaemic and nutritional diary where the child will add his values by selecting the key events during the day. At the top of the screen an icon with a plus sign [+] allows you to enter in the diary.



Then automatically the system detects date, schedule and position, (based on setting).

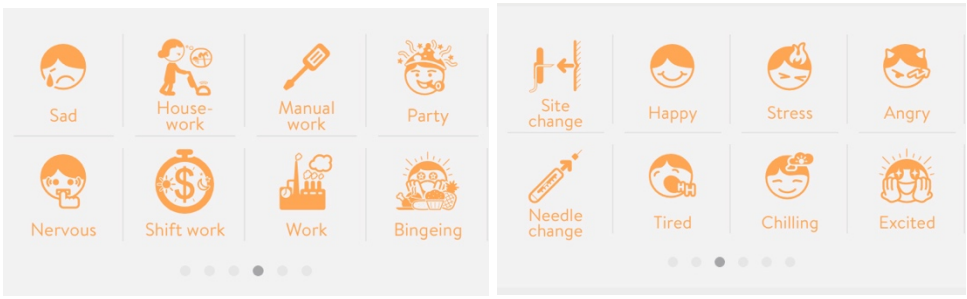
Data input:

- Activity picture (meal / sport / etc.)
- Glycaemia
- Carb
- Meal description (note, text)
- Meal typology:



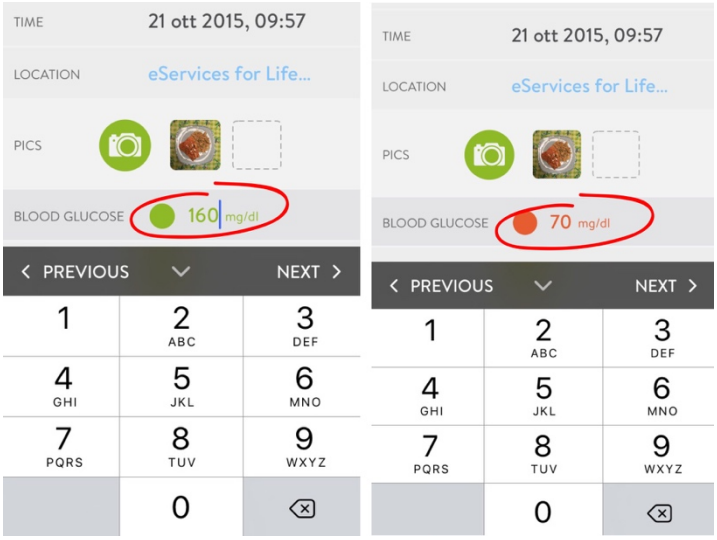
icons: meal typology

- Insert glycaemia values
- Insert activity (sports, etc.) and duration
- hypoglycaemia and hyperglycaemia
- With the PRO version would be possible to add other details like: Feelings e other specific moments of the therapy management.



icons: extra features by pro version

* When the user inserts the data about the blood glucose, the system uses a colour code (green, yellow, red) to communicate a feedback of the value inserted.



Based on the data entered, the application performs a number of statistics available on the homepage within a chart, which shows the trend of the blood glucose level during the day, the average blood sugar, the number hypo- and hyperglycaemia and various other data related to the values of the disease and the variation of these in a given period of time.
Based on these data the avatar interacts to give feedback, encourage, motivate, etc.
In addition, based on the number of details provided for each task the user can earn bonus points that can be used to unlock other features and games "challenge" (motivational activities - Avatar).

The PRO version allows:
-Create a **report pdf**, Excel e CSV (weekly) overview.
-**Challenge system**: motivational tasks – activities provided by the avatar
- Automatic data import from the meter: available in Germany with iBGStar, Italy Beurer GL 50 evo.
-**Reminder**: reminds the management practices at the appropriate times (measuring blood sugar before meals).
- **Synchronization** of data between device and platform.

Accessory applications:

Quiz, collection of questions divided into categories of difficulty:

- Starter (20 questions)
- Rookie (40 questions)
- Pro (40 questions)
- Insulin (30 questions)

Strengths:

- Powerful tool to create statistical trends glucose.
- Customize the name of your avatar.
- Gamification: The app has a "playful" approach aimed to reward any action / interaction that added details, information, etc., about the therapy management.
- Newsletter: According to the usage, the app reminds to take quizzes and activities to promote proper therapeutic management.
- Pedometers: It represents a hypothetical tool used to fix a certain goal, like for instance a challenge where is required a minimum number of steps to get daily (valid for bonus points).
- Quiz: improve knowledge of diabetes (chance to win premium version of the app).

Weaknesses:

- When the user needs to add his activities into the diary the system shows all possible parameters to be filled and then asks to specify the activities. It would be better to define first the activity and then based on it to present a menu of related options, ousting what is not connected.
- There is a monitoring system for medical staff and parents.

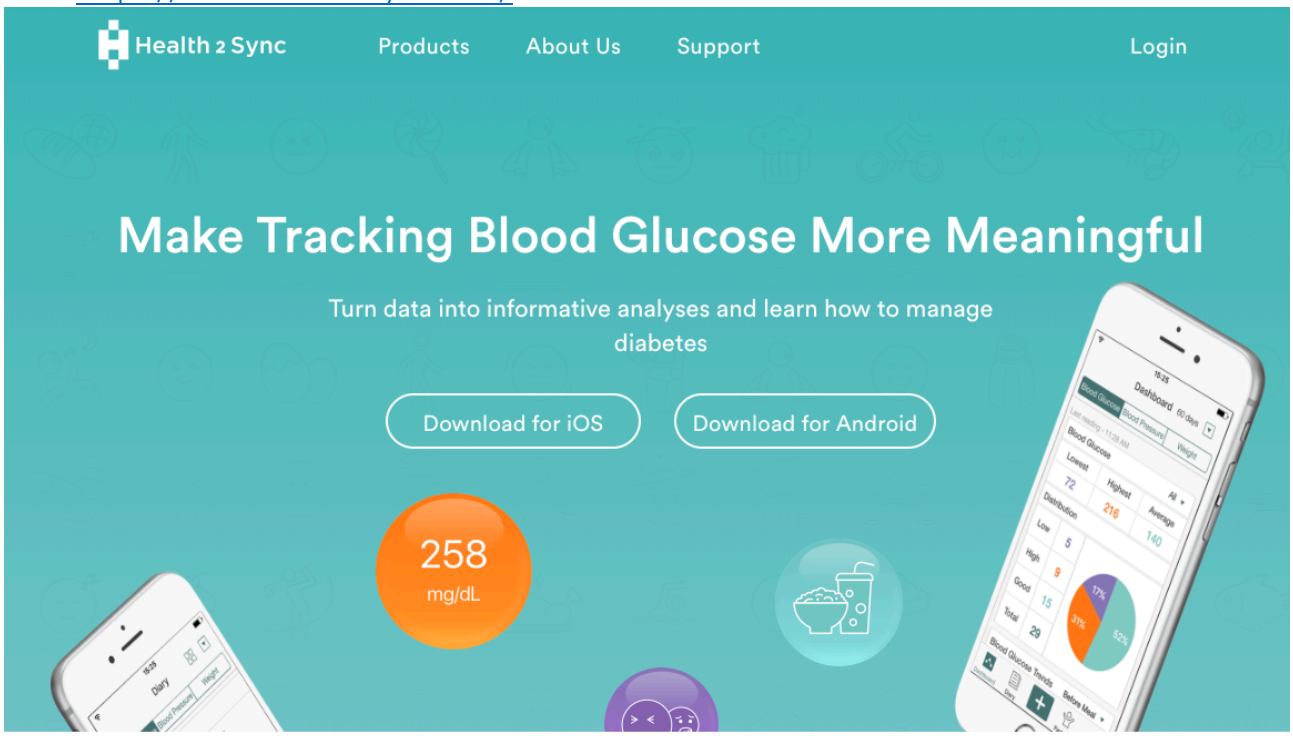
* Note: Would be possible to reduce the number of options shown on the display, like, lunch, breakfast, dinner, etc., simply based on the time schedule. (e.g.: at 22.00 o'clock the breakfast option will not be visible, or in case of physical activity / sport will not be displayed how much carbohydrates to add.

User Reviews:

- 4.5 out of 5

Health2Sync

Link: https://www.health2sync.com/



Factory:

H2 Inc.

Cost:

Base version free

Pro version

- 6-Month Premium Membership $14.99
- 1-Month Premium Membership $2.99
- 3-Month Premium Membership $7.99

Released:

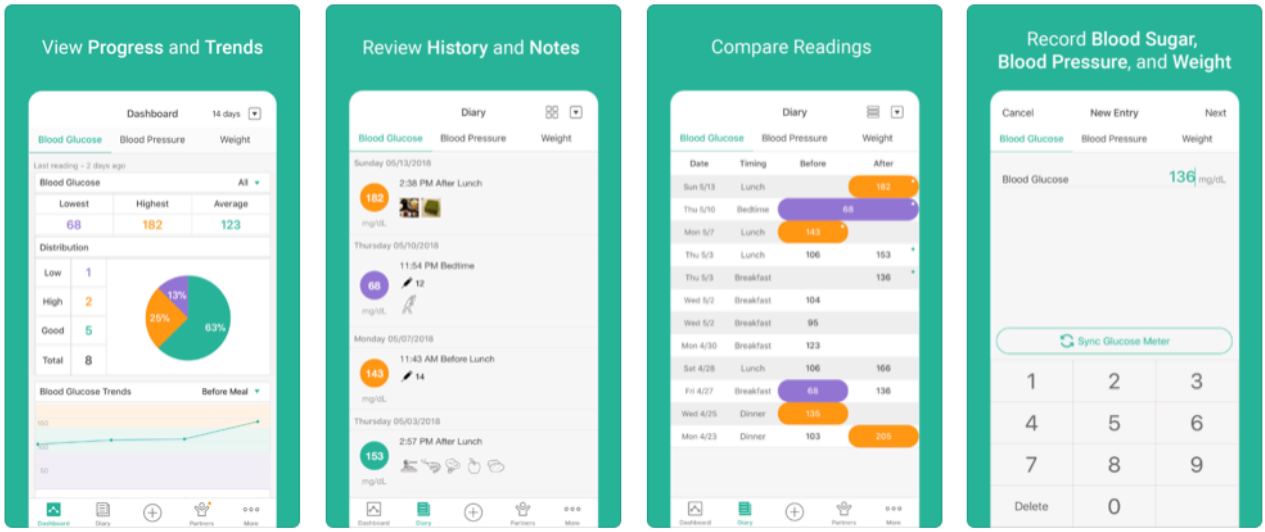
2014

Target:

- Diabetes
- Health professionals

Technical features:

Health2Sync app provides a diary to track personal vitals and metrics like blood pressure, glucose, and weight and share progresses and trends by providing charts, graphs, and numbers.
The feature in your diary to review your 'history and notes' keeps you on track by reminding you how you felt on certain days of personal highs or lows, while also recording the feedback from others with whom you've chosen to share your metrics with friend, family and clinicians added into the personal "Partner-care". It also allows to compare readings from other times and days of blood pressure, glucose, and weight.



Strengths:

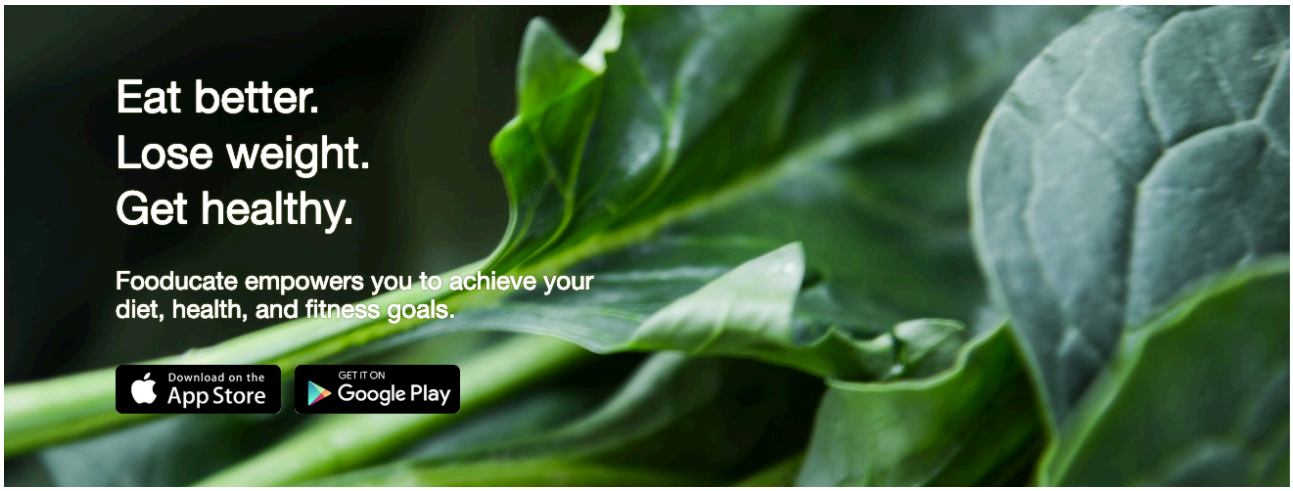
- Supports data syncing with various devices: glucometer, weight scale and blood pressure, allowing to easily import data into the Health2Sync App.
- Set reminders to track the medicine intakes.
- Allows to share data with caregivers (family, clinicians)
- Personalized tips, the system provides tips based on your records, to assist you in making timely adjustments.

Weaknesses:

User Reviews:

- 4.6 out of 5 ("Selected by Healthline - Best Diabetes Apps of 2018")

Fooducate



Link: https://www.fooducate.com/

Factory:

Fooducate Ltd.

Cost:

Base version: free
Pro version: runs from $4.99 for a month-by-month plan, to a lifetime subscription for $74.99

Released:

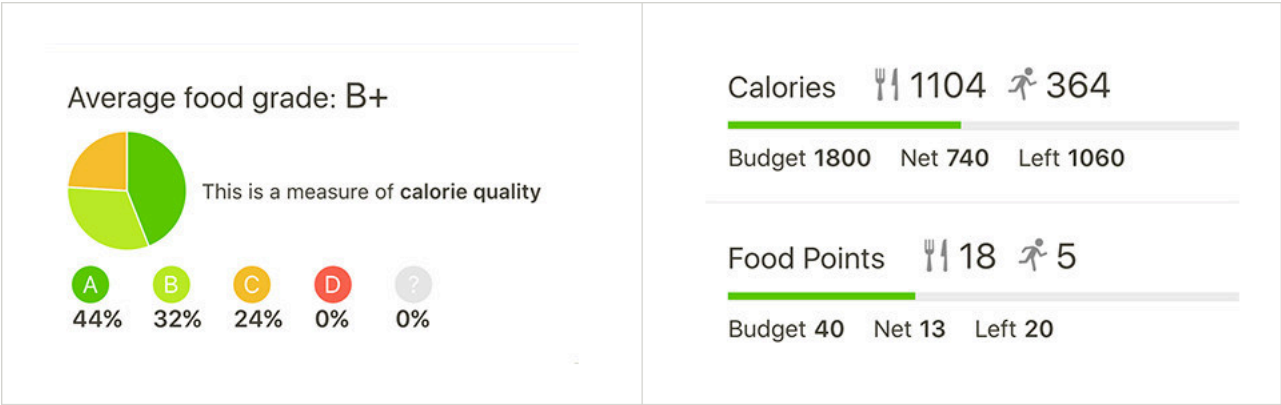
2014

Target:

Adult / children (diet, allergies, nutrition)

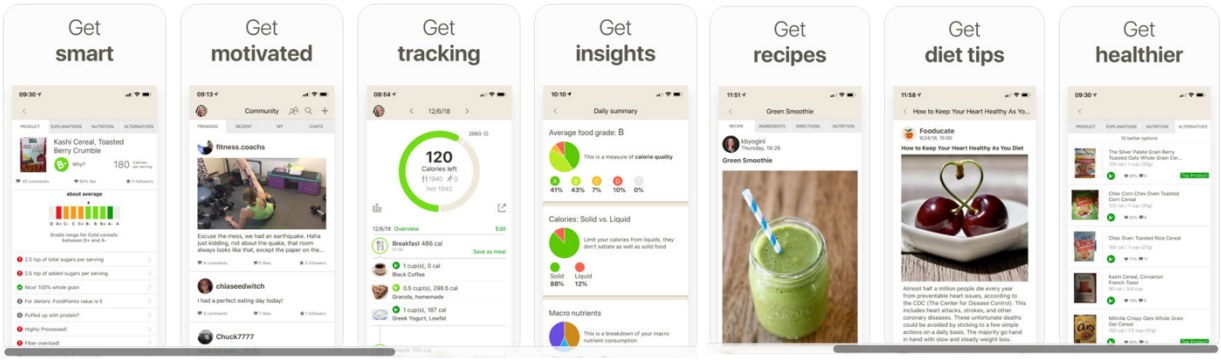
Technical features:

Health Tracker, aimed to track diet habits, progresses to achieve goals.
It's designed to allow you count calories, track diet trends, and steer you to better weight management.
The free part of Fooducate is a comprehensive food library, diary, and calorie tracker. The system first establishes your caloric needs by having you input your basic bio metrics: height, age, sex, current weight, and goal weight. Using these, it calculates a target of daily calories for you to aim for.



You aim for this by logging what you eat at each meal. This can be done a couple different ways. You can search the database of app-provided and user-uploaded food options, adjust the amount consumed, and add it to your diary.

Another option is a visual scanner, where you can scan UPC codes to quickly gather nutritional stats and uploading to your diary.
Fooducate tallies your calorie totals and shows your trending numbers both numerically and graphically. The pro (paid version) provides also insight on your intake of protein, carbs, fiber, vitamins, etc. Moreover, specific training with specific/trending diets such as Paleo, non-GMO, low-sodium, and such. Pro also gives you space to log more specific metrics like body measurements, blood pressure; including gluten and food allergy tracking



Recap functionalities:

- Track your food intake and exercise
- Seamlessly integrated with Apple's HEALTH App
- Track the quality of calories
- Track your macros: protein, fats, carbs
- Track your sleep, mood, and hunger levels
- Add your recipes and “instamagically” see their nutrition values

Strengths:

- UPC codes to quickly gather nutritional stats
- Personalized nutrition and ingredient analysis for hundreds of thousands of foods.
- Healthy recommendations.
- Support and motivation from fellow dieters.

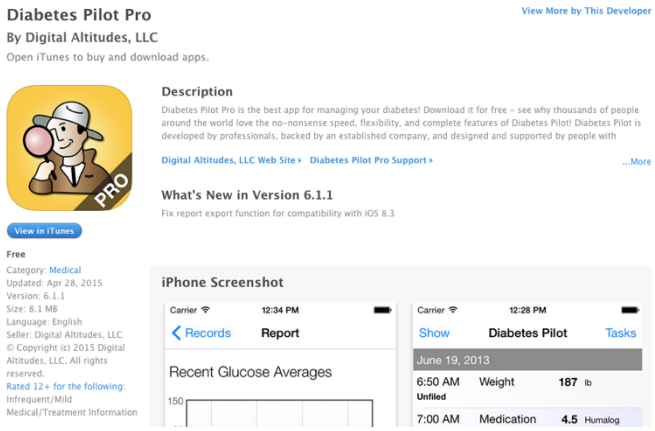
Weaknesses:

- Many of the foods I eat are not in the database.

User Reviews:

- 4.7 out of 5 (apple store)

Diabetes Pilot - app iOS



Link: http://www.diabetespilot.com/iphone

Factory:

Digital Altitudes (USA)

Cost:

Version pro: free
Version classic: 25$

Released:

Last version April 2014

Target:

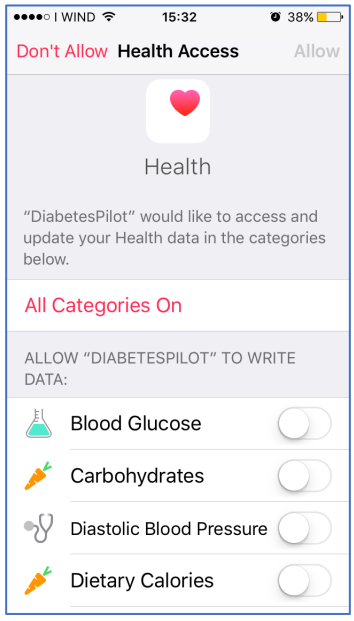
Boy / Adult type 2.

Technical features:

Profile setting:

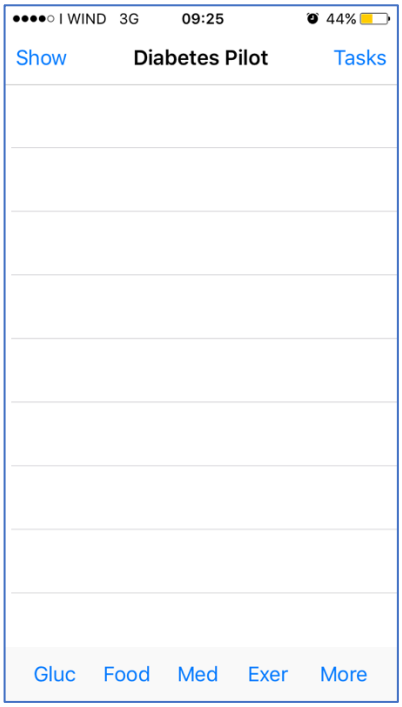
It asks the possibility to synchronize the profile with the default app "Health".

Data treatment:



- Blood glucose (mg / dl or mmol / l),
- Carbohydrates (grams or bred units)
- Blood pressure,
- Calories
- Cholesterol
- Sugar
- Fibre
- Proteins
- Saturated fat
- Sodium
- Body weight
- Heart rate
- Index of body fat
- Body weight

Functionalities:
After selecting which parameter to insert, the home page shows where to enter in your calendar the following activities:
• Blood Glucose Monitor: date / time, meal, values, notes
• Food: date / time, meal, carbohydrates, protein, fibre, fat, etc., (Would be possible to enter these data from the database or by scanning the QR code from the packaging, it's possible also to update and add to the database a personalized meals).
• Medications: date / time, meal, insulin values, notes. (it's possible to add more medicines)
• Exercise: date / time, meal, value, tasks, notes (it's not clear which unit of measure defines the activity)



Strengths:

- Scanning: the possibility to scan the barcode or QR Code of a food product to automatically add on the diary its nutritional values.
- Ability to customize their food database, adding specifications (carb, fibre, protein, calories, etc.)

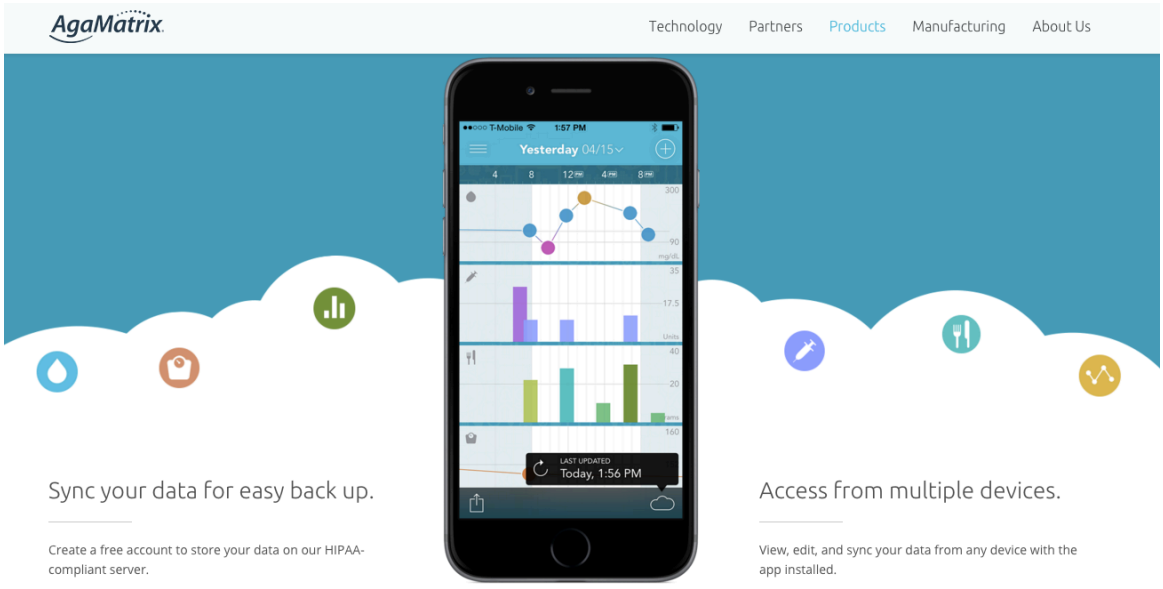
Weaknesses:

- During the test, the scan didn't work properly with many bar codes.
- There is no any function like the monitoring by the physician and parents.
- The app does not provide information content / educational for diabetes.
- The database is too rich of detail and is not easy the browsing.

User Reviews:

1. "The food database is massive and the app contains the most common data you'll need".
2. "Foods functionality is worth its weight in gold".
3. "Kept old version because old records did not go over to the new app".

Diabetes Manager - app iOS



Link: http://agamatrix.com/products/agamatrix-diabetes-manager/

Factory:

AgaMatrix (USA)

Cost:

free

Released:

last version Oct 16, 2015

Target:

Boy diabetes type 1.

<u>Functionalities:</u>

WaveSense Diabetes Manager allows to track:

- Glycaemia values
- Insulin doses
- Carbohydrate consumed

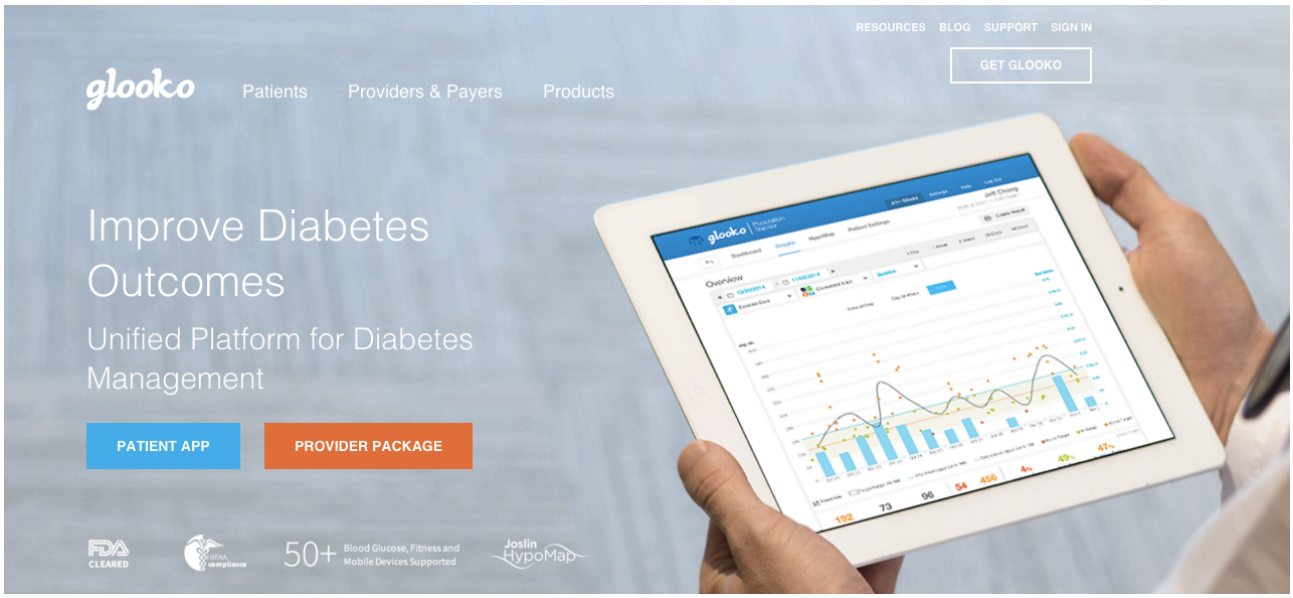
Strengths:

- Clear and easy interfaces.
- Recipes and tips on nutrition.
- It allows for the monitoring of values up to 90 days with the ability to view the data through graphs and statistics.
- The application includes a sharing feature that allows the user to exchange via e-mail the information with the doctor.
- Excellent video library with stories and interviews of celebrities with diabetes

Weaknesses:

The app doesn't include any nutritional diary.

Glooko - iOS or Android



Link: https://www.glooko.com/

Factory:

Glooko (USA)

Cost:

free

Released:

22 October 2015.

Target:

Kid / Boy diabetic type 1.

Technical features:

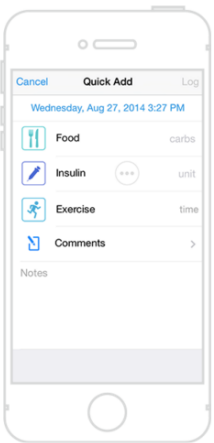
It's necessary to buy a device to connect the own smartphone with the insulin pump and glucometer.

Profile setting:

- Name,
- Surname,
- address e-mail,
- Synchronization with the own device.

Therapy data:

- Glycaemia values
- Carbohydrates
- Insulin dose
- Physical activities



*It contains a database with over 200,000 foods, it can also automatically include carbohydrates of some meals of some restaurants in partnership.

Setting:

- Synchronization with other app related to the physical activities like: Fitbit, iHealth e Strava. It adds automatically the data.
- Reminder: it helps to remind when to measure glycaemia, to take insulin, correction, etc.

Data visualization:

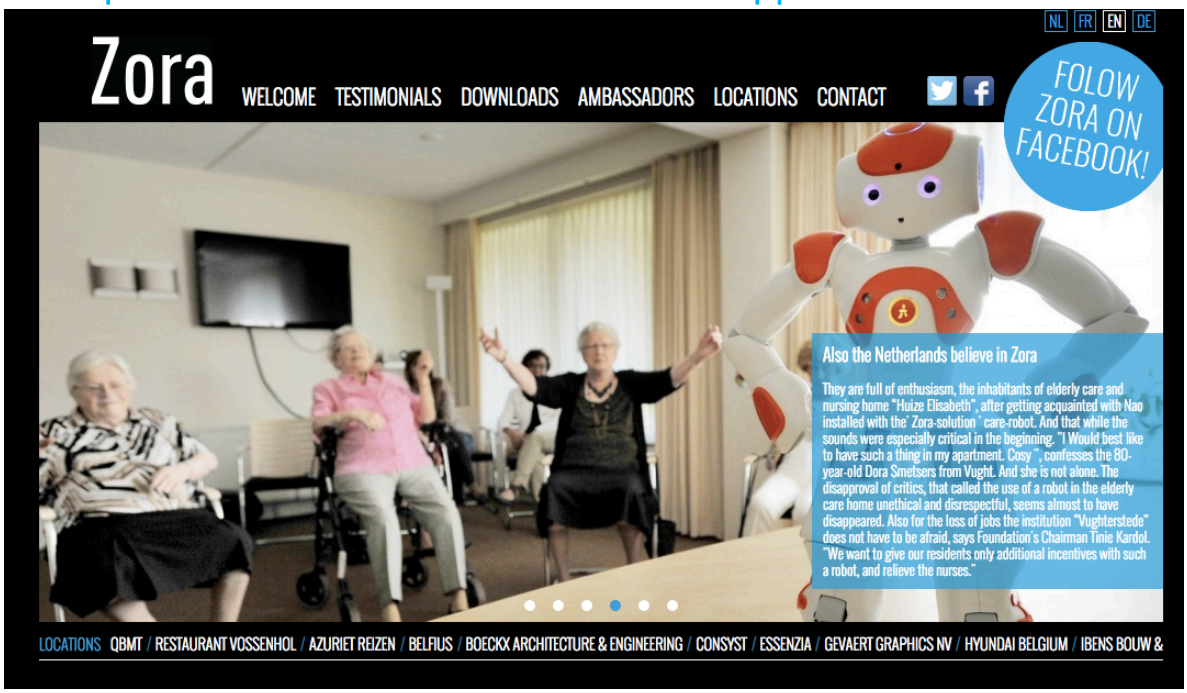
Glooko provides an overview of all measured parameters, furthermore it displays the details that impacted "negatively" on blood sugar spikes in relation to: meals, events, activities, etc. Based on these data it is possible to "learn" to restrict certain effects and optimize the therapy. It can also monitor the operation of the device (insulin pump), possibly suggesting some tips to the proper maintenance.

Glooko has been designed basically to share the therapy values with the doctor.
From the medical staff point of view, would be possible:

- Track the patient data,
- Compare the glycaemia trends,
- Intervene, optimizing and customizing insulin therapy,

- Activate the "spies" on some parameters for patients in particular need,
- Suggest practices and content for patients who are severely deficient

Zora qbmt – Nao Robot + Platform Zora e apps.



Link: http://zorarobotics.be/?lg=en

Factory:

QBMT (Belgium)

Target:

Elderly (nursing homes), children (schools, hospitals).

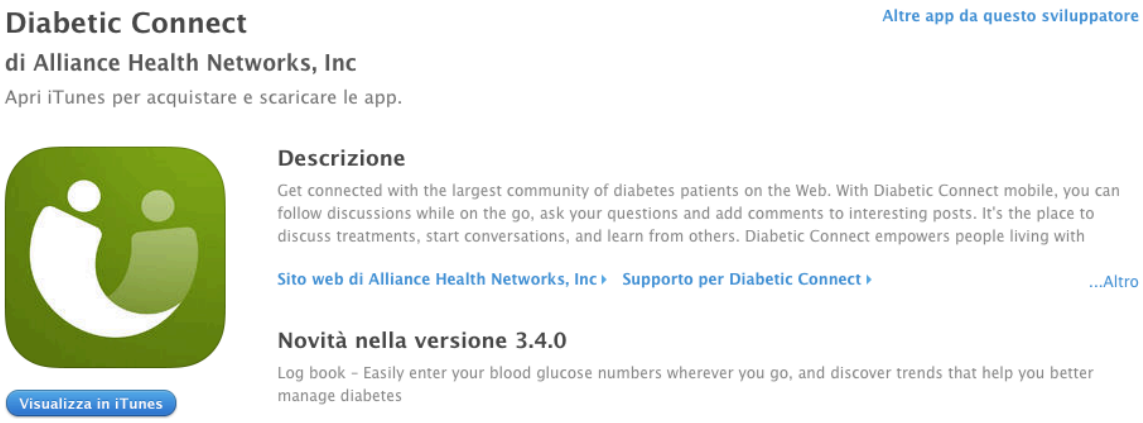
Functionalities:

In 2014, the NAO robot has been used in a study program in several nursing homes for the elderly. The goal of the experiment was aimed to evaluated the patient engagement with certain activities like physical exercises and gymnastics. The robot mimicked some of the movements that seniors patients had to follow and imitate.

According to their experiments, the robot is a medium that facilitates the work of doctors by imparting the practice of therapy, because it is considered as an "equal" to the elderly and children.Through a series of experiments using the technique of "wizard of oz" it was possible to interact with patients of nursing homes. They were open to dialogue with the robot and generally has been detected a decrease of the sense of loneliness. The same experiment was carried out in schools and in hospitals (paediatric wards).

The web platform has different types of dialogues "pre-set", through them the robot can interact with the target audience.

Diabetic Connect



Fonte: http://www.diabeticconnect.com/

Factory:

Alliance Health Networks, Inc

Cost:

Free

Target:

Boys / Adults diabetics type 1 & 2

Functionalities:

Diabetic Connect is one of the main community of people with diabetes. Within this space the participant can follow threads, share his experiences and create new dynamics of support.

Technical features:

- Diary to track the glycaemia values,
- Chat to communicate directly with other community members,
- Find answers, topics, etc.
- Make questions, propose a topic for discussion, comment previous topics.
- Make new friends, by following specific community members.
- Follow the topic of interest.

Carb Counting with Lenny US app (android e ios) and Platform

Link: http://www.lenny-diabetes.com/index.html

Factory:

Medtronic, Inc (USA)

Cost:

free

Realased:

2012

Target:

Kids diabetes type 1.

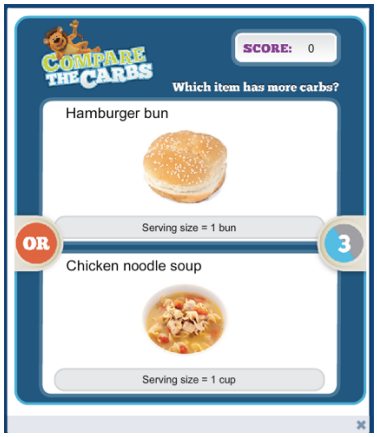
Technical features:

Carb or not carb:

The game asks to the child to answer if a determinate food item contains carb or not.

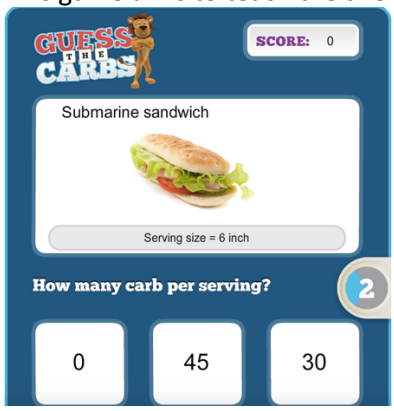
Compare the carbs:

The game provides a comparison between two different foods items, the child has to answer about which one contains more carbs.



Guess the carb:

This game aims to teach the average carb contained usually to a food item.



Build a meal:

This game displays several items food and a carb score to get, the child has to select the right food items in a way that the sum of the single carb of the food items reaches the score designated.

myGlyc – web platform, app (Android, Google Play).

Link: https://myglyc.com/it

Factory:

Alias srl (Italy)

Cost:

Free version (diary), Pro version 4,95€ (diary, therapy management, advanced statistics, sharing data)

Released:

2013.

Target:

Child / Boy diabetes type 1

Technical features:

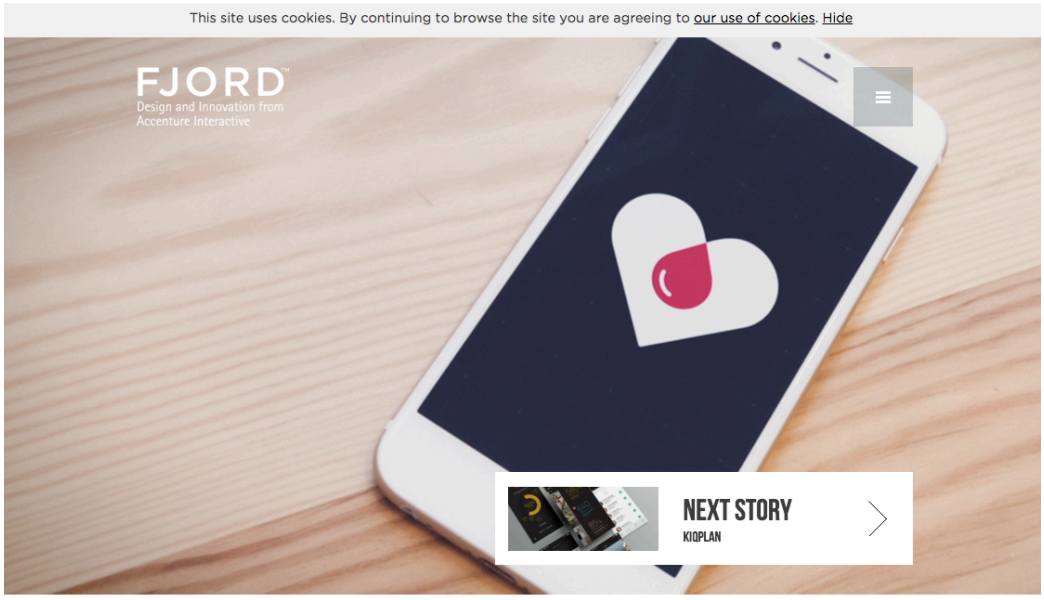
My Glyc is a diabetes diary that allow to save the therapy data in order to create an historical record of the disease and treatments applied. It allows also to share the data diary with other devices, like for instance parents and close relatives. My Glyc also a dashboard visualization of the therapy management records like:
- glycaemic statistics trends,
- glycaemia average value,
- Number of the glycaemic measures,
- Graphics representing the absorption of insulin during the time,
- Duration of insulin peak effect and the initial time of effectiveness.

My Glyc can provide also some suggestions about corrections and therapy management, based on the data diary and settings, by a statistics that will support the user's decisions and control of therapy.

Strengths:

-My Glyc allows to works off-line.
-My Glyc allows to create a network with other devices in order to share the diary data.
-My Glyc take in account the insulin remaining, based on the setting / profile.

Fido, app and platform (living service)



Video: https://vimeo.com/140422986

Factory:

Fjord (Norway)

Realised:

Prototype

Target:

Child / Boy diabetes type 1

Technical features:

Fido has been designed specially to use wearable devices in order to measure constantly all the data like exercise, food consumption, sleep habits and more. Those patterns can help manage uncertainty in the daily life of a diabetic person, for example, by predicting the need for less insulin on a day that historically has higher activity levels.

But the goal is not just to aid people on a personal basis. Instead, Fjord envisions Fido as a "Living Service" platform, sharing and aggregating data from everyone using the app to recognize patterns within communities. The more people use the platform, the more it learns from their experiences. The concept could then be translated to assist others suffering from chronic conditions.

The Fido concept will combine personal "thick data" and environmental "big data" with advanced analytics to create a Living Service platform. In other words, the more you use it the smarter it gets.

Three main features:

To Learn

The Fjord Fido concept's goal is to help to manage uncertainty in a diabetic's daily life. It will help see correlations between the cause (activity, meals, insulin etc) and the effect on blood glucose levels and identify historical patterns so you're better prepared for the future.

To Act

Having quick access to the information you need at the right time is at the core of the Fjord Fido concept. The information needs to be relevant and meaningful for the user. You shouldn't have to be a data scientist to understand how to make use of it.

To Predict

The Fjord Fido concept currently hopes to make use of all the historical data it captures to plan for future activities – like going on a bike ride, spending the day in the office or heading out for a meal. Not only this,

but it is expected that it can feed in calendar events like birthday parties and environmental factors like air temperature so the users can better understand their own situation.

MyStar connect: (platform – medical health record – diabetes patient).

Currently used at OSR.

MyStar Connect

Link: http://www.meteda.it/

Factory:

Meteda (Italy)

Target:

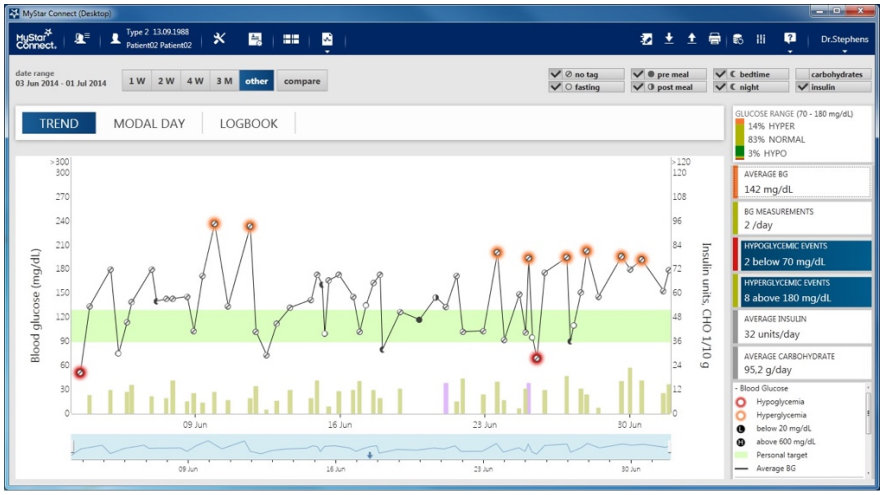
Doctors – Diabetologists / Patient

Technical features:

MyStar connect is a platform that monitors and displays the diabetes patient glycaemic trends. Doctors use it to store the patient data and consult it for the next visit.
Data visualisation focuses on key metrics, targets, and trends to support doctors in their clinical decision making to optimise diabetes therapy for each individual patient.

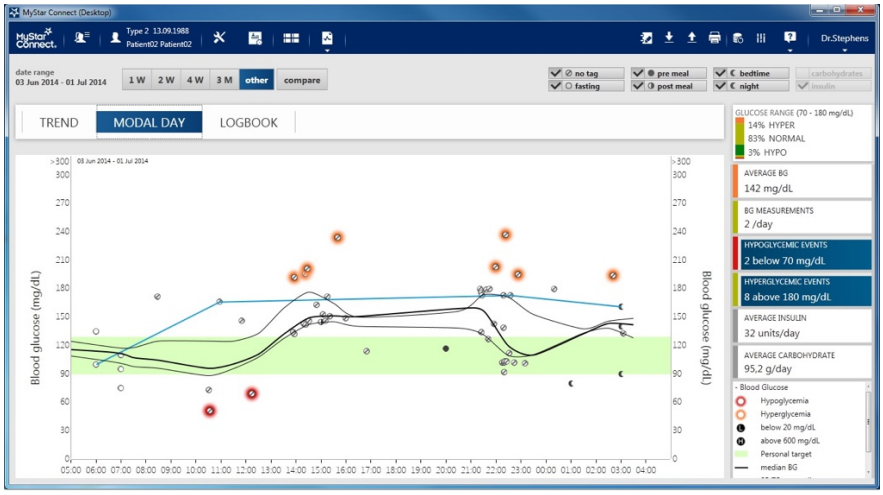
Monitoring Interface:
It shows the glycaemic trends diagram and insulin doses of patient, according his last updates, it comprises a time ranging from **one week to three months**.

- The green area identifies the personal glycaemic target.
- The orange spot identifies the hyperglycaemia
- The red spot identifies the hypoglycaemia.



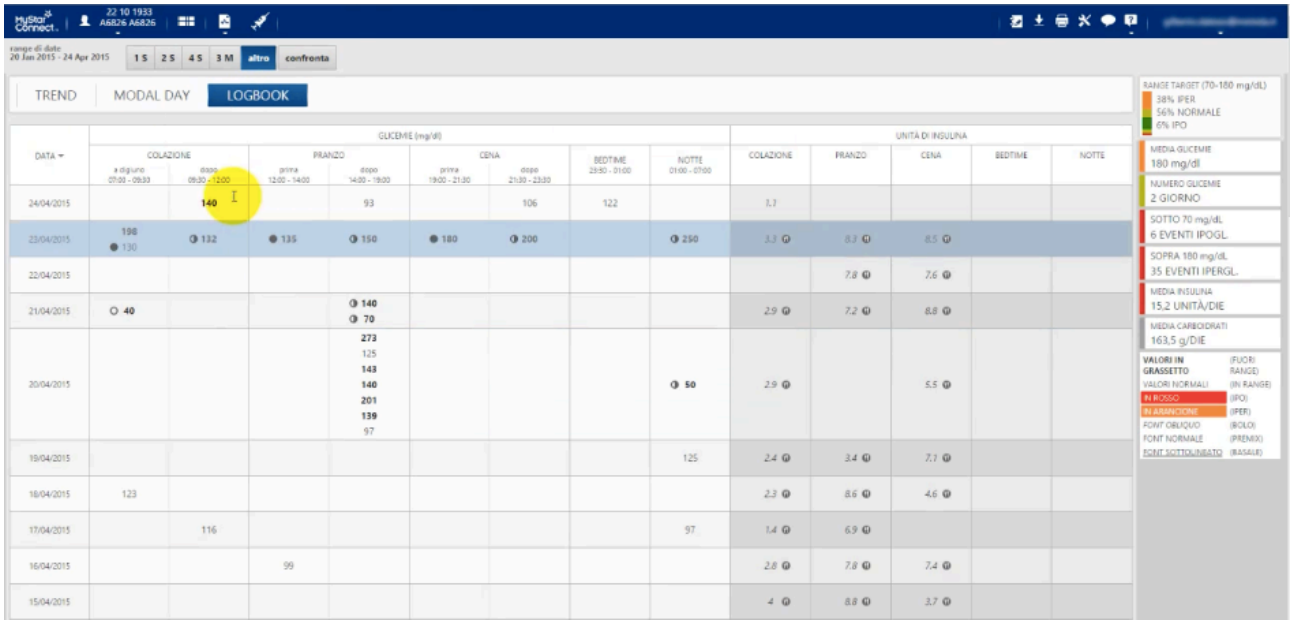
MyStar connect – Glycaemic General Trends Interface

Modal day is useful to highlight in which moment of the day the patient has difficulty to maintain a good glycaemic control.



MyStar connect – Daily Glycaemic Trends Interface

Another way to visualize patient data is represented by **Log Book**:
The logbook shows in tabular form the blood glucose status before and after the meal (breakfast, lunch, dinner). For each one of these moments, it shows the dose of insulin and carbohydrate taken.
Through the menu is possible to highlight the hyper and hypoglycaemia, this information should enable the patient to understand how his daily behaviours affect the blood glucose levels.



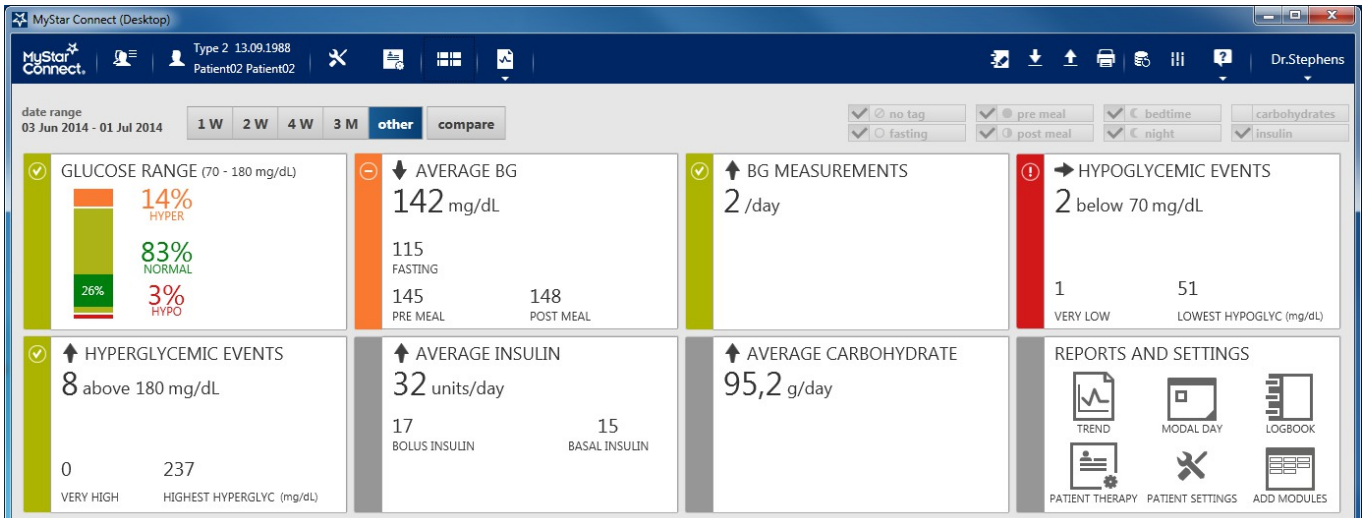
MyStar connect – Log book interface

Data Input:
It allows the patient to update in remote his glycaemic trends to the platform. (It's compatible with some glucometer devices like Accu-Check).
The first access requires the registration with the e-mail and password.
The patient visualises the informed informed consent.
The patient selects the compatible glucometer device used and download data.
As alternative the patient can add manually his data through the icon (Log Book).
This functionality seems a basic diary where the patient can add three different activities:
Insulin bolus, Glycaemic measurement, Carbs taken by specifying for each entry the time and value related.

*The patient can also go to an enabled pharmacy to update his glucometer device.

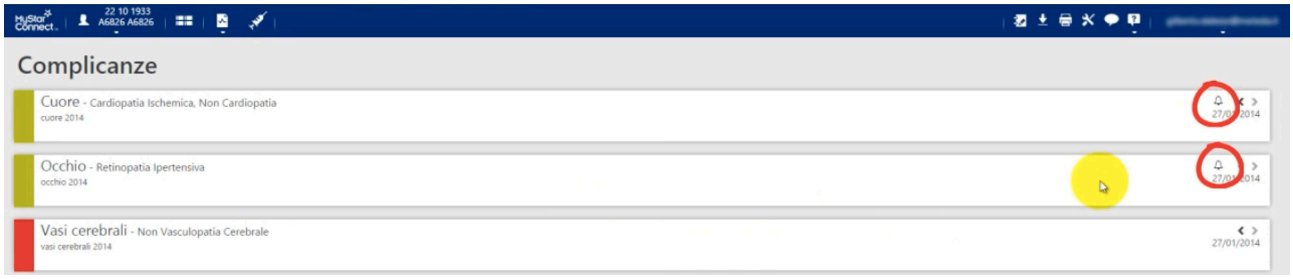
Data Dashboard:
The dashboard provides an area referring the therapy management data, with the following entries:

-Glucose range (percentage of hyperglycaemia, hypoglycaemia, normal status)
-Average blood glucose (pre meal / post meal)
-Blood glucose measurements (number of times for day)
-Hypoglycaemic events (number of events and value)
-Hyperglycaemic events (number of events and value)
-Average insulin (number of units for day – bolus insulin / basal insulin)
-Average Carbohydrate (grams for day)



MyStar connect – Dashboard Monitoring Interface (Therapy management).

Another area of the dashboard refers to the "follow up visit data", with the following entries:
- Cardiovascular complications, according patient's parameters it shows the level of potential risks related to cardiovascular issues.
- Diabetes complications, according patient's parameters it shows the level of potential risks that may affect: heart, peripheral nerves, eye, foot, kidney.
Colours represent the feedback, green means that the parameter is in compliance with the normal status, red represents a bad compliance.
The "bell icon" on the right represents a specialist visit already scheduled referring to the specific complication.



Diabetes complications - Interface

- Laboratory tests (shows the results of the medical examinations)
- Score Q, this entry shows the risk of developing within three years a cardio cerebral-vascular disease. The score is based on four parameters: glycosylated haemoglobin, blood pressure, LDL cholesterol and Albuminuria.

MyStar connect – Dashboard Follow up visit data

Therapy management:
The doctor can adjust the patient therapy by getting access to “Visualize therapy”.
This page shows the previous insulin therapy provided.
The doctor can change the current therapy by specifying the new insulin dosage according the specific time slot: breakfast, lunch, dinner, bed time, night.
In the same way, the doctor can specify also the quantity of carbohydrates suggested.
In additional, the doctor has the possibility to use the entry “Notes” for further details to communicate to his patient.

Data Report:
It allows the doctor to print out a personalized report for patients with graphical visualisations of the data to help patients’ understanding of their disease and therapy progress.

MyStar connect – Follow-up visit report

DID – Diabetes Interactive Diary:

DID – Diabetes Interactive Diary

Link: http://www.meteda.it/en/product/did-diario-interattivo-del-diabete/

Factory:

Meteda (Italy)

Target:

Patient

Technical features:

DID – Diabetes Interactive Diary allows to store all information relating to diabetes management, including blood glucose level, food choices, physical activity of choice, intercurrent illnesses, and insulin boluses. The photographic database of foods, in different serving sizes, allows to memorize the patient's preferred meals, and to receive in real time information relating to each meal's nutritional value and carbohydrate counting.

Data Input

As first tasks, the DID diary home page requires to insert the glycaemia value.
Subsequently, it provides a second page referring to the photographic database of foods.

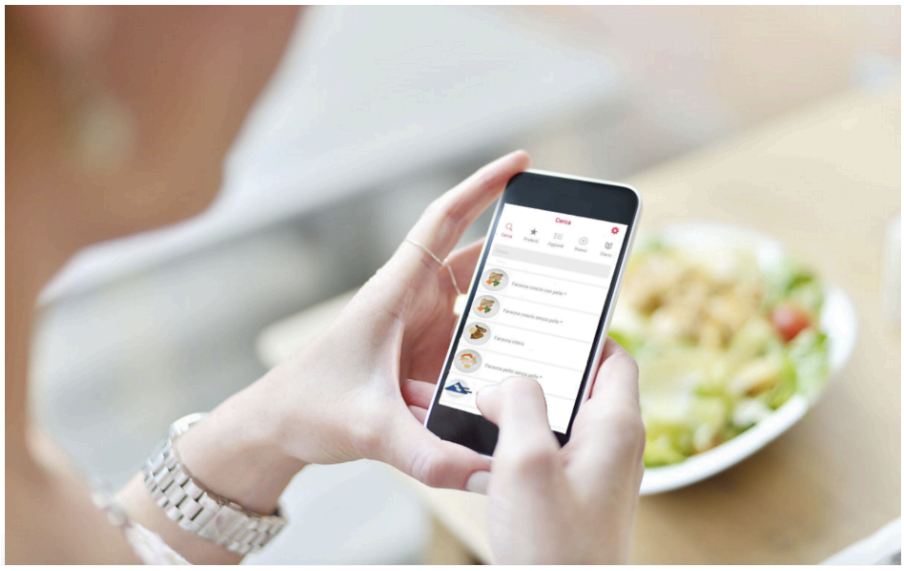
DID – Food Database

In this case, the user selects the type of food and can easily customize the serving sizes. It allows to simplify the daily management of insulin therapy and makes carbohydrate counting easier. User also receives information about the nutritional values and carbohydrate count of their foods of choice.
With the finger is possible to interact with the photo of the meal and "erase" part of it in order to simulate the actual amount that will be eaten, like the following example:

DID – Food Database / Customize serving size.

Moreover, DID provides an additional feature: the insulin bolus calculator that automatically calculates the insulin bolus based upon customized factors set up by their Diabetologists.
This functionality should be considered like an advice or tip, the user can decide to follow or not. In order to access these advanced DID functions, it is necessary to promptly activate the app start up procedure, which can only be completed by a Diabetologists through the MyStar Connect diabetes electronic medical record.
Finally, DID allows patients to communicate remotely with their Diabetologists. With the support of telemedicine, patients can send with a simple touch their system-stored data, which will be received by the physician directly on the patient's electronic medical record (MyStar Connect). The Diabetologists will have the opportunity to assess the efficacy of the patient's therapy and, if necessary, modify it. A Push notification will alert the patient that new settings have been saved.

Insulin & Food (Carbs counting).



Link: http://www.meteda.it/prodotto/insulinfood/

Factory:

Meteda (Italy)

Target:

Patient

Technical features:

Insulin&Food allows to associates to each food, and different serving sizes thereof, the insulin amount needed for its metabolization. This value originates both by calculating the I:C ratio and leveraging the diabetic patients' experience concerning a specific food.
By relying upon a photographic archive, Insulin&Food assists diabetic patients in recognizing and quantifying the carbohydrate intake of each food. By looking at a piece of bread, an expert diabetic patient can already "sees" the insulin units required for metabolization, without any need to estimate the bread's weight or carbohydrate count.

Data Input
The first task requires to setup the *Insulin / Carbs ratio* determined by dieticians and Diabetologists, the menu offers three different entries to use as parameter of reference:

- Carbs for each unit of insulin
- Insulin for 10g of Carbs
- Insulin for 1g of Carbs

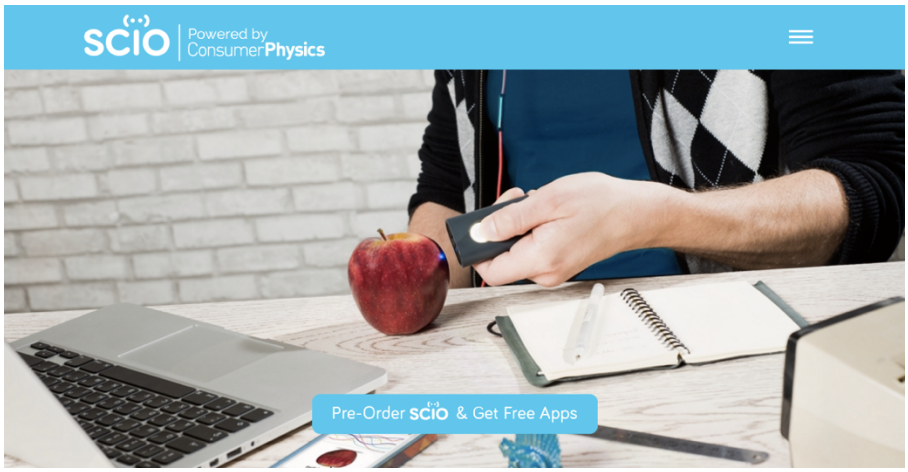
By relying upon a photographic archive, Insulin&Food assists diabetic patients in recognizing and quantifying the carbohydrate intake of each food. This functionality uses the same system of DID (Diabetes Interactive Diary).

- Select the type of food
- Define the quantitative
- Get insulin bolus result (the dosage is based on the number of carbohydrates multiplied to the Insulin / Carbs ratio).

*The user can also update the database with his own recipes and define its parameters.

User Reviews:
Users complain about an excessive price.

SCiO: Molecular Scanner



Link: https://www.consumerphysics.com/myscio/

Factory:
Consumer Physics (Israel)

Cost:
250$

Released:
It is scheduled for the end of 2016.

Target:
Patient

Technical features:
SCiO is based on the proven near-IR spectroscopy technology. It is a device that works as molecular sensor, basically reads the chemical make-up of materials like: food, plants, medication, oil and fuels, plastics.
SCiO communicates the spectrum of the sample to a smartphone wirelessly.
Advanced algorithms utilize an updatable database to analyze the spectrum within milliseconds and deliver information about the analyzed sample back to the user's smartphone in real time.
Referring to the diabetes patience, this device can be used to scan the meal in order to receive the exact quantitative of carbs and in addition also fat and proteins.

Feature Matrix

	Diary	Educational Contents	Reminder	Gamification	Avatar	Robot	Dashboard Visualization Data mining	Evaluation test	Monitoring	Contents Reliability	Emotional Feelings tracking	Communication channel	Device Synch. on Data import	CHO counting	Motivational Hints / Suggestions	Total number of features
MyPAL	■	■		■	■	■	■	■	■	■	■				■	11
MySugr	■	■	■	■	■		■	■			■		■		■	10
Health2Sync	■		■				■	■	■			■				6
Fooducate	■	■	■				■									4
Diabetes Pilot	■						■							■		3
Diabetes Manager	■	■					■		■							4
Glooko	■		■				■		■				■		■	6
Zora qbmt					■	■				■	■	■			■	6
Diabetic Connect	■	■										■			■	4
Carb Counting Lenny US app		■			■			■						■		4
myGlyc	■		■				■		■						■	5
Fido	■		■				■		■		■				■	6

Features description

Diary:
Dedicated section where to insert glycaemia value, food intakes and insulin doses.

Educational contents:
Contents aimed to improve knowledges on therapy management.

Reminder:
Tool aimed to reminds the management practices at the appropriate times (i.e. measuring blood sugar before meals).

Gamification:
The application of typical elements of game playing (e.g. point scoring) to other areas of activity, to encourage engagement with a product or service.

Dashboard (Visualization Data mining):
Tool aimed to visualize data inserted, allowing the user to recognize patterns, trends and correlations.

Evaluation test:
It means that the app allows to perform an assessment about knowledge or therapy management level, in order to track progresses.

Monitoring:
Tool aimed to let family or caregiver to remotely monitor user data entries.

Contents reliability:
It means that the contents provided are generated by professional caregivers. In the case of Zora, pediatrician or physiotherapist.

Emotional Feelings tracking:
Tool aimed to insert into the diary information related to mood and emotions.

Communication channel
Tool aimed to allow communication, like chat.

Device Synchronization Data import
This feature allows to automatically import and synchronize data from devices like glucometer, insulin pump, scale.

CHO Counting

Tool aimed to help the user to count the quantitative of carbs intakes.

Motivational Hints / Suggestions

Tool aimed to provide tips, suggestions, feedbacks about how to improve therapy management.

References:

Sitography

- http://www.healthline.com/health/diabetes/top-iphone-android-apps#2
- http://www.ispazio.net/411445/mysugr-una-nuovissima-applicazione-per-gestire-il-diabete-senza-stress-ispazio-review
- http://www.diabetespilot.com/iphone
- https://community.aldebaran.com/en/news/my-adventure-aldebaran-project-zora-qbmt
- https://www.healthline.com/health/diabetes/top-iphone-android-apps

Articles

The Best Diabetes iPhone and Android Apps of 2015
Written by Elea Carey and Kristeen Cherney | Published on 29 July 2015
Medically Reviewed by George Krucik, MD, MBA on 29 July 2015

Smartphone-Based Glucose Monitors and Applications in the Management of Diabetes: An Overview of 10 Salient "Apps" and a Novel Smartphone-Connected Blood Glucose Monitor
Written by Joseph Tran, BS, Rosanna Tran, BS and John R. White Jr., PA, PharmD |
Published on October 2012, American Diabetes Association(R) Inc., 201

Appendix C Minor thesis commercializing e-health apps

KTH Information and
Communication Technology

Commercializing eHealth apps without ethical consequences

Development of a business case without compromising the users data

BART SCHREUDER GOEDHEIJT

Minor Thesis for the EIT Innovation and Entrepreneurship module at KTH
Supervisors: Drs. R. Looije (TNO) & S. Temiz (KTH)

Abstract

Preventive apps in the eHealth domain are often struggeling with the switch from temporary finances to permanent finances. This research was intended to help eHealth apps to be launched commercially without ethical consequences for the users. The PAL project was used as a case to investigate possible ways to enter the Dutch healthcare sector. As a result, two different strategies were formed after a stakeholder analysis.

Contents

List of Acronyms and Abbreviations

PAL	Personal Assistant for a healthy Lifestyle
T1DM	Type 1 Diabetes Mellitus
UDID	Unique Device Identifier

Chapter 1

Introduction

1.1 Background

The PAL (Personal Assistant for a healthy Lifestyle) project aims to help children with diabetes type 1 (between the age of 7 and 14) to improve their self-management skills using a social robot and a virtual avatar combined with a set of mobile health apps. The robot and avatar act as a pal for these children and help them to achieve diabetes-oriented goals. Next to the robot and the virtual avatar, the PAL system consists out of a module for the health professionals used to instruct and supervise the system, as well as a module to monitor progress and inform the parents. The project is funded by the European Union in the Horizon2020 program (ref. H2020-PHC-643783). It continues work that has been done in earlier projects including the ALIZ-e project [Wölfl, 2012]. The PAL project is coordinated by TNO and includes partners from The Netherlands, Italy, the United Kingdom and Germany [Looije, 2015].

Figure 1.1. PAL robot and mobile health apps [PAL4U, 2015]

1.2 Problem statement

Preventive apps in the eHealth domain are often struggeling with the switch from temporary finances (e.g. subsidy) to permanent finances [Politiek and Hoogendijk, 2014, p. 285].

The permanent finances are often offered by the healthcare industry (pharmaceutical companies, insurance companies, etc.). One of the business developers at TNO mentioned that in order to get funding, it is nowadays quite normal to hand over the data of the users to these companies. He even mentioned that there is no proper business case for eHealth apps without doing so. This also applies to the PAL project.

1.3 Purpose & Goal

The PAL project contains an app for children with diabetes. This app can be seen as a diary which will contain their emotional state, the activities that they did during the day and the measurements of their blood sugar level. In order to make the app accessible, the end customer should be able to download the app for free. The purpose of this project is to find a fitting business model in order to launch the platform commercially that won't compromise the data of the users.

1.4 Research questions and hypotheses

The main research question is:

> **Can eHealth apps be launched commercially 'for free' without ethical consequences?**

In order to answer the main research question, the following subquestions have been defined:

ID	Question
SQ1	Which business models are nowadays often used in eHealth apps?
SQ2	Which data gathered in eHealth apps is valuable without privacy issues?
SQ3	What would be a valid way of funding the solution that won't include selling data of the users?

Table 1.1. Research subquestions

Chapter 2

Literature analysis

2.1 Market analysis

According to Research2Guidance, nearly 100.000 eHealth apps have been added since the beginning of last year. That makes the total number of eHealth apps currently available in major apps stores 259.000 [Research2Guidance, 2015].
As seen in figure 2.1, most eHealth publishers don't use traditional app store revenue sources, such as paid apps, in-app advertisements or in-app purchases. Just 24% of the eHealth apps use these sources. Licensing, app development fees and service sales are the top three most common revenue sources.

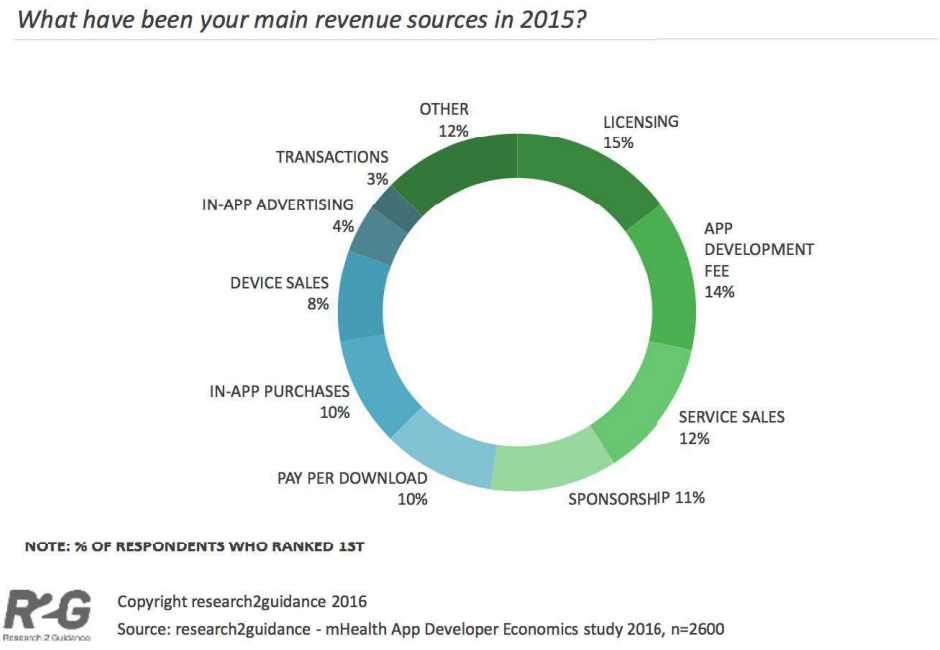


Figure 2.1. Common revenue streams for eHealth apps [Research2Guidance, 2015]

According to 82% of the eHealth practitioners, there could be a key role to play for Health Insurance companies in eHealth app publishing. The industry even expects that health insurance members would be willing to use the apps provided to them by Insurance companies, as well as share their data. "In return, members expect cheaper insurance plans (53%), receive health recommendations (18%) or support research (14%). Only 15% of eHealth market players do not foresee that members would share their data with Health Insurance companies via apps at all."

Research2Guidance further expects that in 5 years from now, eHealth can play a very imporant role in reducing hospital length of stay and reducing readmission costs. They also expect that diabetes will remain the number one chronic disease that offers the best business potential for eHealth app publishers.

2.2 Privacy and laws

Privacy is very important in the eHealth industry and it is a well-discussed topic in ethics. An insurance company could for example use certain information in someone's disadvantage. If the eHealth data shows that the person has an unhealthy lifestyle, it could increase the monthly fee. Big data can help pharmaceutic companies to develop new types of medication, but they can also use it to create a monopoly position using the knowledge that was gained from the data. This could lead to higher medication costs. These examples stress that privacy should have a high priority for eHealth products. In this case, the health related data is from children, which makes it even more crucial to preserve their privacy.
According to a study from Privacy Rights Clearinghouse, many health and fitness applications collect a great deal of personal information [Privacy Rights Clearinghouse, 2014]. Also, mobile applications, especially the free apps, depend on advertising to make money. "They may share personally identifiable information with advertisers, or allow ad networks to track you. Almost all applications send non-personal data about how you use an application to data analytics services. If an application collects your universal device ID (UDID) or embeds a unique ID in the application you download, analytics data can be tracked back to you personally." They found that 55% of paid and 60% of free apps that were investigated use third-party analytics services.

Chapter 3

Case analysis

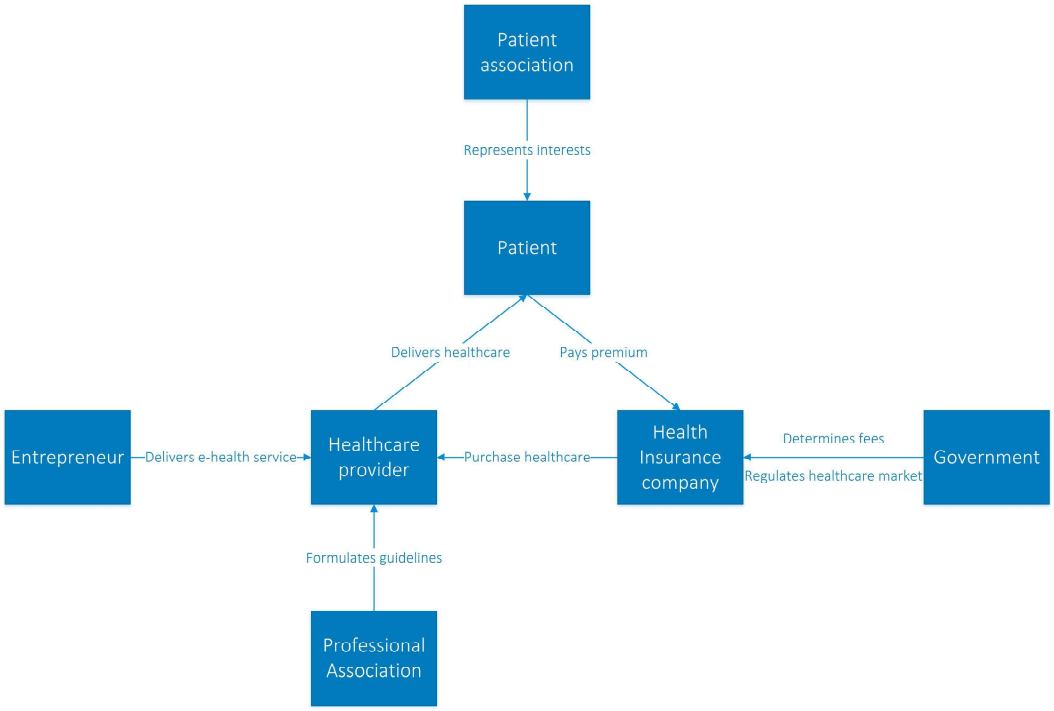


Figure 3.1. Innovation routes in the Dutch healthcare system [Hettinga, 2013]

The case will be analyzed using the innovation routes method from Windesheim [Hettinga, 2013]. This method is applied to the Dutch healthcare system.

3.1 Stakeholders

3.1.1 Patient

The patient is playing the central role in this case. The patients are children with diabetes type 1 (between the age of 7 and 14). Important in this case is that the parents or caregivers are involved as they can influence the usage and effectiveness of the solution. The patients main benefit for using the solution is the stimulation of their self-management skills in diabetes. The child is not able to choose the solution by themselves due to their age. The parents or caregivers need to be convinced in order to gain an user base.

3.1.2 Insurance company

The insurance company is responsible for covering the costs of the care that is given to patients. This party therefore has a big influence, as they want to provide good care for a low price. Insurance companies have different departments with interests in the eHealth market. The innovation department selects and ranks eHealth innovations, while the investment fund supports these innovations. The purchasing department negotiates with companies providing healthcare and purchashes this in big quantities in a preferably efficient way. The role of eHealth services in these negotiations is therefore limited. The commercial department on the other hand assembles the insurance packages for customers and organizations and sees the eHealth as a distinctive feature. The departments therefore don't share the same enthusiasm in eHealth.

3.1.3 Healthcare provider

The healthcare provider is the company that is using the eHealth solution to provide care to patients or customers. This party represents the medical professionals and nurses. Within the PAL project, several hospitals including their stakeholders like medical professionals are helping to co-create the solution. This would benefit the acceptance and integration of the solution in a later stage.

3.1.4 Patient association

The patient association (in our case the Dutch diabetes fund) serves the interests of the patients by influencing the insurance companies, professional associations, healthcare providers and the government. They are well up-to-date in the specifics and ongoing research of the disease and the needs of their target group. A patient association can become a strong partner to support and promote a solution in an early stage when they see a clear added value of an innovation. They can support the development with funds or evaluation with real users and promote the solution for patients, healthcare providers, professional associations, insurance companies, as well as the government.

3.1.5 Professional association

The professional association is the scientific association of professionals in a certain expertise. They tend to improve the education and accreditation of the professionals in order to improve the quality of the provided care. They define the standards and guidelines for doing so. They could be an interesting partner if the solution has a clear improvement in the safety or quality of the provided care.

3.1.6 Government

The Dutch Healthcare Authority is supervising for the healthcare market. They do this by defining performance of the healthcare and by determining the rates. The eHealth solution first has to become a performance before it can be provided and charged for. The National Health Care Institute is the governing body responsible for determining the primary healthcare package that is mandatory for all Dutch citizens. They follow the principles of 'evidence based medicine' for rating which care has to be allowed in the primary package and which not. Next to that, it is responible for stimulating the quality of the healthcare and to advice the government in new healthcare innovations.

3.2 Innovation routes

Innovation routes are different ways to publish an eHealth innovation, each involving different stakeholders. In this section, four different innovation routes are described.

3.2.1 Consumer route

In this route, the eHealth innovation is directly offered to the public (patients and customers). The solution can still be advertised by an insurance company, but the patient/consumer has to pay for it. The main focus point of this route is that the solution has to be fairly priced and that it solves a recognizable problem. It works the best for solutions focusing on wellness and comfort. The user could get the app for free by selling ads or by sharing their data with 3rd parties. This could lead to specific ads about medication according to their preferences, but this conflicts with the privacy of the user. As this solution has a different focus and the fact that TNO doesn't want to charge the end user, this route is not suitable for the solution.

3.2.2 Healthcare provider route

The healthcare provider route seems more relevant. This route is typically used for solutions that give direct benefits to the healthcare provider. These benefits are for example a more efficient healthcare, a competitive advantage, or an image improvement. Healthcare providers generally have own funds available for these kind of investments. Co-creation helps to improve the recognition and acceptation

of the solution for this target audience. The current PAL solution is made in close collaboration with two hospitals in the Netherlands and one hospital in Italy.

3.2.3 Insurance company route

In this route, the insurance company adds the eHealth solution to their insurance packages. Therefore, the patient is compensated for the costs. The contents of the healthcare stays unchanged, but it does change the way it is offered. It for example makes the healthcare more accessible or more efficient. The key to be successful in this route is that healthcare providers, patients and the patient association need to be excited about the solution and support it. They can influence the professional association which plays an important role in the creation of guidelines for provided care. Insurance companies have to follow these guidelines.
If the solution leads to cost or labor reductions without changing the quality of the healthcare, it is recommended to stay on the healthcare provider route without involving the insurance companies. If the solution on the other hand leads to a more sustainable healthcare which is significantly better, the insurance company route would be a good option. It is also recommended to leave the negotiations to an enthusiast healthcare provider instead of doing this directly.
It is furthermore crucial for an insurance company that the solution leads to replacement of the current healthcare, for example due to substitution or self management which in the end leads to less claims and thus reduced costs. As the main focus of this project is to increase the self-management of children with diabetes, this could definitely be interesting for insurance companies.

3.2.4 Government route

The government route is only possible when a medial-technological solution leads to new ways of healthcare, which are not offered or which are not compensated for. The route is used when the solution fundamentally changes the healthcare, the way it works or simply because it was not possible to deliver the healthcare before. The government route is therefore not applicable for most eHealth solutions. The PAL system tends to improve the self-management of the children with diabetes, but the healthcare itself stays unchanged. The children still need to measure and control their blood sugar levels. The government route is therefore not the optimal route for this project.

3.3 Route comparison

The previous section already highlighted certain pros and cons of the different routes. In this section, we defined the criteria and weights in order to properly rank them. The criteria and priorities were defined in collaboration with project members of the PAL project. The scores are based upon interviews with partners from the project.

Criteria	Weight	Consumer	Healthcare provider	Insurance company	Government
The service can be offered without costs to the end-user	10	○	●	●	●
The privacy of the end-user is maintained	10	●	●	◕	●
Valuable data of the end-user won't be sold to 3rd parties	10	●	●	◕	●
Easy to expand service to other countries	7	◕	◑	◑	◕
PAL project goals are important and will be maintained	8	◔	●	◕	◕
Time to market is relatively short	6	◕	◕	◑	○
Own funds that are mandatory for market launch are relatively low	6	◔	◑	◑	○
	57	58%	86%	71%	72%

Figure 3.2. Criteria and scores per innovation route

As seen in the scores, the consumer route is generally not preferred. The healthcare provider route seems to have the best support. The government route had support from the partners, but due to the extended requirements of this route given in § 3.2.4, this route is unsuitable for this project. To conclude, in the following subsections, the two most preferable outcomes are matched with an appropriate strategy.

3.3.1 Healthcare provider strategy

In this situation, the solution will be sold to hospitals providing diabetes care. As the solution is co-created with hospitals, it would be relatively easy to integrate the solution with their workflow. The nurses and specialists are already familiar with the PAL ecosystem, so there is no learning curve for the employees of the hospital. The PAL project brings a more efficient healthcare and an image improvement for the hospitals, thus there is added value for them. This could lead to competitive advantages. The disadvantage is a possible lock-in as specific hospitals can choose to integrate it. The solution is not widely available, but just for patients of the specific hospital(s). An advantage for the PAL team is that this solution is very suitable for retaining the privacy of the users. Hospitals need access to the personal data in order to provide healthcare. The data stays with the professionals and is therefore not available for 3rd parties.
To overcome the hospital lock-in, a freemium business model could be proposed. Hospitals can provide the full extended version to their patients which helps them to achieve personalized goals in self-management. The professionals and nurses can closely monitor their progress and provide an efficient healthcare. In the hospital, the PAL robot can be used, while the patients use the virtual avatar on a tablet at home. The general audience still has access to a simplified version of the virtual avatar in the tablet app. However, to maintain the competitive advantage, the hospital(s) can choose to leave out the personalization of self-management goals, but just make the basic games and diary function available. A premium version could still be made available using in-app purchases. Parents can choose to activate the full functionality including the monitoring functions. Children with diabetes from other hospitals are then able to fully use the app without consequences for the privacy.

3.3.2 Insurance company strategy

In this strategy, the insurance company covers the costs of the PAL system. They can be convinced by underlining the cost reduction due to a more efficient healthcare by improving the self-management skills of the children. This leads to replacement of existing care, and thus less claims. A convinced insurance company is a great first step in nation wide coverage, as insurance companies determine together with professional associations which care is covered by all the insurances. The writers from the innovation route method further recommend to have at least one enthusiast healthcare provider to convince the insurance company instead of trying to do this alone. In this case, the hospitals from the PAL consortium could initiate this process.
In exchange, the insurance company might want to have proof that the solution indeed improves the self-management of the children and thus results in a cost reduction. This could be resolved by making anonymous usage statistics available to them, which they could compare to the overall number of hospital visits from their patients. This number should decrease over time to proof the cost reduction. The insurance company that helps with the funding could have the exclusive right to use the system for their patients at the start. After this period, the system should be generally available to patients from other insurance companies too. This could be arranged in cooperation with the professional associations.

3.4 Conclusion and discussion

We saw that the most-used business models for eHealth apps didn't use traditional app store revenue sources, but rather licensing, app development fees and service sales. To protect the privacy of the end-users, the app should not give information to third parties that could expose the identity of the user in any way. Due to this, advertisements are not an option. For the PAL case in particular, two possible strategies were discussed.
One of the major shortcomings of this research is the fact that it's applied to the specific case of the PAL project, which is not comparable to simple eHealth apps from small publishers or start-ups. The PAL project is a research project with different partners all over Europe.
This leads to the second shortcoming of the research. We discussed the entry of the Dutch healthcare system, which is one of its kind. It would require a more specific research for each country, as they all have their own healthcare system, politics and laws. Currently, only the Dutch and Italian hospitals are involved in testing, so it would be a logical step to launch the solution at one of these countries. In order to continue, it would be helpful to investigate the Italian health care system. Besides partners, there are also potential users in both countries.

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