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LIFANA – User-Centered Design of a Personalized Meal Recommender App for the Elderly

Christoph Stahl[1], Krizia Ferrini[2], and Torsten Bohn[3]

[1]Luxembourg Institute of Science and Technology (LIST), 4362 Esch-sur-Alzette, Luxembourg
[2]Innoval Pharma AG, 6370 Stans, Switzerland
[3]Luxembourg Institute of Health (LIH), 4362 Esch-sur-Alzette, Luxembourg

ABSTRACT

The LIFANA application provided personalized meal plans that helped users to prevent undernutrition or overweight and followed WHO recommendations regarding caloric intake based on height, weight, gender and age as well as measured physical activity. The weekly meal plans maintained a balance between e.g fish and meat and plant-based dishes, ingredient variety, and macronutrients, and considered individual food restrictions. The LIFANA solution distinguishes itself from conventional food logging applications by providing users with seamless access to personalized meal plans that account for factors such as food restrictions, ingredient variety, macronutrient balance, and dietary preferences. The project implemented a User-Centered Design (UCD) process with two iterative cycles of three phases: i) understanding the needs of the target group, ii) conceptualizing, and iii) testing. To facilitate understanding of the user's needs, 34 stakeholders (seniors aged 65+, health professionals, and informal caregivers) participated in focus groups and co-creation workshops in The Netherlands (NL), Portugal (PT), and Switzerland (CH). The insights gathered from these sessions informed the creation of 7 personas and related scenarios, offering our developers a better understanding of the target users and their needs, considering factors such as age, gender, education, disabilities, and food preferences. Further, we added examples of typical meals for the age group in NL and PT. In the conceptualization phase, the functional requirements for the LIFANA solution were defined, and a first prototype was implemented based on the personas defined in the first phase. The testing phase started with usability evaluation studies to validate that seniors can solve typical tasks. After successful request of ethical approval from the responsible national authorities, the LIFANA solution was then tested in a first round of short field trials in PT and NL. The feedback from the trials was used in a second iteration of the process to refine the requirements and develop a second prototype, which was then tested again in larger, long-term field trials in PT (53 participants, 14 months) and NL (107 participants, 3 months).

Keywords: Mhealth, User-centered design, Meal recommender, Meal planning, Aging, Elderly, Clinical nutrition

INTRODUCTION

In recent years, the field of healthcare has witnessed a significant transformation through the integration of digital technology and innovative approaches to address the complex health needs of older adults (LoBuono, 2023). Aging brings about physiological changes that can affect an individual's nutritional status, including decreased appetite, alterations in taste and smell perception, and reduced gastrointestinal function (Dharmarajan, 2021). Moreover, the prevalence of chronic illnesses and medications commonly associated with older age can lead to malnutrition by affecting nutrient absorption and utilization (de Sire, 2022). Malnutrition can have severe consequences for older adults, including weakened immune function, muscle wasting (sarcopenia), decreased bone density, and an increased risk of falls and fractures. Recognizing and addressing this relationship is pivotal for healthcare providers and caregivers to develop targeted interventions and strategies that safeguard the nutritional well-being of the elderly population (Wilson, 2021). Among the possible strategies to counteract this trend are eHealth/mHealth solutions, which are generally affordable and have the potential to complement recommendations by healthcare professions (Lewis, 2016). Such digital solutions can be employed to improve lifestyle aspects that are inherently related to the risk of obesity development, such as physical activity (Wiklund, 2016) and especially balanced and healthy dietary patterns (Kayode, 2021).

The LIFANA Nutrition Solution, developed within the presented project LIFANA (AAL Programme, 2018-2021, www.lifana.eu), helped elderly people maintaining a healthy BMI as their metabolism is changing with age. The core element of LIFANA was a recommender system that created personalized meal plans that assisted users to prevent malnutrition and especially sarcopenia, targeting the total daily calories and proteins consumed. LIFANA implemented World Health Organisation (WHO) recommendations[1] regarding food and nutrient intakes based on height, weight, gender and age. The LIFANA solution distinguished itself from conventional food logging applications by providing users with seamless access to personalized meal plans that account for factors such as food restrictions, ingredient variety, macronutrient balance, and dietary preferences. The recommendations were based on regional recipes, annotated with references to national food composition databases.

The strategy behind LIFANA's consortium was to support users during all phases of ageing – from active seniors to sedentary elderly users and patients in need of daily care. The solution integrated the GoLive[2] wearable clip, provided by the Dutch project partner Gociety Solutions, to measure physical activity and adapt the caloric goal accordingly. Aimed towards users with limited mobility, the LIFANA app included a shopping list where users could add all products they needed to buy for the full week to streamline their shopping process and save time. Users in the city of Porto, PT, were able to benefit from

[1] Second International Conference on Nutrition. Rome: Food and Agriculture Organization of the United Nations/World Health Organization; 2014.

[2] https://www.goliveclip.eu, retrieved 1 August 2022

a grocery home-delivery service from the Continente SIGA[3] app, provided by our retail business partner MC Sonae[4]. The ingredients of the recipes were automatically mapped to products from the Continente database. The Swiss partner Cereneo AG[5] provided a sub-acute stroke rehabilitation program in their clinic. In this context, the LIFANA clinical nutrition prototype demonstrated how meal planning and easy access to relevant nutrient information of consumed meals can help Cereneo's experts to minimize preparation time of personalized food items. Besides, nutritional guidance is crucial for patients for reasons of secondary prevention and preventing malnutrition (Roigk, 2021).

RELATED WORK ON DIET AND NUTRITION APPLICATIONS

Prior literature on interventions using diet and nutrition apps have included both qualitative/observational studies (i.e. Focus Groups) as well as randomized controlled trials (Coughlin, 2015). Findings from these studies have shown that participants identified effective diet and nutrition apps that were quick and easy to administer, as well as those that improved food-intake aware-ness and weight monitoring/management; such apps were highly preferred among study participants. Regarding age groups, research shows that 94% of diet and nutrition apps catered to users of all ages (Schumer, 2018). The LIFANA project stands out as it involved elderly users aged 65+ years in focus groups and usability tests in order to make sure the application meets their needs. Reminders and feedback are some of the least commonly identified features across the diet and nutrition apps. This is consistent with prior studies (Stawarz, 2014), highlighting these features as some of the least identified across health and wellness apps. Nevertheless, empirical evidence suggests that reminders are an essential tool to sustain adherence to the use of health apps in general, and diet and nutrition apps, which require regular information tracking and data entry using food logs. The LIFANA approach significantly reduces the need for the latter, since users mostly follow the plans created by the system. The general effectiveness of app-based mobile interventions for changing nutrition behaviours has recently been confirmed in a meta-analysis of 41 studies, which included more than 6300 participants (Villinger, 2019). The authors further concluded that apps scale well and provide a cost-effective method for improving nutrition behaviour and health indicators. However, long-term follow-up effect sizes were generally smaller and non-significant. LIFANA also addressed this issue by up to 14-months long term studies, which confirmed that motivational strategies and features are paramount to increase user adherence and engagement with the app to overcome routine behaviors in favour of more healthy diets.

[3]https://siga.continente.pt, retrieved 1 August 2022

[4]https://mc.sonae.pt/en/, retrieved 1 August 2022

[5]https://cereneo.ch, retrieved 1 August 2022

USER-CENTERED DESIGN METHOD

The target group of elderly users aged 65+ differs from younger adults in many aspects, i.e., their cognitive and physical abilities, their experience with smartphone apps, and eating habits. There are also considerable differences in food culture within the different regions in Europe, which require a localization of language and recipe content. In order to develop a better understanding of the target group and tailor the LIFANA solution towards their needs, we implemented a User-Centered Design (UCD) process with two iterative cycles of three phases, according to the guidelines published by the AAL Programme in (Nedopil, 2013): i) understanding the needs of the target group and potential benefits of technologies, ii) conceptualizing: specifying use cases and details of the technology, and the assumed benefits; and iii) testing the system for usability and the assumed benefits. In the following sections, we report our findings from each phase of the development process.

Understanding Dietary Needs of Elderly People and Stroke Patients

It is necessary to create a good understanding of the users and their routines, habits, wishes, fears and problems, otherwise there is a risk that the developed technical solution is useless from a user point of view. In our study, we aimed to explore the dietary preferences of elderly individuals and their perspectives on assistive technologies. Given the variations in food culture and socio-economic circumstances among elderly populations across Europe, we incorporated end-users aged 65 and older from three distinct regions: The Netherlands (NL), the city of Porto in Portugal (PT), and stroke patients in Switzerland (CH). To gather comprehensive insights into their requirements, we conducted focus groups in each location. This qualitative research approach convened small, demographically predetermined groups of participants in a moderated setting, where tailored questions were used to delve into the specific aspects of our research interest.

Switzerland - Focus Groups With Stroke Patients: Setting and Results

Developing a neurological patient interface during the LIFANA project was a complex process that involved various considerations to ensure that the interface was user-friendly, effective, and supports the needs of patients with neurological conditions.

Focus Group and co-creation event with 5 patients. LIFANA Focus Groups[6] have provided a step-by-step guide on how to develop a neurological patient interface, including key considerations, design principles, and evaluation methods. The discussion was split in 3 sessions: dietary habits and attitudes, nutrition support after the discharge from the clinic and the willingness to receive a free Tele-Consultation Service using LIFANA system. Facilitated by health professionals, a semi-structured discussion guide was employed during a one-hour session with five participants at the clinic. The clinician-led survey revealed patients' limited awareness of diet's role in chronic disease prevention. The study highlighted patients' enthusiasm

[6]https://clinicaltrials.gov/study/NCT03635476

for technological nutritional support post-rehabilitation, emphasizing the potential impact of innovative approaches in healthcare communication and intervention. When it comes to healthcare technology, the LIFANA Focus Group's patients had specific preferences that contribute to their overall satisfaction and engagement. These patients prioritized a user-friendly interface that is simple to comprehend and navigate. They preferred intuitive designs that require minimal effort to operate, allowing them to focus on their health rather than struggling with complex systems. By having control over the layout, color schemes, font sizes, and other aspects, patients can tailor the technology to align with their individual requirements and enhance their user experience. Integration of voice commands, touch screens, large buttons, and other accessibility tools enables patients to interact with the technology effectively, regardless of their limitations. Patients found great value in receiving timely feedback and tracking their progress. This feature could allow them to stay informed about their condition, observe their improvements, and make informed decisions regarding their treatment plan. They expect healthcare technology to have robust measures in place to safeguard their sensitive data. Patients must feel confident that their personal health information is protected from unauthorized access, breaches, or misuse, fostering a sense of trust and reassurance.

Interview with a Clinical Dietitian. During the project's Focus Group the Researchers made some key considerations when designing a clinical nutrition patient interface. The Clinical dietitian interview underlined that nutrition care in stroke patients should begin with an assessment of the patient's nutritional needs, which can be done through a combination of medical history, physical examination, and laboratory tests. This can help identify any nutrient deficiencies or excesses, as well as any underlying medical conditions that may affect nutritional requirements. Based on the assessment, a nutrition plan can be developed using the LIFANA solution application expert interface. This may include specific nutrient targets, food preferences, and cultural considerations. Regular monitoring of the patient's progress and nutritional status can help identify any changes or challenges that require adjustments to the nutrition plan. Educating and engaging patients in their own nutrition care can help improve adherence to the nutrition plan and overall outcomes. Providing resources such as recipe ideas, meal planning tips, and information on how to make healthy food choices can help patients achieve their nutritional goals. By incorporating these considerations into the design of a clinical nutrition patient interface, healthcare providers can improve patient engagement, satisfaction, and outcomes.

The Netherlands

The focus groups were conducted by project partner KBO-PCOB[7], the largest association of senior citizens in NL, with their members in four events:

Focus group 85+ on eating habits and possible support by IT solutions. Two seniors, Lena and Nora, were visited at their home. Lena is a 92-year-old former bank clerk, who lives independently. She cooks daily, but has to

[7]https://www.kbo-pcob.nl

prepare her meals well ahead, otherwise she gets tired. She walks with to the supermarket with her rollator. Nora is 85 years old, widowed for two years. She lives independently but calls her daughter daily to plan food delivery. She is afraid that an app solution would remove this opportunity for social contact. Both adore soup for providing fresh vegetables and water. Both experience reduced taste sensitivity, while the smell of food is still important to them. Nora is losing her appetite. Occasionally they consume ready-made meals, but eat only half of it.

"Imagine you could do it all over again?" was the second event's topic with two former participants in the co-creation activities of the Cordon Gris project (Ribeiro, 2018). Tinus, 67, a former nutrition expert, commented that he would add gamification elements to challenge and engage the user, e.g. questions or awards. Recipes must consider the habits of users, and ready-made meals should be promoted carefully. The user interface should use nice graphics instead of text. Dina, 91, suggested to classify the target users in three groups: i) completely independent, ii) no longer leaving the house, and iii) completely dependent on care. This would imply three different modes of using the app. She expects different international styles of food for inspiration but prefers simple recipes that don't require many ingredients. She points out that from 85 onwards, seniors can't manage to change their diet and eat smaller portions, recipes must adapt. She would appreciate more social contacts.

Two in-depth-interviews with healthcare professionals were conducted. They generally recommend the five basic food groups ('schijf van 5'), and less salt, fat and carbohydrates. Herbs are very important to replace salt. Malnutrition is most important issue for elderly, more calories and proteins need to be consumed.

The co-creation event with 6 participants involved speed-date and mind map activities, followed by a discussion. Participants stated that nutrition apps will never work for vulnerable elderly people, and that healthier eating patterns require support from social peers, and meals should be considered as social events. They further expect that a digital bonus or reward works better than insight into nutritional values only, which are complicated and difficult to read.

Personas and Scenarios. The insights gathered from the Focus Groups informed the creation of 7 fictional personas and related scenarios, offering our developers a better understanding of the target users and their needs. Persona (Cooper, 1999) provide a description of archetypical end-users or stakeholders, specifying their characteristics or demographics. We provide details about their lifestyle, education, chronic conditions, and affinity with technology. Personas were categorized in primary or secondary personas. Primary personas are the elderly users of the system, secondary personas are other users who interact with part of the system such as caregivers, or nutrition experts, family members (daughter, son, wife, partner). Table 1 shows to examples from the deliverable *D3.1-Scenarios and Personas*[8], which is available online from the project website.

[8]D3.1-Scenarios and Personas, https://www.lifana.eu

Table 1. Two example personas out of 7 representing typical LIFANA users from NL and CH.

Emma, 67, Utrecht, NL	**Julieta, 65, Stroke Patient, CH**
Family status: Married Education: Vocational education Profession: Public sector, just retired Disabilities: None Emma is 67, lives in the suburbs of Utrecht, has just retired and is an avid cook. During the week, she mostly had lunch with her colleagues in the canteen, even though she was questioning if the type of food served is really that good for her. She has always been interested in healthy and good, tasteful food. Having an allergy, Emma must avoid products and meals that contain nuts. Now that Emma has retired from work, she has more time to enjoy her passion: cooking! She wants to spend part of her well-deserved spare time to learn more about food and nutrition. Emma prefers traditional Dutch dishes, but she likes to try something new from time to time. She is also planning to spend more time on physical exercise. Emma is very proud that she is still looking well and staying in shape. In time, she feels that her condition is more and more decreasing, and that her body is changing. She has gained a few kilo's and her muscle power decreases. Emma is using her tablet computer to stay in contact with her friends on Facebook and occasionally posts pictures of her creative dishes and gets excited when she receives positive comments. She also uses her smartphone to manage her shopping list, and to look up recipe ideas on the internet several times a week. She is also aware of the growing market of fitness trackers and nutrition apps and already tried to lose weight with some of them but didn't succeed.	Family status: Divorced Education: Elementary school Profession: Housewife Disabilities: Dysphagia, left arm paralysis Julieta is a diabetic woman who suffered a stroke 4 months ago. After being discharged from the hospital, she has spent the past 3 months in a rehabilitation clinic, where she receives dedicated care and guidance on how to deal with the disability occasioned by the stroke. The stroke left Julieta with severe dysphagia (swallowing difficulties), among other impairments. In addition, due to her age and her pre-existing diabetic condition, her food options are limited. At the rehabilitation clinic, Julieta's daily menu is specially tailored by a nutrition specialist, who considers her current and pre-existing conditions, medications, and results from laboratory analysis (e.g. blood, urine and stool). Her weight, food and fluids intake are closely monitored. [..] Due to her impairments, she had severe problems to use her smartphone. Now she has switched to a tablet computer with large display. [..] Julieta will be discharged from the rehabilitation clinic soon, as she is already able to deal with some of her physical limitations (e.g. walking, difficulties with activities-of-daily-living). The nutrition specialist has provided Julieta with dietary recommendations on how she should keep eating at home. However, the contact between Julieta and her nutrition specialist and speech therapist will be broken after discharge, as it usually happens, which leaves Julieta at high risk of malnutrition.

Conceptualization and Implementation of the LIFANA Solution

The requirements and use cases for the LIFANA solution have been collaboratively defined and agreed on by all partners, considering their specific target markets, and information gained from the focus groups. In parallel, a service-oriented architecture was specified to integrate existing components of the different partners to create the LIFANA solution. The meal recommender was provided by Fraunhofer AICOS, and Gociety Solutions contributed their GoLive application that collects physical activity level measurements from a wearable device (GoLive Clip[1]). Two versions (alpha and beta prototype) have been iteratively designed, developed and evaluated to integrate user feedback from the field trials. Data collection tools were integrated in the app to acquire usage statistics during the trials of the project. Features related to the integration of a clinical environment were developed for partner Cereneo, allowing nutritionists to create plans for their patients. Recipes used in the recommendations were revised and additional Dutch recipes were included, for details see (Stahl, 2020). The usage and interface design of the LIFANA app are described in (Bohn, 2023). The apps' usability was evaluated by 17 seniors before the field trials started.

Testing the LIFANA Solution in Field Trials

The trials were approved by the responsible Ethical Review Boards (NL: CCMO, PT: Ethical Committee of the SCMP, CH: Swiss Association of Research Ethics Committees) and written informed consent was obtained from all subjects. The GDPR guidelines regarding conducting human studies were followed. The field trials assessed aspects including user friendliness, as well as changes of health-related aspects. Anthropometric measures were taken (height, weight, (BMI), waist-hip circumferences, and partially (due to COVID restrictions) body fat, body water and blood pressure) to observe major effects on health status. A total number of 292 users originally participated in these trials (NL: 196, PT: 96), of which 55 (32 NL, 33 PT) completed the trials. The following section gives a brief outline, for further details please see our article focusing on the trials in (Bohn, 2023).

Field trials in The Netherlands. Three trials with elderly participants (age >65, BMI normal or overweight) were carried out: A first one, which was stopped after 3 months due to high drop-out rate, owing to the perceived non-technical readiness of the product. 27 participants were included in the active group, 13 in the control group. A second trial which was then run for 3 months with 16 persons (1 drop-out) and was then ended in order to allow for further improvements of the LIFANA solution. A third and final trial of 3 months length in which the majority of the data regarding questionnaires and anthropometric data (self-reported) was obtained from. This trial entailed 140 persons of which complete information was obtained at baseline, though only 23 complete entries were obtained at the end.

When combining participants from trial 2 and trial 3, a dataset for BMI entailing 32 persons was obtained. The net change of BMI over time was –0.32 kg/m^2, which can be considered small, and was not statistically significant. Questions were asked at the beginning and the end to assess the

motivation of persons regarding the use of LIFANA, also in the future. It was found that, when comparing the mean of the timepoint 0 and 1 (at month 3), there was a significant average change was from 2.56 to 3.57 or from rather agree-neutral to neutral to disagree, whereas in 10% of the persons, LIFANA was more favourably evaluated with time.

Field trials in Portugal. Participants were recruited and assisted during the 1-year trial by project partner Santa Casa da Misericordia do Porto. Primary end-users included subjects living in Portugal aged 60–85 years, with normal weight or being overweight (BMI <30 kg/m^2). Observed outcomes were changes over time (before-after) of the targeted parameters, comparing these changes within the same persons. Blood pressure and anthropometric measurements, including height, weight, body fat, waist-hip circumferences, and body mass index (BMI) were measured during the three points. In total, 53 elderly delivered complete datasets at time = 0 and truly started the trial. Due to dropouts, 34 participants were active at month 9 (from whom 33 complete datasets were collected), and the same persons stayed and delivered data at month 14. However, due to COVID-19, personal meetings were only possible for a limited number of cases (n = 10), so that complete datasets with also blood pressure etc. were only obtained from 10 persons.

Considering data from all 3 time-points over the 14 months trial (n = 15), there were no significant changes of blood pressure over time (P>0.05). Systolic blood pressure of men increased over time. For fat mass, a significant effect of time on fat mass was registered (n = 10, P = 0.08). A tendency (P = 0.058) for an increase in the percentage of body water was seen in these persons with time.

The questionnaires probed on the motivation of persons to use LIFANA in the future, no significant influence of time was noted. In PT, the participants had also the possibility (January-April 2021) to use the app for online ordering via the Continente home delivery service, which was used by 32 seniors, spending on average of 120 Euros per person, ordering items such as especially milk, rice, potatoes. The questions revealed rather positive feedback of this ordering option.

Observational, prospective cohort, pilot study in Switzerland. In Switzerland, the registered trial[9] started in August 2019, but due to ongoing technical development, testing was delayed to 2020. This pilot study had the intent to document the observations of two groups of patients, one offered a 'traditional' and another one a 'technology-supported' approach by the healthcare provider. Due to the altered situation following the COVID-19 pandemic, recruitment was much impeded following governmental regulations and for these reasons, Cereneo CEO and Medical Director decided in March 2020 to cancel their trial.

CONCLUSION

In brief, field trials conducted in Portugal and the Netherlands yielded neutral outcomes concerning participants' anthropometric measures and blood

[9]Investigating Adherence to Cereneo Tele-service Support After Clinical Discharge in Stroke Patients. https://clinicaltrials.gov/study/NCT03635476

pressure. Over time, motivational levels exhibited a modest decline in Portugal and a more pronounced decrease in the Netherlands. Despite the absence of significant enhancements in anthropometric and blood pressure indicators, participants maintained stable anthropometric parameters throughout the study. In the context of COVID-19, where the sense of hunger and satiety changed for more than half of the population and a weight gain was perceived by 48.6% of the population, according to a study with 12–86-year-old Italians (Di Renzo, 2020), one could argue that the intervention had a positive effect, stabilizing BMI as targeted.

User comments indicated that further improvements on both the app and content need to be implemented to prepare the LIFANA solution for the market. For example, some participants missed support to consider food restrictions of multiple users. The trials also revealed different opinions regarding healthy food; while some disliked recipes that suggest pre-processed ingredients, others asked for more convenience. In PT, 10 out of 33 participants (30%) agreed or strongly agreed that they would consider buying LIFANA if it were on the market. The numbers in NL were lower, with 1 out of 23 persons (4.3%) declaring that he/she will use the LIFANA solution in the future, though 6 (26%) were neutral to this question. We consider that 5% makes a reasonable market share for a product, and this number was reached in PT, with some uncertainty in NL.

Regarding the efforts taken to implement the user-centered design method, the reported user satisfaction was below our expectations. However, we learned from the feedback how to improve meal recommendations in the future. Motivational features, such as nudging or gamification, are required for sustained adherence. Recipe content must cater for individual preferences, from traditional dishes to particularly healthy meals made of fresh vegetables to recipes that are easy and convenient to prepare. Further suggestions considered e.g. use of left-overs and situations of multiple users and restrictions.

The field trials allowed Sonae to collect relevant information about the studied population and possible improvements to the solution. However, the population studied under the project is quite specific and may not be representative of the elderly population in Portugal in general, e.g., in rural areas. Sonae is evaluating the possibility of conducting further studies to understand the real market interest.

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