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Designing Healthy Consumption Support: Mobile application use added to (e)Coach Solution

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Abstract
Healthy living is an increasingly important topic on the agenda of policy makers. Containment of health care cost through public health and specific prevention programs is seen as a key element of the current social-economic policies in the western world. mHealth technology holds the promise to make healthy living more effective than traditional prevention programs. As part of a broad healthy living support program (including food, physical activity, stress management, social support and smoking cessation), we extended web-based and coach-based 'healthy consumption' support with smart phone application (mApp) assistance. This paper focuses on the design analysis phase, following a design research cycle. We start from a user needs analysis, then proceed to solution analysis and service development. The result is a design solution, using an mApp for the support of healthy food consumption, together with practical 'optimal diet' guidelines. This solution is embedded in a health coach relationship. For the future, we anticipate more personal and intelligent mobile applications for health behavior tracking and feedback, plus an increasing role in health provider processes.

Keywords: mobile application, lifestyle intervention, health behaviors, dietary guidelines

1 Introduction

When looking at our food intakes and health, there are a number of challenges our Western societies face, and increasingly the developing countries as well: cardiovascular disease, obesity, diabetes-2, several cancers, and as one underlying cause: 'metabolic syndrome' and 'cardiometabolic risk management'. The latter two concepts highlight the fact that distorted lipid and carbohydrate metabolisms often coincide, and it was estimated that 43% of people >60 yr of age have metabolic syndrome (Lakka 2002). This may put them at a 4.26-fold risk of death in 11-yr follow up compared to healthy men, and they are estimated to have a 3.7-fold risk for coronary artery disease and a 24.5-fold risk to develop diabetes-2 (Sattar 2003).

A healthy lifestyle is composed of various elements such as physical activity, stress management, social support and avoiding known disease determinants as smoking and excessive alcohol use (Ezzati 2006, Lopez 2006). Healthy dietary habits are an important aspect in the prevention of chronic conditions and to avoid their complications.

This paper focuses on designing a 'multi-channel' service concept (Sperling 2009, Simons and Bouwman 2004, Simons 2006) for healthy consumption assistance, where a mobile application (mApp) is added to existing web-based and coach-based support. This design is made in the context of in-company healthy living support, with a majority of participants being at increased risk for developing chronic conditions such as cardio-vascular diseases, diabetes and obesity.

In terms of health motivation and behavioral change, focus points are: 1) education to create awareness and understanding of healthy consumption (Schwarzer 2010), 2) goal setting and planning (Gollwitzer and Scheran 2006), 3) monitoring based feedback to facilitate and maintain healthy behavior (De Vries 2008). And in terms of ICT (Information and Communication Technology), the question is if and how to support user needs with mApps that are integrated into existing health coach processes.

The main research question is: How to (e)Support healthy consumption? And given the mApp opportunities that were encountered: How to integrate mApps for this purpose into existing coach processes?

Our subquestions address:

1. How to achieve maximum empowerment (Anderson 1991), motivation and health behavior improvement for participants using mApp assistance?

2. Which dietary guidelines and recommendations are appropriate to facilitate informed choices of participants for an 'optimal healthy consumption', (what type of design variables the food categories are: e.g. 'more is better', 'less is better', '2 portions/wk is optimal')?

3. What are the requirements for successful ICT-support for healthy consumption? (With successful meaning: creating increased adoption of ICT support and increased health behavior).

2 Theory

In relation to designing healthy living support, we build on the following three areas of expertise, which will be described in the text below:

1. (Lifestyle) Coaching and motivation
2. Healthy consumption guidelines
3. Designing ICT for health support

2.1 (Lifestyle) Coaching and Motivation

Effective healthy lifestyle coaching builds on general motivation theory and on more specific health behavior change models.

Regarding motivation theory, there are a few key elements that we use (see also Simons and Hampe 2010 for a more extensive overview). Firstly, there is the aspect of increasing knowledge and self-efficacy: 'I know where I can make the biggest improvements and I can be effective in reaching goals XYZ' (Bandura 1997, Reiss, 2004). Secondly, for long term sustainability of health behaviors, it is important to link to intrinsic motivations like feeling better or the joy or positive self-perceptions of taking care of one's health. These types of intrinsic motivations like the joy of feeling good or of mastering a behavior tend to increase the achievements more and be more self-propelling in the long run (Deci and Ryan 1985). Thirdly, it is beneficial to use positive psychology: every step forward counts and should be valued (by the coach and by participants themselves). Fourthly, it helps to let people chose their own goals and their own ways of experimenting with new behaviors: if it is their choice, their commitment and their preferred way of adapting everyday behaviors, the chances grow that the new behaviors will fit in and that there is mental ownership (Ornish 2008, Deci and Ryan 1985). This also increases robustness: if temporary life events throw people out of their health patterns, the chances that people will restore these patterns later on are larger.

Next, there are specific health behavior change models which provide useful insights. In the HAPA (Health Action Process Approach) model (Schwarzer 2008, Lippke 2009) and i-change models (De Vries and Mudde 1998), three important phases are distinguished. Barriers or motivators for change can reside in each of these phases, which are: awareness, intention, and practice (including coping, experiencing, improving). And as an underlying theme self-efficacy is important in these models: can we support people in developing skills to live more healthily and with tactics to deal with challenges? And if participants have barriers to change, it is useful to address the question in which phase these barriers are located. Are people aware of opportunities to improve and the extent of improvement? Do they have some intentions to change, but they lack specific plans and tactics of where and how to start? Or are there practical barriers: for example, they have started healthy eating, but work or private obligations regarding social eating and drinking are in the way? From a design perspective, these phases represent different types of user support needs. And these support needs must be made explicit during design analysis and solution design (Wiedeman 2011).

2.2 Healthy consumption guidelines

Our process for defining and using healthy consumption guidelines is as follows. Firstly, our primary focus is on preventing and reversing cardiovascular and metabolic risks; these risk factors have been implicated in cardiovascular disease, obesity, diabetes-2 and some common cancers (Roberts and Barnard 2005, McCullough 2011). Hence they have large health relevance. Secondly, we use recommendations from organizations like WHO (World Health Organization), AHA (American Heart Association), WCRF (World Cancer Research Fund) and the leading nutrition research group from Harvard as a basis. Thirdly, we have to define answers to the everyday questions from our user groups regarding what the optimum food amounts would be for health, even if the answers are not always 100% clear.

Firstly, cardiovascular disease, obesity and diabetes-2 are the primary targets, given their high incidence and preventability. These are partly related to lifestyle factors like sedentary lifestyle and smoking, and partly to food. For example, about 60-70% of the large reductions (40-80%) in cardiovascular disease in Scandinavia over the past few decades can be contributed to smoking cessation plus lowering intakes of saturated fats, cholesterol and 'trans fats' (Pedersen 2011). The latter types of fats are most famous from industrial hardening of oils, but currently the main dietary source of trans fats in Europe is 'ruminant trans fat' which is found in butter, cheese and beef: ruminant animal food products (Brouwer 2010).

Secondly, if we look at the trends in dietary advice, it can be observed that naturally fiber-rich foods have gained increasingly prominent roles in the past decades. They are relatively high in micro-nutrients and satiation, in comparison to their caloric density (WHO 2003, NHLBI 2012). Thus the advice is to eat more vegetables, fruits, pulses, beans and legumes, more whole grains, more seeds and nuts. On the other hand, sugars and carbohydrates with a high glycemic load are advised to consume sparingly: if replacing fats with high glycemic load carbohydrates then triglycerides go up which increases cardiovascular risk (Roberts and Barnard 2005). And diabetes risk is increased significantly (Hu 2001). Carbohydrate containing foods with high fiber content and low glycemic load do not appear to have these effects (Haskell 1994, Hu 2001, Roberts and Barnard 2005, Anderson 2009). The 'high glycemic load' problem appears extra significant for people with a sedentary lifestyle and a BMI (Body Mass Index) of 25 or higher (Liu 2000), which holds true for many people above 45 years old. The problem for this group is that sugars are not absorbed and burned effectively enough: hence they are converted to fats and weight gain (Willett 2001). The final group of food substances which are advised to eat only in moderation are (WHO 2003, Roberts and Barnard 2005, Pedersen 2011): saturated fats, dietary cholesterol and trans fats (whether from industrial or ruminant origin). Cholesterol is only found in animal products, trans fats have increasingly been removed from industrial fats so now fats from dairy, beef and sheep are the main dietary sources in Europe, and saturated fats are also mainly consumed in the form of meats and dairy (Brouwer 2010, Pedersen 2011). Overall, these recommendations point to a more plant-based and fiber-rich food pattern than is the current average (Willett and Ludwig 2011).

Thirdly, there is the design question: Is there a health optimum for the various foods? Because the healthy consumption guidelines are used within an everyday coaching relationship, we are continuously faced with questions that users ask for various food

items: if there is a health optimum? 1 And if there is an ambiguity, many users want to know about it. Moreover they show that they can deal with it.

One type of ambiguity leading to an optimum is caused by the phenomenon of trade-off. Alcohol provides an example: it appears as protective in studies on cardiovascular disease and diabetes-2, but as harmful in relation to cancer risk (WCRF/AICR 2007). Hence, the trade-off guideline is 'up to 2 consumptions per day for men and 1 per day for women' if you are concerned about your heart or diabetes, but less to nothing if your main concern is cancer prevention (WCRF/AICR 2007, McCullough 2011). A similar trade-off optimum exists for fatty fish. Eating one or two servings per week of fatty fish per week has cardio protective benefits for Western populations. However, pollution with substances like mercury, dioxins and PCB (polychlorinated biphenyl) creates cardiac and nervous system problems (Willett 2001; Kushi 2012). Hence no more than one or two consumptions per week is advised.

Another type of ambiguity is caused by controversy, which hampers a clear optimum definition. An example is low fat dairy. Most Western health organizations (though not the WHO) recommend consuming low fat dairy every day, with osteoporosis prevention as one of the main arguments. In the past, the reason for this position was thought to be simple: consume more calcium to prevent hip- and other fractures. However, it has turned out that this is hard to prove. And some concerns have risen regarding increased ovarian and prostate cancer risks. Hence Willett and Ludwig (2011) explicitly oppose the dairy recommendation. Firstly, in international comparisons, countries and regions with more calcium and dairy consumption tend to have higher bone fracture rates (instead of lower). Secondly, also within Western populations, like in the Nurses study, no protective relation is found between calcium or dairy consumption and hip or other fractures. On the contrary, above a certain threshold of protein consumption, calcium is extracted from bone tissue to counter protein-induced acidity (Willett 2001). The relation between milk and prostate cancer may be linked to the fact that calcium hampers vitamin D activation which is needed for prostate protection. This has been shown for calcium supplements as well as dietary calcium (Giovannucci 1998). Another link is IGF-1 (Insulin-resembling Growth Factor-1), which is a significant risk factor for cancers of the prostate and several other sites, and which increases with dairy consumption (Pollak 2008).

Regarding the other foods discussed above, the optimum is of a different nature: regarding vegetables, fruits, pulses, beans and legumes, more whole grains, more seeds and nuts there is a positive dose-response: 'more is better' (within caloric limits). And for sugars, high glycemic load carbohydrates, and fatty meats and dairy there is a negative dose-response: 'less is better'. With these guidelines in the back of their minds, participants can make their own choices, also based on their taste preferences, culinary traditions and other practical considerations. This fits the overall empowerment approach taken in the hybrid (e)Coach program.

2.3 Designing ICT-support for Health Behaviors

Regarding ICT design, we are in the field of designing 'multi-channel' or 'hybrid' service designs. This means that the designs aim to combine the relative strengths of

1 These practical user questions are also the reason why the healthy consumption guidelines should preferably aim at foods, and less at chemical compounds (Mozaffarian 2010)

face to face coaching with ICT-support. The goal is to develop hybrid service concepts which generate more user benefits than purely ICT-based or coach-based solutions alone.

Regarding the adoption on new ICT for health interventions, a large review of e-health projects formulated a number of recommendations/design guidelines (Jimison 2008). One is to use ICT interfaces which are already used regularly by the user group, for example email or mobile phones. A second guideline is to be attentive to ease of use: many initiatives in the review showed hampered results because of usability barriers. Thirdly, the applications need to be embedded in a health provider relationship, such that the data capturing and feedback from the applications have a meaningful added value for the users.

These three guidelines are used for the design decisions described in section 4.

3 Method

Regarding our design research approach, we follow the design cycle of (Vaishnavi & Kuechler, 2004): from problem awareness and solution suggestion to development, evaluation and conclusion. Our research method follows three steps: a) As 'awareness' and 'suggestion' steps: based on user feedback on the previously existing hybrid (e)Health service concept (web-based and coach-based support), what are users needs? b) Define how an mApp addition could contribute to the service concept, and how integration with existing health provider processes should occur. And c) as 'development' step: Define and create an mApp extension to the (e)Health solution. The 'evaluation' and 'conclusion' steps are scheduled for the coming project phases.

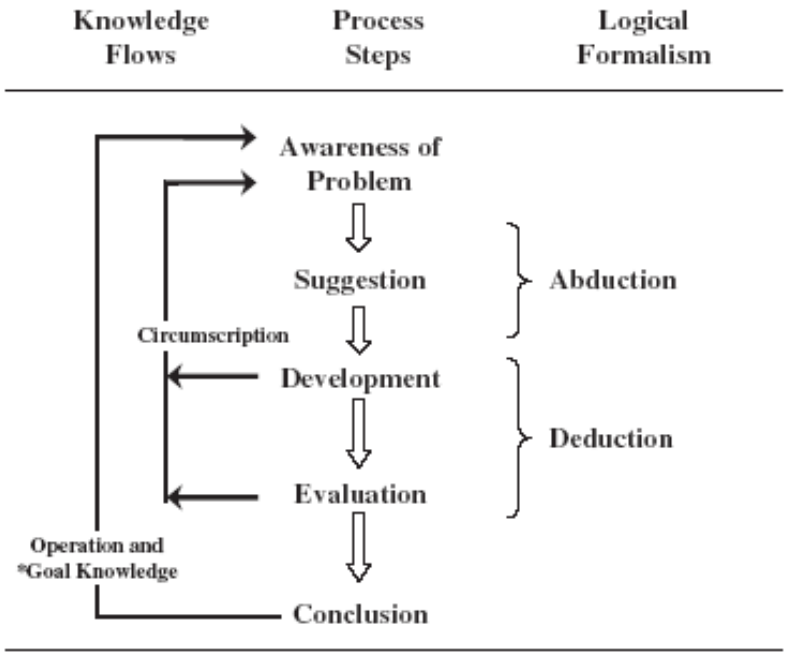

Figure 1: Design Cycle: Knowledge Creation via Design Iterations and Evaluations (Vaishnavi and Kuechler 2004)

Case context and design approach

This paper is based on the 2011 user experiences from a specific case: (e)Coaching for 101 employees of Delft University selected by the company physicians as eligible for the Health Coach Program. This is a broad lifestyle support program, using a hybrid solution: eDashboarding to monitor health progress, plus interpersonal coaching in group- and individual sessions. Previously, a design analysis has been conducted in order to identify and use the strengths of the ICT- and interpersonal service components (Simons and Hampe 2010).

The Health Coach Program is also the name of the health support provider offering these services to other organizations as well. In the 2011 situation the Health Coach Program used a web based dashboard for weekly logging of physical activity, stress management activities, buddy contact or other social support and food consumption. To limit registration burdens on participants, food assessment was based on one 'average' day per week, with the option to also indicate whether the week also contained non-standard food days or events. Many liked the fact that this approximation approach limited the registration burdens, but others indicated that they would prefer to maintain a complete log on a day-to-day basis.

Together with the user feedback rounds where other requests were voiced and with the fact that some participants started using mobile applications for sports logging, the Health Coach Program decided to explore ICT innovations, including mobile supported food logging. The design approach consisted of three steps. First, there was the user needs analysis. This was based on satisfaction surveys after 3 months and at year-end (average follow up of 9 months). In this step, the aim was to focus on needs which are largely solution-independent. In the second step, it was defined in which way a mobile application for healthy consumption might add value. In this phase the decision was made that using best of breed would be better than making. And requirements from the health provider perspective were defined, regarding how to integrate the mApp solution in the existing solutions and processes. In the third step a selection was made from three candidate applications, and this application was integrated in the overall service concept (e-dashboard, individual coaching and group sessions).

4 Results

The design process results are grouped in three parts: First obtaining user requirements in the analysis phase. Second is defining the solution and health provider requirements for integration in existing processes ('suggestion' phase from Vaishnavi and Kuechler 2004). And the third phase is selecting a best of breed mApp according to the requirements, and integrating this into the hybrid (e)coach solution concept.

4.1 Analysis: Extracting and defining user requirements

User needs were voiced at two abstraction levels: general needs and ICT-specific needs. The satisfaction surveys conducted for the Delft University human resource department contained a section on main challenges for participants (at three months, n=76) and points to improve (at nine months, n=84). These were remarks in relation to the program in its broadness.

The top 5 answers from users at three months when asked for challenges were (n=76): making healthy consumption changes, also in relation to the family (27%), experienced no challenging issues (24%), discipline in general (17%), continuing with sports and everyday physical activity (9%) and being on time with dashboard progress logging (8%). The top 5 points for improvement that users mention at year-end is (n=84): Longer and more intensive coaching would have been appreciated (12%), improving ease of logging with the dashboard (12%), more focus on physical activity and doing more sports together (9%), more stress management attention (9%) and suggestions for using different structures and processes (7%). (And when looking at the positive feedback, appreciation for the hybrid service concept was confirmed: ways of supporting education, tracking, coaching and using group sessions. But this is outside the focus of this paper.)

In relation to the question of ICT support for healthy consumption, it can be concluded that making and maintaining healthy consumption changes is a challenge (27%) and improved logging is an issue (8% and 12%). When looking at this in more detail, and including the qualitative feedback elicited during group sessions, the following list of user requirements for ICT support additions were collected:

- Complete day-to-day logging of foods consumed
- Logging when ‘on the move’, not just behind the PC
- Including more extensive food databases, less need to self-insert food items
- Improving ease of use (food entry, remembering preferences and favorite food items)
- Getting positive feedback when above average scores are obtained
- Using smart phone apps
- Reporting which shows foods and nutritional composition per day or week

4.2 Solution definition

Solution definition was conducted in two steps. First, a strategic design direction was chosen (whether to use a healthy consumption mobile application, and if so: how?). And next, health provider requirements were defined regarding integration of the solution into existing processes.

The strategic design direction that was chosen was to select and use a ‘best in class’ mApp for healthy consumption (next to other mApps for physical activity and stress management). The reasons for this choice were a) that about half of the participant population is expected to be smart phone user: not only in the Netherlands #ref but also in this working population, b) that ‘use’ is better than ‘make’: this provides more flexibility (another mApp can easily be chosen), is cheaper, and most likely provides better quality to users (popular mApps gain income and scale to further improve themselves), and c) it is possible to select a popular mApp, which has obtained high scores for attractiveness and ease of use, and test it before adopting it.

Interestingly, this choice to select a best of breed mApp opened a playing field where all the top applications were amply provided with useful and easy to use functionality (like remembering preferences, previous entries, bar code scanning of food items etc). The remaining requirements that were relevant for supporting this user group were:

- Dutch language application, with extensive Dutch foods database

- Price / free app (no cost threshold for participants)

- At least iPhone and Android versions available

Given the choice for this strategic design direction, the integration requirements from the health provider perspective were as follows (in the mApp evaluation of 4.3 these are summarized under 'reporting fits coach processes'):

- Solution will have to be integrated into existing health coach processes

- Food reports must be present in participant and coach dashboard

- Summary scores based on food logging must be made to monitoring progress

4.3 Development: select and integrate mApp in existing solution

Based on recommendations from existing food App users around us and popularity scores we took the following three apps as our final candidates to choose from: CalorieTeller (from Fatsecret), MyNetDiary (from MyNetDiary.com), and Cal Counter (from MyFitnessPal). In Table 1 these are evaluated using the Pugh method from engineering evaluation. This means that a promising solution is taken as reference point or datum. Next, the other solutions are scored as better (+), worse (-) or same (S) in relation to the datum on all requirements.

Requirements	CalorieTeller (datum)	MyNetDiary	Cal Counter
Ease of use		S	S
Dutch language and food items		-	-
Price		-	S
Platforms (iPhone and Android)		S	S
Reporting fits coach processes		+	-

Table 1: mApp Evaluation (via Pugh method); + better than datum, S same as datum, - worse than datum

From Table 1 it can be observed that CalorieTeller comes out relatively well. It combines international quality standards (some Dutch candidates did not make it to our final three mApps) with extensive support for Dutch food items. Besides, the other ease of use and reporting qualities were sufficient for the Health Coach purposes.

Hence, the next development step was integrating the solution into the hybrid (e)coach solution concept. This was done as follows, supporting regular coach processes:

- In the e-dashboard there are explicit links to the mApps (food and others)

- In the group sessions the mApps are explained

- Food entry fields highlight the mApps entry options

- Food logs and reports from mApp easily linked into dashboard for coach consultation

For 2012 there is a user test planned. The mApp addition to the existing (e)coach service concept will be evaluated against several groups of criteria: 1) how well do users

think that the mApp performs in relation to the design criteria, 2) attractiveness of using the mApp (how many users start using the mApp and how many use it longer than 1 week, do users rate the use of the mApp as helpful, easy to use, attractive?) 3) added value according to the health coaches: does it help coaches in better tracking and coaching participants, have coaches observed benefits for participants (does it help participants keep logs, to gain insight into their food patterns, to gain motivation, or to effectively adopt healthy behaviors), and are other future benefits to be expected (meal planning for example)?

5 Discussion and Conclusion

One of the most important opportunities we expect for the future of eHealth is the use of very personal and interactive mobile applications (mApps) for health behavior tracking and feedback. This will include food as part of a broader range of health behaviors (for example physical activity, stress management, quality of sleep, smoking cessation, and social media for social support). It will likely also include increasing levels of biofeedback: some none-invasive (like heart rate measurements) others more invasive (like tracking blood markers), some discrete/occasional (like stress management technique support), some more continuous (like blood sugar variations throughout the day). The design of a generic solution is under way, which allows the combination of relevant parameters for each participant. These values may be extracted from mApps or networked devices already existing (for fitness, for food consumption, a weight scale, a blood pressure measurement device etc.). Beside storage of these data on the local smart phone, replication to the web-based dashboard is assured. Furthermore, access for health coaches or medical specialists may be provided by simply using data containers in cloud infrastructures with appropriate security mechanisms in place. For the implementation a cross-platform approach based on PhoneGap and jQuery will allow broad availability and rapid development.

However, mApps by themselves are likely not enough. When their use is integrated in overall health improvement processes, larger benefits can be expected: on the operational level of behavior change and on the more tactical/strategic levels of using self-perception and social structures for long term healthy lifestyle. On the operational level, as expressed in health behavior change models like i-change and HAPA we expect four benefits: better health awareness and education within a coach relationship (‘awareness phase’, see theory), more explicit planning and reflection on health behaviors with the help of coach (‘intention phase’), more commitment to continue improving health behaviors as a felt reciprocal responsibility towards the efforts of the coach (Cialdini 1993; ‘practice phase’) and as a consequence: more health behaviors which are learned (‘increased self-efficacy’).

On the more tactical/strategic level of health behavior improvements, we have seen from our user needs analysis several suggestions towards the benefits of ‘not having to do this alone’. Firstly, several users mention ‘discipline and maintaining time and attention’ as one of the challenges for long term health behaviors. So institutionally supporting health behaviors as an employer (with sports facilities or healthy food choices in the canteens) helps. Secondly, and thirdly, others mention as two potential support forms: ‘by doing this as a group and sharing experiences we support each other’, and ‘by sending around health messages (mail) and having occasional events, we

can maintain health awareness and renew health efforts'. Fourthly, participants appreciate the institutional level reports: 'as a group, we have achieved XYZ in this initiative'. This creates pride and reinforces individual efforts and achievements. In short, besides ICT design (preferably user centered) and health intervention design, we also need institutional design (Simons and Verhagen 2008). And an employment setting with an active vitality management from the 'human capital' angle appears promising in this regard.

With regard to this design analysis study for healthy consumption using mApp support, several generic design knowledge findings are:

1) Integration of best of breed mApps is easy, flexible, and it can add functionality and quality to health provider processes at virtually no cost. We may be entering a new era of ubiquitous options for enhancing health provider processes with mApps. And it may often be more useful to integrate existing mApps into health provider relationships with clients, than trying to develop one's own applications. The new elements are that a) it is potentially very easy and cheap to adopt (or replace) mApps in health support processes, and that b) it may empower users to the extent that indeed 'health is what happens between doctors visits'.
2) On the other hand, a new mApp appears to be perceived and adopted like a new ICT application, even though it uses an every-day, familiar interface (the smart phone). Hence email may still be a more 'pervasive' and familiar communication channel for many users, than new mApps will be. Further research will have to confirm this hypothesis.

For the future any empowerment of patients as well as continuous monitoring will likely incorporate mobile devices and applications. Currently this development seems in its infancy (e.g. integration across applications, and integration into health provider practices). Still, we see many future opportunities to support healthier living by innovative technologies and raised awareness for the advantages of healthy lifestyles.

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