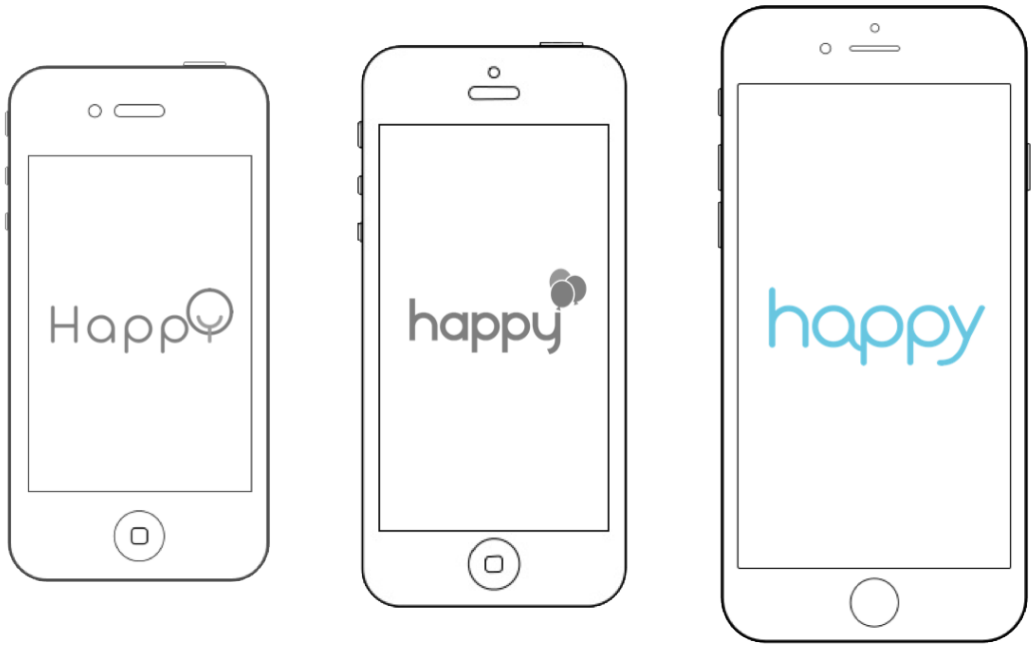
**Universidade de Aveiro** Departamento de Comunicação e Arte
**2018** Departamento de Educação e Psicologia

**NUNO MIGUEL GONÇALVES MENDES RIBEIRO**

# PREVENÇÃO DE CANCRO MEDIADA POR TELEMÓVEL

# CANCER PREVENTION MEDIATED BY SMARTPHONES



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# PREVENÇÃO DE CANCRO MEDIADA POR TELEMÓVEL

# CANCER PREVENTION MEDIATED BY SMARTPHONES

Tese apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Multimédia em Educação, realizada sob a orientação científica da Doutora Ana Margarida Pisco Almeida, Professora Auxiliar do Departamento de Comunicação e Arte da Universidade de Aveiro e do Doutor Luís Filipe Santos Silva, Professor Afiliado da Faculdade de Medicina da Universidade do Porto e Investigador no Instituto de Patologia e Imunologia Molecular da Universidade do Porto.

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Para a Jú, o principal motivo para fazer deste um mundo melhor

**o júri**

presidente

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**agradecimentos**

Costuma-se dizer que *é preciso uma aldeia para educar uma criança*. O mesmo se aplica a este caso. Este trabalho não teria sido possível sem o contributo de muitas pessoas que, em momentos diferentes, foram essenciais para os muitos passos desta caminhada que se estendeu por vários, e longos, anos.

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**keywords** cancer prevention, behaviour change, smartphone app, mhealth.

**abstract**

Estimates show that more than half of all cancer cases are attributable to inadequate behavioural options. Tobacco and alcohol consumption, excessive sun exposure and lack of physical exercise, for instance, are important risk factors for cancer. If everyone adopted a healthier lifestyle cancer incidence would fall dramatically.

Behaviour change is possible, despite being recognized as very hard. Smartphones, due to their portability and built-in capabilities, can be powerful tools to support innovative approaches towards cancer prevention and provide health education strategies to effectively change behaviours.

This thesis aims to understand how smartphones can be used to promote cancer knowledge and support behaviour change towards cancer prevention in a healthy young population. This research used development research as a methodological framework and led to the iterative development of a cancer prevention smartphone app called Happy.

Five studies were conducted with different methods and under diverse settings. The first study provided vital information for the design of a cancer prevention app and allowed the development of the prototype app. The prototype was then validated in the second and third studies with participants of the target population. These studies showed that the app was usable and easily accepted by users. They also highlighted the need for improvements and allowed the identification of some technical issues; these were tackled and the solutions were embedded in the app's final version, which was then used in two more studies that looked into the context of usage in real world settings aiming to assess its effectiveness.

Based on the findings of these studies we conclude that, in general, healthy young adults don't comply with cancer prevention guidelines, despite the use of health-related apps. Also they are willing to use a cancer prevention app, which will open the opportunity to deliver smartphone interventions. It was shown that a large number of users were reached by this app, but the dropout rate and nonusage attrition are very high. Several factors induced attrition, with gamification features appearing to be effective in attrition reduction. Happy proved to be effective as a behaviour change support system, merging into the users' daily routine and seamlessly persuading him/her to adopt cancer prevention behaviours.

This thesis provides support to the feasibility and potential impact of cancer prevention interventions delivered by smartphone.

**palavras-chave**

prevenção de cancro, mudança comportamental, aplicação para telemóvel, mhealth

**resumo**

Mais de metade dos casos de cancro são atribuídos a comportamentos inadequados. O consumo de tabaco e álcool, a exposição excessiva ao sol e a falta de exercício físico são alguns exemplos de comportamentos que aumentam o risco de cancro. Se um estilo de vida mais saudável fosse adoptado por todos, a incidência de cancro diminuiria drasticamente.

A mudança comportamental é possível, apesar de ser uma tarefa difícil de realizar. A portabilidade e as funcionalidades dos telemóveis atuais tornam-nos ferramentas poderosas que possibilitam formas inovadoras de promover a prevenção de cancro e facilitar a mudança comportamental.

O objetivo do estudo descrito nesta tese foi investigar de que forma os telemóveis podem ser utilizados na promoção da prevenção de cancro e de comportamentos saudáveis que reduzam o risco de cancro numa população de jovens adultos. Foi seguida uma metodologia de investigação de desenvolvimento que levou à criação de uma aplicação de prevenção de cancro chamada Happy.

Foram realizados cinco estudos no decorrer deste projeto. O primeiro estudo permitiu reunir informação essencial para o desenvolvimento do protótipo da aplicação. A aplicação foi depois validada junto da população alvo no decorrer do segundo e do terceiro estudo. Os resultados desses estudos permitiram validar a usabilidade e aceitação da aplicação pelos utilizadores, bem como identificaram problemas técnicos e enfatizaram a necessidade de melhoramentos da aplicação. A resolução destas questões foi incorporada na versão final da aplicação utilizada nos dois últimos estudos que abordaram a sua utilização em contexto real e avaliaram a sua eficácia na promoção de comportamentos de prevenção de cancro. Os resultados dos cinco estudos realizados mostraram que, em geral, os jovens adultos não cumprem as recomendações de prevenção de cancro, apesar de utilizarem aplicações de saúde. Mostraram também que é uma população receptiva à utilização da aplicação de prevenção de cancro, identificando-se uma boa oportunidade de intervenção baseada em telemóvel junto destes indivíduos. Foi possível verificar que este tipo de aplicação consegue chegar a um grande número de utilizadores, mas que muitos deixam rapidamente de a utilizar, levando uma taxa de abandono (*dropout*) muito elevada. Vários fatores induziram este comportamento, sendo que o uso de elementos de jogo (*gamification*) parece reduzir a taxa de abandono. Os resultados também demonstraram que a aplicação Happy é eficaz enquanto sistema de suporte à mudança comportamental, imiscuindo-se na rotina do utilizador e persuadindo-o a adotar comportamentos de prevenção de cancro.

Esta tese fornece argumentos a favor da viabilidade e do potencial da utilização de telemóveis na promoção da prevenção de cancro.

# Contents

# List of figures

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# List of original publications

The work presented in this thesis has been described in the following publications, in referred the text by roman numerals I-V. The listed publications are appended at the end of this work.

Paper I. Ribeiro, N., Moreira, L., Almeida, A. M. P., & Santos-Silva, F. (2016). Smartphones: Innovative Tools in Cancer Prevention. In M. M. Cruz-Cunha, I. M. Miranda, R. Martinho, & R. Rijo (Eds.), *Encyclopedia of E-Health and Telemedicine* (pp. 1041–1058). IGI Global. http://doi.org/10.4018/978-1-4666-9978-6.ch081

Paper II. Ribeiro, N., Moreira, L., Barros, A., Almeida, A. M., & Santos-Silva, F. (2016). Guidelines for a Cancer Prevention Smartphone Application: a mixed-methods study. *International Journal of Medical Informatics*, *94*, 134–142. http://doi.org/10.1016/j.ijmedinf.2016.07.007

Paper III. Ribeiro, N., Moreira, L., Almeida, A. M., & Santos-Silva, F. (2016). Happy: Cancer Prevention Using Smartphones. *Procedia Computer Science*, *100*, 466–473. http://doi.org/10.1016/j.procs.2016.09.183

Paper IV. Ribeiro, N., Moreira, L., Almeida, A. M. P., & Santos-Silva, F. (2017). Mobile Seamless Learning Tool for Cancer Education. In Ó. Mealha, M. Divitini, & M. Rehm (Eds.), *Citizen, Territory and Technologies: Smart Learning Contexts and Practices* (pp. 3–10). http://doi.org/10.1007/978-3-319-61322-2_1

Paper V. Ribeiro, N., Moreira, L., Almeida, A. M. P., & Santos-Silva, F. (2017). Pilot Study of a Smartphone-based Intervention to Promote Cancer Prevention Behaviours. *International Journal of Medical Informatics, 108,* 125-133. http://doi.org/10.1016/j.ijmedinf.2017.10.013

# List of abbreviations

| | |
|---|---|
| API | Application-Programing Interface |
| apps | Smartphone applications |
| BCSS | Behaviour Change Support System |
| BMI | Body Mass Index |
| FBM | Fogg Behaviour Model |
| HBM | Health Belief Model |
| HBV | Hepatitis B Virus |
| IT | Information Technologies |
| HPV | Human Papillomavirus |
| HSc | Happy Score |
| mHealth | Mobile health |
| PSD | Persuasive System Design |
| RCT | Randomized Controlled Trial |
| SMS | Short Message Services |
| TTM | Trans-Theoretical Model of stages of change |
| UI | User interface |
| UV | Ultraviolet radiation |
| WHO | World Health Organization |

# 1 Introduction

Cancer is a major cause of morbidity and mortality. It affects almost everyone, directly or indirectly. New medical treatments have revolutionized the way we fight this disease, widely improving patients' survival rates and quality of life (Jemal, Bray, Ferlay, Ward, & Forman, 2011; "Nature Milestones in Cancer," 2006). However, cancer incidence and mortality are still on the rise and all estimates point to an increase in the coming decades (Torre et al., 2015). If we want to reduce these numbers, we will have to focus on prevention.

Several cancer risk factors are behaviour-linked and, thus, are potentially modifiable. Population-wide measures targeting behaviours like smoking, excessive alcohol consumption, inadequate sun exposure, unhealthy diet, and physical inactivity could reduce overall cancer incidence in fifty per cent (Colditz, Samplin-Salgado, & Ryan, 2002; Colditz & Wei, 2012; Schüz et al., 2015; Soerjomataram, de Vries, Pukkala, & Coebergh, 2007; Song & Giovannucci, 2016; Stein & Colditz, 2004; Wu, Powers, Zhu, & Hannun, 2015). But behaviour change is a very complex task. People have generally favourable attitudes towards healthy behaviours, but they often lack the skills needed to maintain it as part of their daily routine (Kaptein, De Ruyter, Markopoulos, & Aarts, 2012). Smokers offer the most paradigmatic example. Despite all the warnings and campaigns designed to promote smoking cessation, many people continue to smoke (Nunes, Narigão, et al., 2016).

Smartphones can be helpful tools to support behaviour change. For the purposes of this thesis, smartphones are defined as mobile phones with advanced computing capability, as opposed to feature phones (mobile phones that can make and receive calls among other basic features). Smartphones have changed the way we access information, move around, and interact with others. They are personal, always connected, and follow us around all day long. They are also very powerful devices: current smartphones have more computational power than the one used to put the man on the Moon (Puiu, 2017).

All this potential can be harnessed to develop behaviour change interventions that might have a positive impact on cancer prevention. Several efforts have been done in this area, with some encouraging preliminary results (Davis & Oakley-Girvan, 2014; ITU, 2014). However, the cancer prevention potential of smartphone applications (apps) remains largely unproven (Coughlin et al., 2016).

The thesis is organized as follows. The remaining sections of chapter 1 provide an overview of the research, focusing on the objectives, research questions, and methodological framework. Chapter 2 outlines what is known about cancer prevention, theories of behaviour change, persuasive technologies, and mobile health interventions, focusing on the use of smartphones in health promotion. Chapter 3 summarizes the studies in the thesis, and discusses the main findings and their implications. Chapter 4 draws the final conclusions, emphasizing the main contributions to the field and future research directions.

## 1.1. Structure of the Study

The main purpose of this work was to conceive and develop an innovative cancer prevention strategy, using smartphones, capable of inducing and supporting behaviour change in a young adult population. This research had an exploratory nature, defined by an iterative process of app development and refinement, starting from a theoretical basis, and enriched by a qualitative analysis of app requirements. It followed a multi-step process that led to the development of a fully functioning cancer prevention smartphone app.

### 1.1.1. Objectives

This research aimed to:

- Determine the fundamental features of a cancer prevention smartphone app designed to induce and support behaviour change in a young adult population;
- Define effective communication strategies, using smartphones, to prompt healthy behaviours on users;
- Prototype and develop a cancer prevention smartphone app;
- Validate the cancer prevention smartphone app in a young adult population;
- Understand how a cancer prevention smartphone app is used in real-life settings;
- Understand the role of sociodemographic- and engagement-related determinants in smartphone app use;

- Analyse the effectiveness of the cancer prevention application, considering both cancer prevention knowledge and behaviour change.

### 1.1.2. Research Questions

This work was guided by the following research question:

> How can we promote cancer knowledge and support behaviour change towards cancer prevention in a young population through the use of smartphones?

In order to answer this question, four subsequent questions should be posed:

(1) What features should be implemented in a cancer prevention smartphone app to promote cancer knowledge and support behaviour change in a young adult population?
(2) Can smartphones be used to effectively deliver a cancer prevention intervention?
(3) How will a cancer prevention smartphone app be used in real-life settings?
(4) How can a smartphone app promote long-term user engagement to support the behaviour changes needed for cancer prevention?

### 1.1.3. Methodology

This work used development research (Akker, 1999; Coutinho, 2011; Richey & Klein, 2005) as a methodological framework. According to Coutinho and Chaves (2001), this methodology:

- Allows the handling of complex problems in technological environments;
- Integrates all types of theoretical and technological knowledge in the search for viable solutions;
- Leads to a "prototype solution" for the problem;
- Is conducted in a rigorous and reflexive environment to iteratively design, implement, field-test, and refine the "prototype solution" (seen here as a new product, program, technology, procedure, scenery, or process).

Development research is often used in complex, innovative tasks for which only very few validated principles are available. In these contexts, the impact of the intervention to be developed is unclear, thus, the research focuses on implementing limited but promising "prototype solutions" of the intervention. The aim is to develop successive prototypes that increasingly meet the innovative aspirations and requirements (Akker, 1999). The goal is not to test in practice the predictive value of a theory. The interrelation between theory and practice is more dynamic and complex. It's the iterative improvement of prototypes that leads to the development of the intervention. Therefore, the research process is often cyclic or spiral through

a series of analysis, design, evaluation, and revision events (Akker, 1999; Coutinho & Chaves, 2001). Development research uses multiple quantitative and qualitative research methods and designs, with different designs often being used for different phases of the research project (Richey & Klein, 2005). Thus, projects conducted under this methodology are classified as mixed methods research (Akker, 1999; Bryman, 2012; Coutinho & Chaves, 2001).

Given the exploratory nature of the work presented here, it was considered that development research provided the best methodological framework, facilitating the search for answers to the research questions and the fulfilment of the research objectives. Complementary to this general approach, different research methods were used, as presented in Figure 1.

### 1.1.4. Overview of the Study

The research process used in this work involved several steps, each with different research methods (Figure 1):

| Research step | Objectives | Research Methods |
|---|---|---|
| Study I<br>Requirement Analysis | Determine the fundamental features of a cancer prevention smartphone app designed to support behaviour change in a young adult population. | Focus groups<br>Online questionnaire |
| App development:<br>Prototype | Define effective communication strategies, using smartphones, to prompt healthy behaviours on users.<br>Develop a functional version of the app. | Literature review<br>Technical development |
| Study II<br>Usability Test | Validate the cancer prevention smartphone app in a young adult population. | Think Aloud Method<br>Questionnaire |
| Study III<br>Pilot Study | Validate the cancer prevention smartphone app in a young adult population. | User-generated data analysis<br>Questionnaire<br>Interviews |
| App development:<br>Full App | Improve and refine app features based on the feedback provided by the pilot study participants. | Literature review<br>Technical development |
| Study IV<br>Observational Study | Understand how a cancer prevention smartphone app is used in real-life settings.<br>Understand the role of sociodemographic- and engagement-related determinants in smartphone app use. | User-generated data analysis<br>Questionnaire |
| Study V<br>Quasi-experimental Study | Analyse the effectiveness of the cancer prevention application, considering both cancer prevention knowledge and behaviour change. | User-generated data analysis<br>Questionnaire |

Figure 1 Study overview.

- **Study I: Requirement Analysis**. Focus groups were conducted to explore: (1) prior experiences with health-related apps, (2) points of view concerning currently available health-related apps, (3) points of view concerning desired features in a health promotion app, and (4)

opinions on what influences long term usage of health promotion apps. Based on the focus groups analysis, a questionnaire was designed and applied to a larger sample of healthy Portuguese young adults. The results from the two methods were pivotal to define a guideline set for the design and development of a cancer prevention smartphone app.

- **App Development (Prototype).** Prototype development took into account the resulting guidelines of the requirement analysis and the information extracted from specialized literature. This step resulted in a functional app prototype suitable for field-testing.
- **Study II: Usability Test.** Usability tests were performed with the prototype app using the Think Aloud Method. The goal was to assess the app's ability to be used by real users in non-controlled contexts. After the usability tests, all participants answered a usability questionnaire.
- **Study III: Pilot Study.** A nonrandomized study design was used to field-test the app prototype. Volunteers downloaded and used the app for 28 consecutive days (4 weeks). At the end of this period, all participants answered a questionnaire and some were interviewed. Usability, feasibility, message receptivity, and perceived impact of the app were assessed.
- **App Development (Full App).** Results from study II and III were used to refine and further develop the app. This step resulted in the fully functioning app that was published in Apple App Store and Google Play Store.
- **Study IV: Observational Study.** All user-generated data collected through the published app was analysed to: (1) examine user participation and engagement with the app in real-life settings, (2) explore the reasons and sociodemographic- and engagement-related determinants of nonusage attrition, and (3) assess changes in the users' cancer prevention behaviours. A dropout questionnaire was sent to all users that stopped using the app.
- **Study V: Quasi-experimental Study.** A three-arm quasi-experimental design with baseline, 3 month, and 6 month assessments was used to assess the effectiveness of the app in terms of behaviour change and cancer prevention knowledge.

This research led to the development of a published cancer prevention smartphone app. However, the app is still considered a "prototype solution" to the problem. Thus, this work should be viewed as a first development cycle towards an innovative solution to a very complex problem.

# 2 Background

## 2.1. Cancer and Society

Over 14 million new cancer cases were diagnosed and 8 million deaths occurred in 2012 worldwide. By 2030, the global burden of cancer is expected to grow to 21 million new cases and 13 million deaths simply due to the increase and aging of the world population (Torre et al., 2015).

In Portugal, cancer is the leading cause of premature death (Instituto Nacional de Estatística, 2017). In 2012, there were 49,174 new cancer cases and 24,112 cancer related deaths. The most commonly diagnosed cancers were colorectal, prostate, breast, lung, and stomach (IARC, 2017). Together, they were responsible for more than half of all cancer cases (Table 1).

Table 1 Most common types of cancer (excluding non-melanoma skin cancers) in Portugal, 2012 (extracted from IARC, 2017).

| | Incidence | | | Mortality | | |
|---|---|---|---|---|---|---|
| Cancer | Both | Female | Male | Both | Female | Male |
| Colorectal | 7,129 | 2,920 | 4,209 | 3,797 | 1,557 | 2,240 |
| Prostate | 6,622 | ——— | 6,622 | 1,582 | ——— | 1,582 |
| Breast | 6,088 | 6,088 | ——— | 1,570 | 1,570 | ——— |
| Lung | 4,192 | 977 | 3,215 | 3,441 | 803 | 2,638 |
| Stomach | 3,018 | 1,184 | 1,834 | 2,285 | 898 | 1,387 |
| **Total** | 27,049 | 11,169 | 15,880 | 12,675 | 4,828 | 7,847 |

It is clear that the burden of cancer will increase in the years to come. Biomedical research has done an amazing effort to improve treatment and early detection, and new therapies are being developed with very promising results (Hanahan & Weinberg, 2011; "Nature Milestones in Cancer,"

2006; Parakh et al., 2017; Ventriglia et al., 2017). However, as Vogelstein et al. noted in a discussion concerning cancer genomics published in *Science* (Vogelstein et al., 2013, p. 1557):

> *When we think about eradicating cancer, we generally think about curing advanced cases – those that cannot be cured by surgery alone because they have already metastasized. This is a curious way of thinking about this disease. When we think of cardiovascular or infectious diseases, we first consider ways to prevent them rather than drugs to cure their most advanced forms.*

Treatment by itself won't suffice. We can figure out new ways to deal with the disease and improve the life of cancer patients but we won't be able to control it if we don't focus on prevention. An effective decrease in cancer incidence can only be obtained by two fundamental strategies: reducing exposure to cancer-causing agents (primary prevention) and promoting early detection and treatment of pre-clinical forms of the disease (secondary prevention) (National Public Health Partnership, 2006).

One can argue that primary prevention is the most efficient and cost-effective way to fight cancer. Using this strategy, we could remove or greatly reduce the cause of cancer in the long term. It might also have an effect for people other than the ones directly targeted by it. For instance, banning smoking in public spaces has a positive effect not only on those potentially exposed to second-hand smoke but on the smokers themselves, who will tend to smoke less or quit (Zablocki et al., 2014). Furthermore, primary cancer prevention has the advantage of preventing other diseases that share risk factors with cancer (e.g. cardiovascular diseases).

Secondary prevention, on the other hand, has the ability to lower cancer mortality. Cancer screenings allow the detection and removal of precancerous lesions and can be very effective. In fact, the World Health Organization (WHO) as recognized cervical cancer screening as a "best-buy" due to its potentially large public health impact, cost-effectiveness, and feasibility (World Health Organization, 2011). Screening is also known to reduce mortality for cancers of the colon and rectum, and breast. Likewise, a heightened awareness of changes in the breast, skin and testicles may also result in early detection of cancer and potentially contribute to reduce cancer mortality (Torre et al., 2015).

## 2.2. Preventability of Cancer

More than half of all cancer cases could be prevented if everyone adopted a healthier lifestyle (Colditz et al., 2002; Colditz & Wei, 2012; Schüz et al., 2015; Soerjomataram et al., 2007; Song & Giovannucci, 2016; Stein & Colditz, 2004; Wu et al., 2015). Figure 2 summarizes the relative contributions of intrinsic and extrinsic risk factors for cancer:

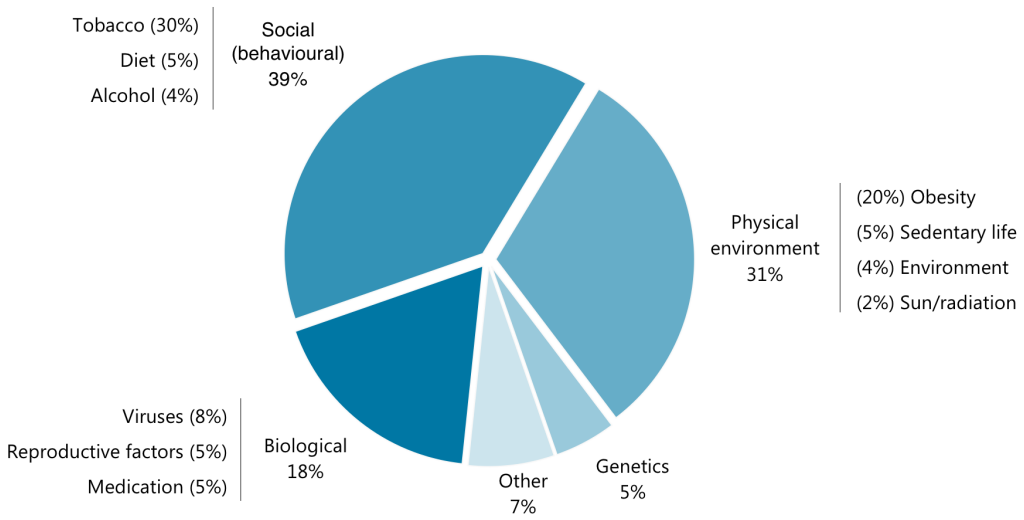



Figure 2 Relative contributions of intrinsic and extrinsic risk factors of cancer (adapted from Colditz & Wei, 2012).

Tobacco, obesity, viral infections, diet, alcohol, sedentary lifestyle, and sun/radiation exposure are all behaviour-linked factors and, thus, are potentially modifiable. Population-wide measures targeting these behaviours would have a substantial impact on cancer incidence.

As we can see, the benefits of cancer prevention are clear but much remains to be done. This "prevention paradox" is puzzling. Fineberg (2013) recognized several reasons that might explain why prevention is not implemented in practice including that the success of prevention is invisible, that statistical lives have little emotional effect, that prevention is expected to produce a net financial return (as opposed to treatment that is worth its cost), and that commercial interests and personal, religious, or cultural beliefs could conflict with disease prevention. Colditz et al. (2012) identified several obstacles that stand in the way in the particular case of cancer prevention:

- Scepticism that cancer can be prevented – until very recently we didn't have the epidemiological data needed to clearly state that certain behaviour changes could effectively reduce cancer

incidence. For instance, the causal link between tobacco and cancer was only established 50 years ago and, since then, evidence has accrued showing tobacco as a cause of at least 11 different cancers (Colditz et al., 2002). Most modifiable cancer risk factors still don't have well established causal links;

- The short-term focus of cancer research – the effects of prevention through behaviour change in cancer incidence and mortality can take decades to be identified, making it less attractive for research, since researchers are accustomed to more immediate results;
- Interventions deployed too late in life – we now know that most cancers develop over a long period of time. Thus, to really be effective, interventions should target children and young adults. But, again, the effects of such interventions can only be assessed by studies with very long-term follow-up periods (years or even decades after the study started);
- Research focuses on treatment, not prevention – only a very small fraction of cancer research funding goes to prevention and early detection studies;
- Debates among scientists – many researchers disagree over the exact fraction of preventable cancer cases, implying that we should wait until we are sure.
- Societal factors that affect health outcomes – the influence of social context on individual behaviour decisions has to be recognised and taken into account when designing cancer prevention interventions;
- Lack of interdisciplinary approaches – there is no coordinated action between different cancer-interested institutions and enterprises, causing a dispersion of cancer prevention efforts;
- The complexity of successful implementation – cancer prevention must rely on coordinated strategies that include health care providers, government regulations and policies, and social and behavioural changes at individual and community level. For instance, tobacco consumption has decreased due to a collective effort that includes strict legislation limiting smoking in public spaces, health warnings on cigarette packs, education programs targeting children and young adults that led to attitude changes towards tobacco, anti-smoking campaigns spread through different media channels and through time, among other measures. No single intervention could have achieved this.

Cancer prevention relies on changes at the individual level, whether by adopting new healthy habits or by adhering to cancer screenings programs. Research has shown that people are more likely to adopt cancer prevention behaviours if they know more about cancer, are aware of the preventability of cancer, perceive cancer prevention as important, and actively seek cancer information (Burak & Boone, 2008; N. A. Hawkins, Berkowitz, & Peipins, 2010; Keeney, McKenna,

Fleming, & McIlfatrick, 2010; Shneyderman et al., 2015; Sociedade Portuguesa de Oncologia, 2011; Werk, Hill, & Graber, 2016).

A survey[a] from the Portuguese Society of Oncology (Sociedade Portuguesa de Oncologia, 2016) gives an indication of the level of cancer knowledge among the Portuguese young adult population. A quarter of the respondents couldn't adequately define cancer. The majority correctly identified tobacco smoking (80.0%) and sunburns (57.0%) as cancer risk factors. However, only a small portion pointed out obesity and sedentarism as risk factors (16.0% and 10.0%, respectively). The majority stated they were aware of the existence of cancer screening programs (79.0%) but this was almost always limited to breast cancer screening. The prominence of breast cancer was also seen in another study (Costa et al., 2016) and may reflect the large coverage of this cancer type by the mass media (several prevention campaigns have aired in the last decades), the existence of the national breast screening program, and the prevalence of popular initiatives, such as the "Corrida da Mulher" race, that take place every year in several cities of Portugal. This underlines the importance that these types of initiatives and campaigns have as cancer awareness strategies.

**Methodology notes:**

Promoter: GfK
n=254
Sample: Nation-wide
Population: 15-30 years

Almost half of all respondents stated that they have actively searched for cancer information (44.0%). Among these, Internet was the main source of information (80.0%), highlighting the important role this media channel has for cancer prevention. This is corroborated by a recent study that found that people who search for cancer information online are more likely to adhere to screenings (Shneyderman et al., 2015). The majority of respondents (69.0%) believe that cancer can be prevented. Yet, a third doesn't adopt cancer prevention behaviours. This observation contradicts the study by Niederdeppe and Levy (2007) that saw a link between the belief that cancer can be prevented and the adoption of cancer prevention behaviours. This dissociation between belief and action suggests that intricate mental and emotional processes are at play and that it takes more than just knowledge for individuals to adopt cancer prevention behaviours.

Based on current scientific evidence (de Vries et al., 2010; Friedenreich, Neilson, & Lynch, 2010; Jung, Kim, Tae, Kong, & Kim, 2013; Kushi et al., 2012; Martin, Zhang, Tonelli, & Petroni, 2013; Renehan, Soerjomataram, & Leitzmann, 2010; Sanchez et al., 2012; Schüz et al., 2015; Soerjomataram et al., 2010; Steindorf, 2013; World Cancer Research Fund/American Institute for Cancer Research, 2007), we can identify several cancer prevention behaviours that should be

adopted by all:

1) **Do not smoke.** Avoid tobacco consumption in any form, being around smokers or in a smoking environment (passive smoking). Not smoking is the single best thing you can do for cancer prevention.
2) **Have a healthy diet.** Eat plenty of fruits and vegetables (≥5 servings a day); limit the intake of red meat, high-calorie foods (foods high in sugar or fat), sugary drinks, and high-salt foods. Avoid processed meat.
3) **Be physically active.** Get at least 150 minutes a week of moderate aerobic activity — such as brisk walking or mowing the lawn — or 75 minutes a week of vigorous aerobic activity – such as running or playing football. Limit the time spent sitting.
4) **Maintain a healthy body weight.** Avoid obesity by controlling your diet and physical activity level.
5) **Do not drink alcohol or limit your intake.** If you drink alcohol, limit your intake to less than one (women) or two (men) drinks a day. Not drinking alcohol is better for cancer prevention.
6) **Be sun smart.** Avoid too much sun and use sun protection. Do not use sunbeds.
7) **Take part in vaccination programmes.** Be vaccinated against Hepatitis B Virus (HBV) – causing agent of liver cancer – and Human Papillomavirus (HPV) – causing agent of cervix cancer and risk factor for other cancers such as anal and penile cancer.
8) **Take part in organised cancer screening programmes.** Participate in colorectal, breast (women), and cervix cancer (women) screenings.
9) **Do regular self-exams.** Do routine skin, breast (women), and testicular (men) self-exams and seek medical advice if you notice any change. There is no strict protocol for self-exams, the idea is to be body aware and report any changes to the doctor.
10) **Avoid exposure to know cancer-causing substances and radiation.** Protect yourself against cancer-causing agents by following health and safety instructions.

Recent national health statistics allow us to characterize the cancer prevention behaviour of the Portuguese population (Instituto Nacional de Estatística, 2016; Lopes et al., 2017) (Figure 3).

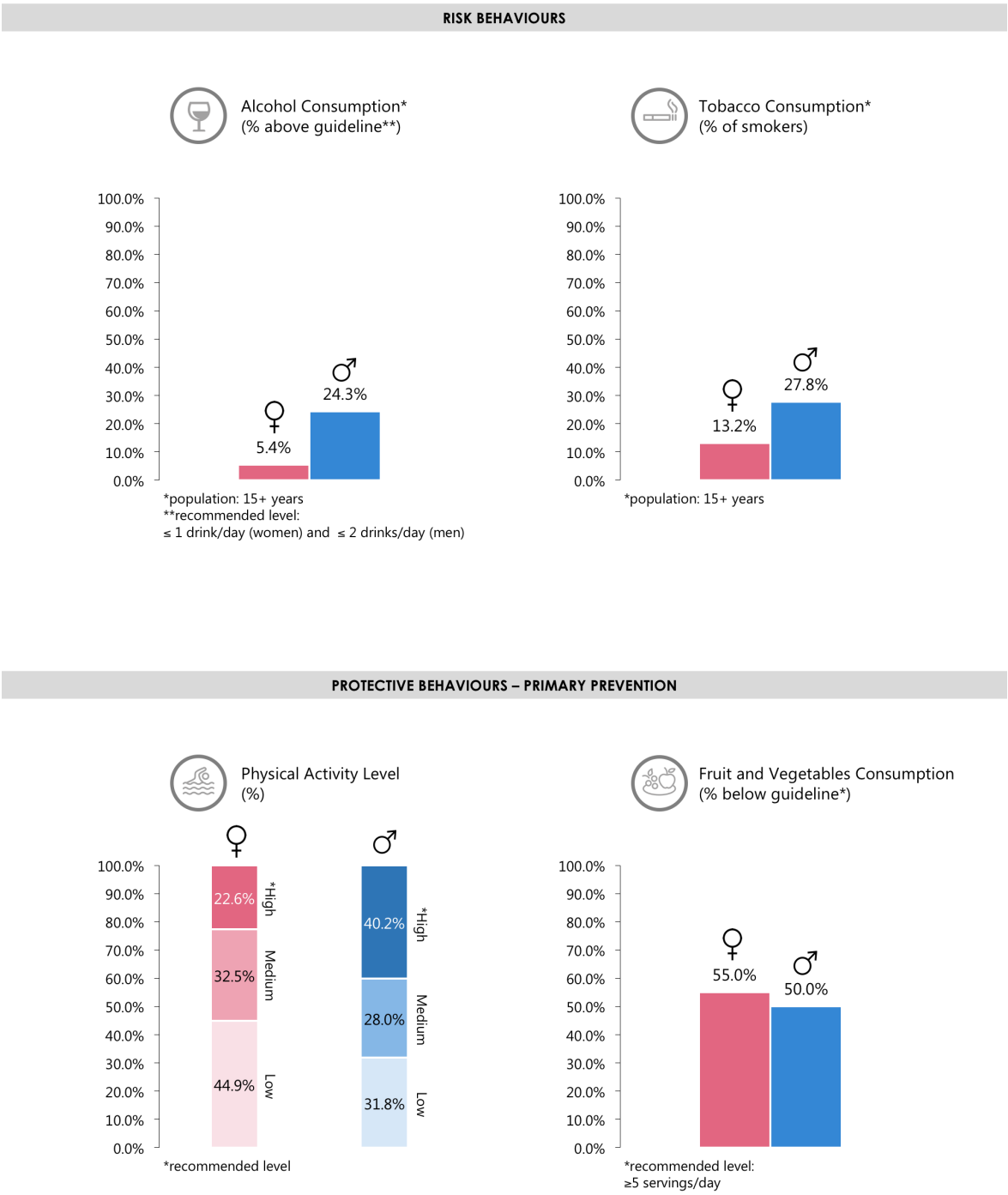



Figure 3 Risk and protective cancer-related behaviours in the Portuguese population (data from Instituto Nacional de Estatística, 2016, and Lopes et al., 2017).

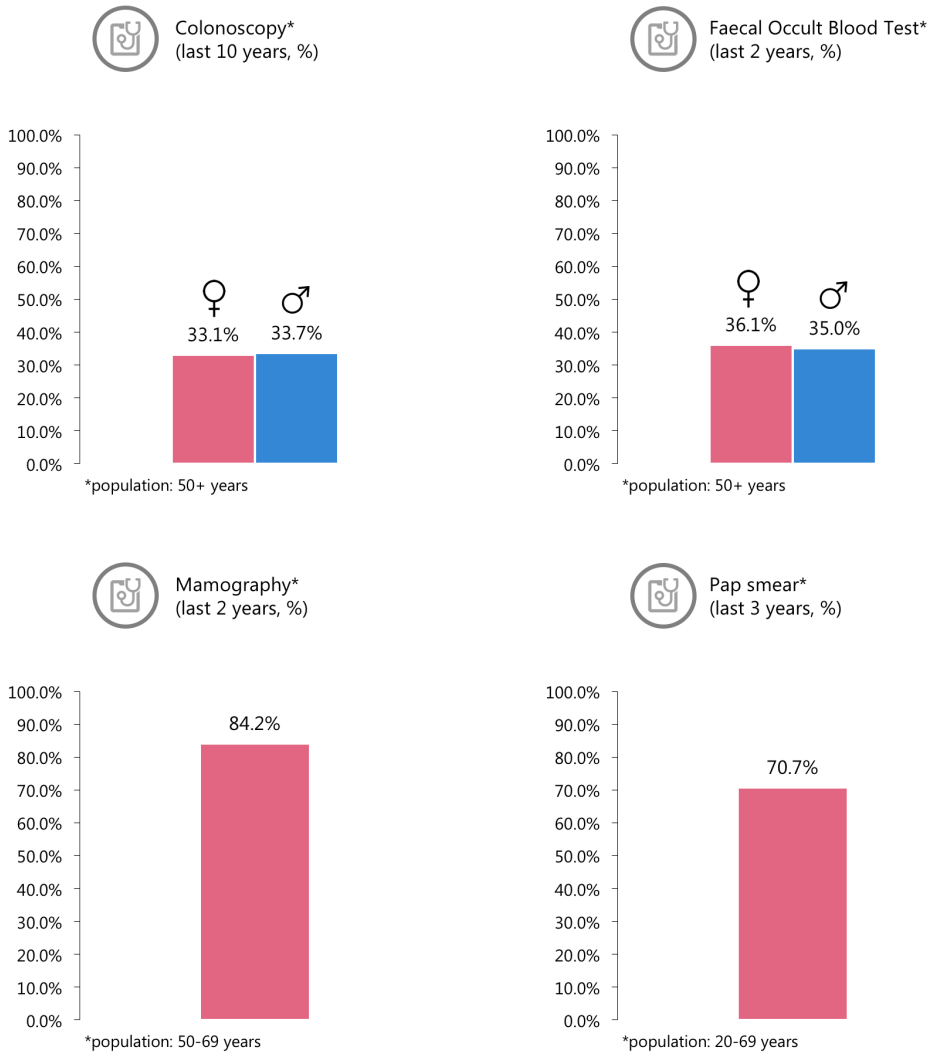



Figure 3 (continued) Risk and protective cancer-related behaviours in the Portuguese population (data from Instituto Nacional de Estatística, 2016, and Lopes et al., 2017).

As we can see in Figure 3, a quarter of the population drinks alcohol and/or smokes tobacco. Although this number has decreased over the years (Nunes, Miguel, et al., 2016), it is still very high. In terms of gender differences, it is worth noting that consumption is higher in men than women, putting them at a higher risk of cancer.

The scenery is also negative when we focus on protective behaviours. More than half of the population doesn't meet the fruit and vegetables recommendation and over 40% have a low physical activity level and are classified as "sedentary". This is more evident in women.

In terms of secondary prevention, it is worth noting the large coverage of the breast cancer screening program, reaching 84.2%. This certainly reflects the successful implementation of the national breast screening program (Miranda et al., 2015). However, when we consider cervical cancer, coverage is lower: almost a third of all women haven't done a pap smear in the last 3 years. Given the importance that this exam has on cervical cancer prevention, this is something that has to be improved. Finally, when we consider the numbers for colorectal cancer (the most frequent type of cancer in Portugal), we can see that only a third performed a colonoscopy or did a faecal occult blood test. This low coverage is mostly explained by the lack of a national screening program (Miranda et al., 2015). From the population's point of view, there are some barriers that might also explain the underutilization of cancer screening programmes. Rutten, Nelson, and Meissner (2004) found that "lack of awareness" and "not recommended by a doctor" are the two main barriers for all cancer screening tests. These barriers can be directly addressed by cancer education programmes and highlight the importance of these type of initiatives.

Another cancer risk factor that needs to be considered is obesity (Figure 4).

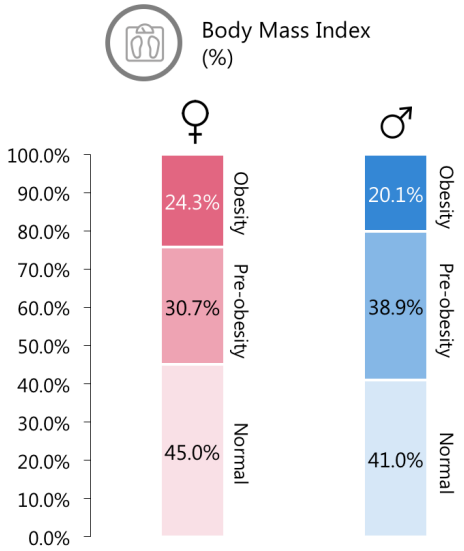



Figure 4 Prevalence of normal weight, pre-obesity, and obesity in the Portuguese population (data from Lopes et al., 2017).

As we can see in Figure 4, more than half of the Portuguese population is above normal weight. The prevalence of obesity is slightly higher in women (24.3%) than men (20.1%).

Considering that all these risk factors are important contributors for cancer incidence and mortality, it is clear that we need to take action and promote cancer prevention behaviours. Behaviour change interventions are needed to promote healthy habits and increase adherence to cancer screening programmes.

## 2.3. Theories and Models of Behaviour Change in Health Promotion

Human behaviour is a result of the interplay between habit, automatic responses to the immediate and wider environments, conscious choice and calculation, and is located in complex social environments and cultures (Michie, West, Campbell, Brown, & Gainforth, 2014). It is a very complex process influenced by intrinsic and extrinsic factors and dependent of both cognition (knowledge, attitudes, beliefs, personal values, perceived cultural truths) and context (social and environmental conditions, government policies). Interactions between cognition, context, and behaviour determine if a healthy behaviour can occur. For instance, a given healthy behaviour may not be practised simply because it is not seen as necessary by society (e.g. underappreciation of sun protection), the appropriate choice is not available (e.g. unhealthy eating at work), there are pressures that drive society to unhealthy behaviours (e.g. tobacco and soda advertisement), or there are contingencies that force the unhealthy behaviour (e.g. busy agendas reinforce driving instead of walking) (International Union Against Cancer, 2004).

The relation between cognition and behaviour is clear. The fact that we all have experienced the development of new skills through formal education provides the needed evidence for this observation. Likewise, behaviour can influence cognition. When individuals are trying to practice more physical exercise but don't have time to frequently go to the gym, they tend to consider physical exercise as less important. It is easier to find explanations for what they do than to change routines. This is known as "cognitive dissonance": when a person's behaviour conflicts with the person's beliefs, a dissonance is generated and the person becomes psychologically uncomfortable. A change is needed to create agreement (consonance) between thoughts and acts. This occurs in the less resistant site, usually on the cognition side (International Union Against Cancer, 2004). This explains why so many smokers ignore the health warnings present on cigarette packs and tend to minimize the dangers of smoking.

Context can also directly influence behaviour by limiting access to certain actions (e.g. restrictive laws that prohibit smoking in public spaces) or by informing people of their choices (e.g. media campaigns promoting cancer screening). Conversely, behaviour can influence context. For instance,

smokers tend to reinforce each other's behaviour by creating a positive context for smoking (Chen, White, & Pandina, 2001).

There are almost one hundred different theories and models of behaviour change (R. Davis, Campbell, Hildon, Hobbs, & Michie, 2015; DiClemente, Crosby, & Kegler, 2009; Glanz, Rimer, & Viswanath, 2008; Kwasnicka, Dombrowski, White, & Sniehotta, 2016; McKenzie, Neiger, & Thackeray, 2013). Overall, they can be classified as cognitive or environmental, depending on the emphasis given to cognition or context.

Cognitive theories of behaviour are based on the assumption of volitional behaviour. These theories assume that behaviour is cognitively determined and that individuals ponder their choices and actions. In this sense, preventive behaviour is based on the perception of threat and the belief that a new behaviour will lead to an improved health status (International Union Against Cancer, 2004). The Health Belief Model (HBM) and the Trans-Theoretical Model of stages of change (TTM) are good examples of cognitive theories.

HBM is based on the premise that attitudes and beliefs are the major determinants of health behaviour. According to this model, if individuals regard themselves as susceptible to a condition, believe that condition could have potentially serious consequences, believe that a new behaviour could benefit them by reducing either their susceptibility to or the severity of the condition, and believe that the benefits of the new behaviour outweigh the costs, they are likely to adopt the new behaviour as they believe it will reduce their risk (Glanz et al., 2008). HBM relies on several constructs:

- Perceived susceptibility – belief about the chances of experiencing a risk or getting a condition or disease.
- Perceived severity – belief about how serious a condition and consequences are.
- Perceived benefits – belief in efficacy of the advised action to reduce risk or seriousness of impact.
- Perceived barriers – belief about the tangible and psychological costs of the advised action.
- Cues to action – strategies to activate "readiness" (e.g., provide information, promote awareness)
- Self-efficacy – confidence in one's ability to take action.

TTM is a stage model of behaviour that perceives behaviour change as a process that unfolds over time. Different types of cognition operate at different stages. According to this model, there are six stages of change:

- Precontemplation – no intention to take action within the next 6 months.
- Contemplation – intends to take action within the next 6 months.
- Preparation – intends to take action within the next 30 days and has taken some steps in this direction.
- Action – adopted new behaviour for less than 6 months.
- Maintenance - adopted new behaviour for more than 6 months.
- Termination – no temptation to relapse and 100% confidence.

The six stages are sequential and allow a quick application of the TTM in interventions. Each individual is assessed and placed in one of the stages predicted in the model. Each stage has specific processes of change that help the individual evolve to the next stage until he/she reaches termination. This last stage is considered irreversible and, when reached, means that the new behaviour is fully acquired (Glanz et al., 2008; International Union Against Cancer, 2004).

Environmental theories, on the other hand, are based on the premise that, even if attitude mediates a person's actions, it is the environment that influences and ultimately drives behavioural choices.

According to the theory of Ecological Approach, there are multiple and reciprocal levels of influence including intrapersonal factors (biology, psychology and behaviour), interpersonal factors (family, friends, and peers that support and help form social identity), institutional or organizational factors (rules, regulations), community factors (social networks, social norms), and public policy factors (policies and laws that promote healthy behaviours, prevention, screening and disease control) (DiClemente et al., 2009; International Union Against Cancer, 2004; McKenzie et al., 2013). As we can see, cognition plays a relatively small role on behaviour comparing to context. Thus, individual behaviour changes are essentially considered to be a result of changes in the social structures where a person is included, rather than personal choice and attitude. This theory is supported by evidence from cancer epidemiology. The observed decrease in stomach cancer incidence is attributed to the quality and variety of foods that became available thanks to modern refrigeration and food preservation techniques rather than to individuals deciding to change eating patterns (Hwang, Dwyer, & Russell, 1994).

Choosing the right theory as the framework of a behaviour change intervention can be a daunting task. There are almost one hundred different theories and models of behaviour change. Also, several theories have similar (or the same) constructs but with different names (Davis et al., 2015). For instance, both HBM and TTM include the construct of self-efficacy (Bandura, 2004;

DiClemente et al., 2009; McKenzie et al., 2013). Similarly, there is no available guidance on how to select the most appropriate theory for a particular purpose. However, Davis et al. (2015) found that just a few theories informed the majority of behaviour change interventions. The same study showed that TTM was the most frequently used theory. Despite being a very attractive theory, TTM has been widely criticized and its empirical support has been questioned more than once (Davis et al., 2015; Glanz et al., 2008; McKenzie et al., 2013). Thus, frequency of use does not seem to indicate quality. One possible explanation is that people may not be aware of the full range of theories available and, instead, opt to choose from the most commonly applied in the literature. Consequently, the frequent use of TTM may simply reflect familiarity, exposure, and incentivization. Ultimately, the choice of the "right" behaviour change theory should rely on the specific goals and type of intervention that is being designed.

Recently, several authors have pointed out that current behaviour change theories don't fit the needs of the rapidly changing field of digital health interventions (Hekler et al., 2016; Patrick et al., 2016; Riley et al., 2011). They claim that current theories are largely descriptive and past-oriented. Newly available technologies, like the ever-growing market of wearables and body sensors, are able to detect and monitor behaviours of interest in real time, providing dense data on individuals and populations across time. Some authors propose the adoption of dynamical system models informed by the same constructs used in current behavioural theories (Riley et al., 2011; Spruijt-Metz & Nilsen, 2014). This approach would allow the adaptation to the intra-individual dynamics and patterns that emerge when analysing large data samples. The predominantly static and linear nature of the current behavioural theories are a poor fit in this rapid changing, technologically evolved context.

A final point to consider is that standard models of behaviour change, like the ones described above, assume that individuals think deliberately all the time and take volitional actions. We might tend to agree with this assertion but evidence from psychology shows us that this is not the case in our daily lives. In fact, people tend to rely on the automatic system, rather than the deliberative system of thinking (Table 2). They evaluate alternatives quickly, based on what comes to mind (World Bank, 2015). Although we are perfectly capable of more careful analysis, we are hard wired to only use a small part of the relevant information to reach conclusions. This system of thinking provides several advantages to humans living in highly stimulating environments. For instance, when people are considering what to get for lunch, they do not consider the colour of their shirt and then decide it is irrelevant. This information never enters the decision process because their

automatic system has already decided that it is not important. Thus, individuals do not spend cognitive energy to think about it.

Table 2 The two systems of thinking present in humans (World Bank, 2015).

| Automatic system | Deliberative system |
|---|---|
| Narrow frame (considers what comes to mind) | Wide frame (considers a broad set of relevant factors) |
| Effortless | Effortful |
| Associative | Based on reasoning |
| Intuitive | Reflective |

The automatic way of processing information can lead to several biases in judgment that undermine the effectiveness of behaviour change interventions. These include the confirmation bias (tendency to automatically interpret information in ways that support prior beliefs), anchoring (using an aspect of the environment that has no direct relevance to a decision but that nonetheless affects judgements), and the present bias (overweighting the present relative to the future, resulting in inconsistent choices over time) (World Bank, 2015).

Due to our reliance on the automatic system, merely providing information, for instance, will have little effect on behaviours. Behaviour change interventions must engage with the automatic system to overcome resistance to new points of view and increase effectiveness.

### 2.3.1. Fogg Behaviour Model

Fogg Behaviour Model (FBM) is, in essence, a cognitive model. Contrary to many others, this model does not try to explain why a behaviour occurs; it provides a framework based on three factors that control whether a behaviour is performed (Fogg, 2009, 2011). FBM offers a practical understanding of what is needed for a behaviour to occur and provides a good framework for the design of persuasive technologies. The use of persuasive technologies can be the gateway to the automatic system of thinking and, thus, be very effective in behaviour change interventions.

According to FBM, a behaviour is performed when three elements converge in a given moment: motivation, ability and trigger (Fogg, 2011). A person has to have enough motivation, has to be capable of performing the target behaviour, and has to be triggered at that precise moment for the target behaviour to happen. If one of these three elements is missing, the target behaviour will not occur. FBM can be graphically visualized for a clearer understanding of how these factors interact (Figure 5).

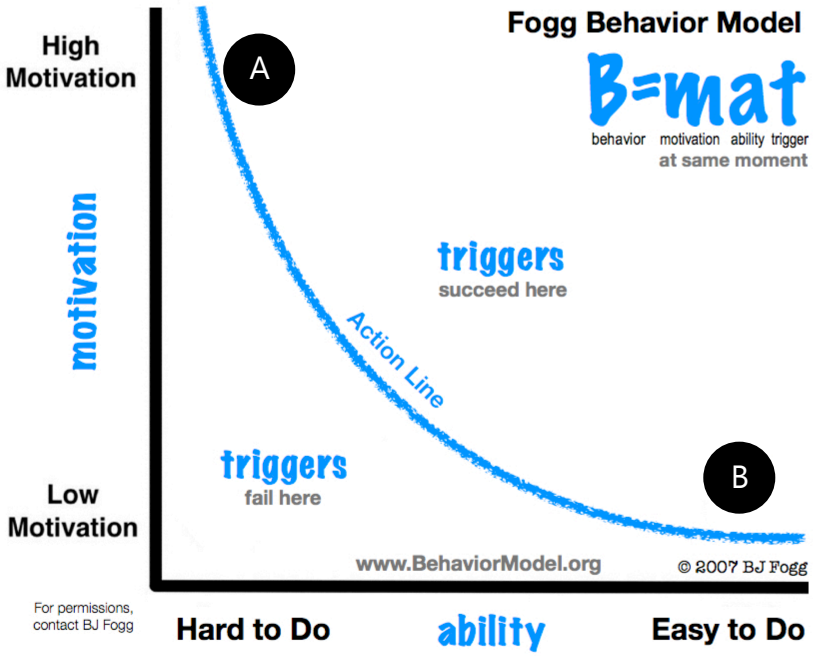



Figure 5 Fogg Behaviour Model (adapted from Fogg, 2011).

As Figure 5 shows, FBM has two axes. The vertical axis represents motivation and the horizontal axis represents ability. The model also predicts an action line. This line determines whether a trigger will succeed or not. When a person is highly motivated to perform a behaviour, a trigger might succeed even if the behaviour is hard to do (point A in Figure 5). When a behaviour is easy to perform, even a person with low motivation will do it if prompted by the right trigger (point B in Figure 5). This model clearly points out that motivation alone is not enough to induce a new behaviour; the target behaviour has to be simple enough to be performed by that person and a trigger has to be present to remind that person to perform that behaviour (Stanford Persuasive Tech Lab, 2010). Fogg (2009, p. 6) defines trigger as "something that tells people to perform a behaviour now". It can be a post-it, an email, a beep on a mobile phone, or anything that reminds or tells the person to perform a behaviour. Behaviour will only occur if the person is triggered to perform it. Conversely, triggers won't work if a person does not have enough motivation or does not possess the ability needed to perform the behaviour, placing him below the action line. In this case, a persistent trigger can lead to frustration if the behaviour is very hard to do and the person doesn't have the ability to do it (no matter how motivated he/she is) or to annoyance when the person lacks motivation and doesn't want to do the behaviour (no matter how easy the behaviour

is). According to FBM, behaviour change is possible by motivating people, keeping the target behaviours simple and using the right trigger in the most appropriate moment. A key requirement of FBM is that the initial target behaviour be small; larger behavioural goals can be achieved through the concatenation of smaller changes through time.

Regarding motivation, FBM highlights three core motivators, each with two sides (Fogg, 2011):

- **Sensation** (pleasure/pain) – this motivator has an immediate action. Individuals respond immediately to changes in this motivator by increasing (pleasure) or decreasing (pain) the frequency of a behaviour.
- **Anticipation** (hope/fear) – this motivator is characterized by the anticipation of a result. Hope is the anticipation of a positive result (health improvement, for instance) and fear is the anticipation of a negative result (loss of a loved one, for instance). This is a very powerful motivator, overcoming in many instances the previous one. For example, individuals often tolerate pain (the flu shot) to avoid fear (anticipation of getting the flu and experiencing its symptoms).
- **Belonging** (social acceptance/social rejection) – this motivator controls our social behaviour, from what we wear to the language we use. People are motivated to perform behaviours that guarantee social acceptance and to avoid behaviours that put them at risk of social rejection.

It is worth noting that this model recognizes that there are other motivators at play but these three are enough to explain the levels of motivation required for a behaviour to be perform by a person.

In light of FBM, ability is seen as something extrinsic to the individual. If we want a person to perform a target behaviour, we should not expect the person to increase its ability to perform it. Instead, we should simplify the behaviour so that is easier to perform. Behaviour change interventions should understand the power of simplicity: the easier the behaviour, the more likely the target population will perform it. If we want people to do a hard behaviour (one hour of intense physical activity, three days a week) we should start with an easier behaviour and increase difficulty until we reach the target behaviour (start with 15 minutes in one day in the first week, increase to 30 minutes in two days the second week, increase to 45 minutes in three days the third week, and so on). According to Fogg (2011), we can breakdown ability into six elements of simplicity:

- **Time** – if the target behaviour requires time to be performed and the person hasn't got that amount of time, the behaviour is considered difficult.

- **Money** – if a person has limited financial resources (as the large majority does) a target behaviour that costs money isn't simple.
- **Physical effort** – behaviours that require physical effort may not be simple. This depends on the physical ability of each person.
- **Brain cycles** – behaviours that need us to think hard to perform it may be considered hard. This is particularly true if the person has other things on her mind.
- **Social deviance** – behaviours that put people at risk of social rejection (that break social norms, that require social deviance) are considered hard to perform.
- **Non-routine** – behaviours that are part of a routine are considered simple. Behaviours that are not integrated in a person's routine are considered hard to do.

Finally, FBM considers three types of triggers (Fogg, 2011; Stanford Persuasive Tech Lab, 2010):

- **Spark** – this type of trigger is designed to motivate behaviour. It can take several different forms. For instance, it can be a text that highlights hope or a video that instigates fear.
- **Facilitator** – this type of trigger is designed for individuals that are motivated but lack the ability to perform the target behaviour. The goal of a facilitator is to trigger the behaviour while making it seem simple to perform. Facilitator should target strategies to take down behaviour barriers. An effective facilitator should tell individuals that the target behaviour is easy to do, and that it won't require any resources he/she doesn't have at that moment.
- **Signal** – this type of trigger works best when individuals are motivated and have the ability to perform the target behaviour. It only serves as a reminder to perform the behaviour. A phone notification reminding us of someone's birthday is an example of a signal.

Triggers have a fundamental role on behaviour change. Triggers make the difference between performing and not performing the target behaviour, no matter the motivation level or ability of the individual. Manipulating triggers can be the easiest and most effective way to change behaviours. Thus they should be the first element to consider when designing behaviour change interventions (Stanford Persuasive Tech Lab, 2010). The concept of kairos is intimately related to the concept of trigger in this model (Fogg, 2007a; Fogg, Cuellar, & Danielson, 2003). Kairos means the right and opportune moment. A trigger will be more effective if it reaches a person at the right kairos. Another way to see it is by considering that the opportune moment for behaviour performance is any time motivation and ability put people above the action line. Considering the importance of kairos for behaviour change and the ubiquity of mobile devices, one can argue that

these devices can have an important role on behaviour change interventions using FBM as a framework (Fogg, 2007a, 2009).

Figure 6 summarizes the main elements and related sub-dimensions of the FBM:

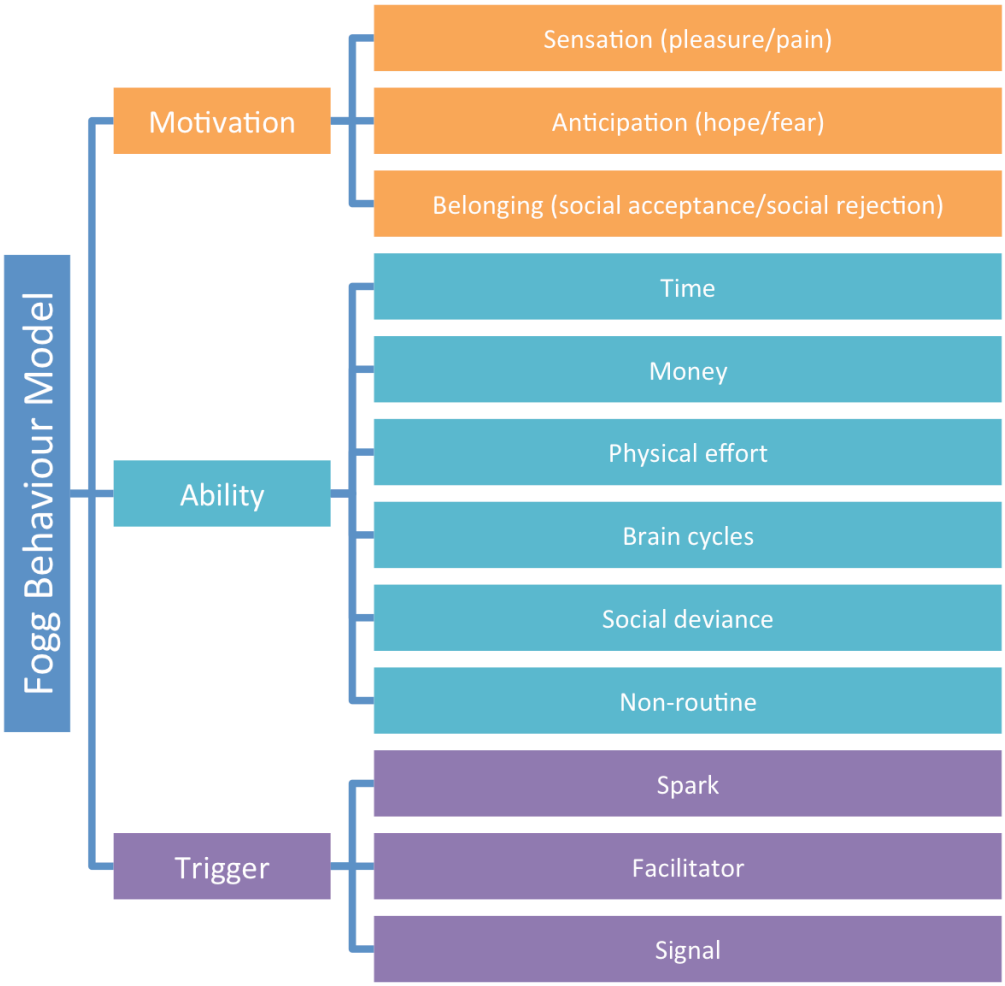



Figure 6 Main elements and sub-dimensions of the FBM.

## 2.4. Persuasive Technologies in Health Promotion

Fogg (2003, p. 1) defined persuasive technology as "any interactive computing system designed to change people's attitudes or behaviours". The goal of such a system is to *persuade* people to change. For the purposes of this thesis, persuasion is defined as the attempt to change attitudes and behaviours (or both) without the use of coercion or deception. Thus, persuasion neither implies the use of force nor the use of techniques that distort or conceal the truth. It relies on the power of verbal and nonverbal symbols (Miller, 2002). Persuasion is intentional (conceived with a defined

purpose) and relies on voluntary change. The point of intentionality might seem subtle but shouldn't be considered trivial. It's the difference between a planned effect and a side effect of a technology. We easily recognize that many high-tech products have changed the way people think, feel, and act. You just have to reach your pocket and take out your phone to get a clear example of a "life-changing" technology. But many of these changes were unimaginable when these technologies were invented. These changes were side effects. Persuasive technologies are designed with deliberate intentions to change attitudes and behaviours. These planned effects can vary widely from persuading people to buy things online, to motivating people to exercise more often (Table 3).

Table 3 Potential areas for persuasive technology products (Fogg et al., 2003).

| Domains for persuasive technologies | Example |
|---|---|
| Commerce | To buy a certain product |
| Education | To engage in activities that promote learning |
| Safety | To drive more safely |
| Environmental conservation | To reuse shopping bags |
| Occupational productivity | To set and achieve goals at work |
| Preventative health care | To quit smoking |
| Fitness | To exercise with optimal intensity/frequency |
| Disease management | To manage diabetes better |
| Personal finance | To create and adhere to a personal budget |
| Community involvement/activism | To volunteer time at a community centre |
| Personal relationships | To keep in touch with their aging parents |
| Personal management and improvement | To avoid procrastination |

Figure 7 shows a simple representation of the impact persuasive technologies can have on health care. The three circles represent:

- Technology, the motor of persuasion. Should be designed in a way that has a clear and deliberate impact on people's lives;
- Persuasion techniques, applied with an intent to change attitudes and behaviours;
- Healthcare sub-domains where persuasive technologies could have a potential impact, bounded by lifestyle, disease, and the natural lifecycle between birth and death. These natural phenomena, particularly lifecycle and disease, provide particularities that have to be taken into account in the design of a persuasive tool (a child, a pregnant woman and a cancer patient have very different

needs that must be embedded into the technologies designed to persuade them).

Persuasive technologies are placed in the intersection between the three cycles. This area is expected to grow very quickly, as new technologies are developed to improve the health of every individual.

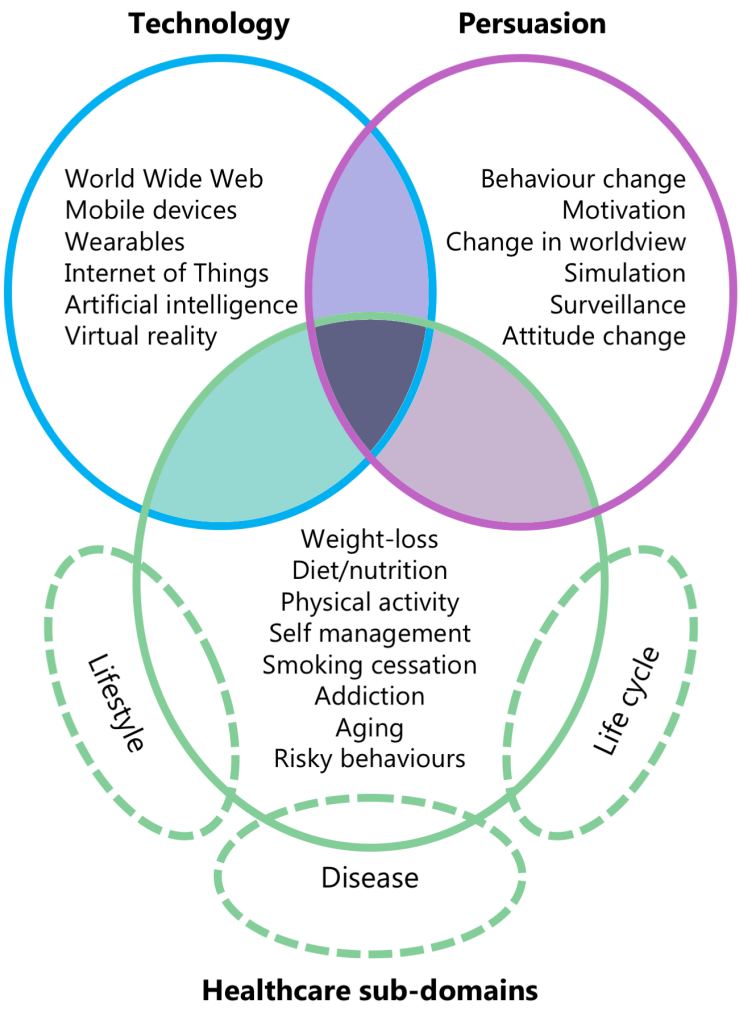



Figure 7 Framework for the impact of persuasive technologies on health care (adapted from Chatterjee & Price, 2009).

According to Fogg et al. (2003), persuasive technologies can play three different roles: as tools, as media, and as social actors (Table 4). As a tool, persuasive technologies can facilitate target behaviours, guiding people through a process or performing measurements that are then provided to users with the intent to motivate them. For instance, a smartphone app that tracks the amount of steps taken and then converts this information graphically and shows it to the user. As a medium, technologies can persuade by allowing people to explore cause-and-effect relationships, providing

experiences that motivate, or helping people rehearse specific behaviours. For instance, a virtual coach that shows how to perform fitness exercises and then motivates people to repeat them. As a social actor, technology can persuade by rewarding people with positive feedback and praise, modelling a target behaviour or attitude, and providing a social network of support. For instance, a social network that connects pregnant women and allows them to share experiences and advice about motherhood. It is worth noting that, in the context of healthcare, a single persuasive technology can take on more than one role at a time (Chatterjee & Price, 2009).

Table 4 Persuasive technology's roles and respective persuasive affordances (Fogg et al., 2003).

| Persuasive technology role | Essence | Persuasive affordances |
|---|---|---|
| As **tools** | Increases capabilities | Reduces barriers (time, effort, cost)<br>Increases self-efficacy<br>Provides information for better decision making<br>Changes mental models |
| As **media** | Provides experiences | Provides first-hand learning, insight, visualization, resolve<br>Promotes understanding of cause-and-effect relationships<br>Motivates through experience, sensation |
| As **social actors** | Creates relationships | Establishes social norms<br>Involves social rules and dynamics<br>Provides social support or sanction |

Fogg (2003) proposed a set of design principles that should be taken into account in the development of persuasive technologies. The Persuasive System Design (PSD) framework, proposed by Oinas-kukkonen and Harjumaa (2009), delivers this set of design principles explaining how they can be transformed into software requirements and further implemented as actual system features (Table 5). The PSD framework is divided into four categories: primary task, dialogue, system credibility, and social support.

Table 5 PSD framework (Oinas-kukkonen & Harjumaa, 2009).

| Category | Principle | Definition |
|---|---|---|
| Primary task support | Reduction | A system reduces complex behaviour into simple tasks that help users perform the target behaviour, and it may increase the benefit/cost ratio of that behaviour. |
| | Tunnelling | Using the system to guide users through a process or experience provides opportunities to persuade along the way. |
| | Tailoring | Information provided by the system will be more persuasive if it is tailored to the potential needs, interests, personality, usage context, or other factors relevant to a user group. |
| | Personalization | A system that offers personalized content or services has a greater capability for persuasion. |
| | Self-monitoring | A system that keeps track of one's own performance or status supports the user in achieving goals. |
| | Simulation | A system that provides simulations can persuade by enabling users to observe immediately the link between cause and effect. |
| | Rehearsal | A system that provides means with which to rehearse behaviour can enable people to change their attitudes or behaviour in the real world. |
| Dialogue support | Praise | By offering praise, a system can make users more open to persuasion. |
| | Rewards | A system that rewards target behaviours may have great persuasive powers. |
| | Reminders | If a system reminds users of their target behaviour, the users will more likely achieve their goals. |
| | Suggestion | A system offering fitting suggestions will have greater persuasive powers. |
| | Similarity | People are more readily persuaded through a system that reminds them of themselves in some meaningful way. |
| | Liking | A system that is visually attractive for its users is likely to be more persuasive. |
| | Social role | If a system adopts a social role, users will more likely use it for persuasive purposes. |
| System Credibility Support | Trustworthiness | A system that is viewed as trustworthy will have increased powers of persuasion. |
| | Expertise | A system that is viewed as incorporating expertise will have increased powers of persuasion. |
| | Surface credibility | People make initial assessments of the system credibility based on a first-hand inspection. |
| | Real-world feel | A system that highlights people or organization behind its content or services will have more credibility. |
| | Authority | A system that leverages roles of authority will have enhanced powers of persuasion. |
| | Third-party endorsements | Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility. |
| | Verifiability | Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources. |

Table 5 (continued) PSD framework (Oinas-kukkonen & Harjumaa, 2009).

| Category | Principle | Definition |
|---|---|---|
| Social support | Social learning | A person will be more motivated to perform a target behaviour if he/she can use a system to observe others performing the behaviour. |
| | Social comparison | System users will have a greater motivation to perform the target behaviour if they can compare their performance with the performance of others. |
| | Normative influence | A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behaviour. |
| | Social facilitation | A system user is more likely to perform target behaviour if they discern via the system that others are performing the behaviour along with them. |
| | Cooperation | A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to cooperate. |
| | Competition | A system can motivate users to adopt a target attitude or behaviour by leveraging human beings' natural drive to compete. |
| | Recognition | By offering public recognition for an individual or group, a system can increase the likelihood that a person/group will adopt a target behaviour. |

As persuasive technologies, mobiles devices, and particularly smartphones, hold great potential for health promotion and behaviour change. In fact, they are foreseen to be the most important platform for changing human behaviour in the near future (Fogg, 2007b). This prediction is based in three different observations:

- Mobile devices travel with us almost everywhere. It's always within reach as we sleep, live our lives, seek information, make decisions, and take actions. For instance, a recent survey[b] found that 85% of respondents keep their smartphone in direct reach, even at night, and almost half check the smartphone more than 50 times a day (B2X, 2017). These devices can respond with help when we need information or guidance, by providing the gateway to the information available in the Internet. Mobile devices gather important information, our personal digital traces, which can then be analysed. When the time is right, information can be returned to the user in a meaningful way and the mobile device can prompt the user to take action. Finally, mobile devices are used for entertainment purposes through games, fun information, and social interactions. Amusement can be an effective vehicle for persuasion. This is why serious games are so promising for behaviour change (Johnson et al., 2016; Orji, Vassileva, & Mandryk, 2014).

> [b] **Methodology notes:**
>
> Promoter: B2X
> n=2,600
> Sample: Brazil, Germany, India, Russia, and US
> Population: 15+ years

- Mobile devices are extremely powerful devices. All the embedded sensors and processing power in todays' mobile devices can be harnessed to change human behaviour. Using this power, the device can be used in tailored behaviour change interventions that can enhance motivation and help people achieve their own health goals. It can leverage the concept of *Kairos*, attempting to persuade at the right moment. This can be extremely useful to discourage unhealthy behaviours, given that they tend to occur in very specific contexts (Klasnja & Pratt, 2012).
- We tend to form personal relationships with our mobile devices. This observation might seem odd but is easily confirmed. For once, the ability to personalize mobile phones (by changing the ringtones, background images, etc.) increases the identification between human and device. Also, mobile phones are with us to schedule important meetings, to photograph and register special moments, to manage personal finances, increasing the subjective importance that we give to the device. The mentioned survey from B2X (2017) also found that people prefer giving up family and friends, and even going to prison to not losing their smartphones. Likewise, people reported feeling frustrated, lost, stressed and sad when they were without their mobile devices. This illustrates well the importance that this particular piece of technology has gained in our lives. As Fogg (2007b, p. 6) puts it, "we don't merely adopt mobile devices; we marry them". As people interact with their mobile devices, they experience feelings of trust, competence, and delight. Since emotions and behaviour change are linked, we can hypothesize that people will be more prone to new behaviours and new experiences when suggested through their loved personal devices. This can reduce barriers and resistances to behaviour change interventions delivered by mobile devices.

## 2.5. Internet as a Health Information Source

Information is an important first step in health behaviour change. Information seeking behaviours can lead to numerous benefits including information gain, affective support, emotional and social adjustment, attitude change, knowledge increase, behaviour maintenance, a feeling of greater control over events, reduction of uncertainty and compliance with medical advice (Johnson & Case, 2012). The information possessed by the individual will influence his/her health beliefs and judgements and will determine how he/she will act when facing an important health decision. Generally, individuals have different actions depending on their proximity to disease. This can be seen in the cancer care continuum, where four different information seeking stages have been identified (Johnson & Case, 2012):

- Casual stage – this stage is characterized by the lack of concern, interest, or purposive information seeking. The search for health related information is accidental and aimless. The individual will

encounter information while reading magazines or newspapers, or when searching information online. Information seeking at this stage is sporadic or determined by information campaigns and specific events. For instance, when the former Brazilian president Lula da Silva disclosed his laryngeal cancer in 2011, an illness he attributed to smoking, there was an unprecedented smoking cessation media coverage and a peek in smoking cessation Google queries. This effect was larger than all Brazil's major cessation awareness events (National No Smoking Day, World No Tobacco Day, New Years Day) from the same year (Ayers, Althouse, Noar, & Cohen, 2014). An impressive and unprecedented event like this can have a significant effect in people's information seeking behaviours. The information gathered in this stage provides the foundation individuals can draw from in later stages.

- Purposive-placid stage – this stage is characterized by the central question: What can I do to prevent disease or promote health? Individuals start to run more purposive and rational information seeking. However, the searches relate to preventing diseases in some distant future. This stage can be triggered by many factors such as a generalized health consciousness, family history of cancer, media agenda through persistent information campaigns, or advice from trusted health professionals.
- Purposive-clustered stage – this stage is motivated by the question: Do I have a specific health problem? Information seeking becomes much more focused on issues that will provide a direct answer to that question. This triggers a search for very particular content related to symptoms, means of detection, and consequences. At this stage, individuals might search for answers through cancer screening or diagnostic tests, a specialized form of information seeking.
- Directed stage – this stage follows a cancer diagnosis. The crucial question is: How can I cope? Patients must learn to adopt a new role while being confronted with an overwhelming array of negative and confusing feelings. This stage starts after authoritative diagnosis and the beginning of a treatment plan. Information seeking becomes a functional coping strategy at the cancer patient's disposal. The content and sources of information become much more specialized.

Undeniably, the Internet represents an increasingly important source of health information in the developed world, and Portugal is no exception (Baumann, Czerwinski, & Reifegerste, 2017; Espanha, Mendes, Fonseca, & Correia, 2011; Santana et al., 2011). In relation to sources of cancer information, the Internet appears only behind television and family and friends (Sociedade Portuguesa de Oncologia, 2011). The number of Internet users in Portugal has been rising steadily over time (PORDATA, 2017). According to Google's Connected Consumer Survey[c], 71% of the Portuguese population currently uses the Internet, with 59% reporting daily use (Google, 2016). Likewise, half of the Portuguese population has searched for health information online (European Commission, 2014a). Studies have shown that these searches are mainly to get general information on health-related issues or ways to improve health, and information on specific health problems (Espanha, Mendes, Fonseca, & Correia, 2013; European Commission, 2014a). The Internet seems to be perceived as an information source almost without barriers or restrictions, allowing easy access to general as well as specific health information. However, the same studies point out that most health information searches are done through search engines, such as Google, to access generic health information websites. Almost everybody prefers this method instead of using websites from official health organizations (Espanha et al., 2013; European Commission, 2014a). This raises the serious question of information quality and scientific validity.

[c] **Methodology notes:**

Promoter: TNS Infratest
n=1,000
Sample: Portugal
Population: 16+ years

By providing a huge amount of health information, the Internet can be an empowering tool for individuals. In fact, people that have a closer relation with the Internet tend to seek more information about diseases in general (Espanha et al., 2013). Thus, as individuals become consumers and even co-producers of health information online, they are in an advantage point: many state that the medical information and guidance they get online surpasses the information provided by physicians. Conversely, general practitioners report an increased consultation length due to patient questions based on information they got online (Santana et al., 2011). This phenomenon fundamentally changes the patient-doctor relationship, by empowering the patient. The role of the Internet in this discreet health system revolution can be enhanced by smartphone use, since it further facilitates access to health information through web browsers and dedicated applications (Apps). According to Google's Connected Consumer Survey, 59% of the Portuguese population owns a smartphone and 57% accesses the Internet at least as often via smartphone as via computer (Google, 2016). This means that all the information available online travels with us in our pockets and is at the distance of a couple of taps on a screen.

### 2.5.1. Importance of an eHealth Literacy

Modern societies are characterized by an explosive growth of health information coupled with immediate access instantiated in the Internet. There are literally millions of articles published every year, making it impossible to keep up with all the latest medical advances. Not long ago, information related to cancer, for instance, was exclusive of doctors and other health professionals. Nowadays, individuals have free access to an abundance of health information provided by different sources. This information overload forces decentralization of effort, moving responsibility from the medical institutions to individuals. In this increasingly complex context, individuals have to be able to gather, process, and then act on health information. This is only possible if individuals possess adequate health literacy.

WHO provides the following definition of health literacy (Kickbusch, Pelikan, Apfel, & Tsouros, 2013, p. 4):

> *Health literacy is linked to literacy and entails people's knowledge, motivation, and competences to access, understand, appraise, and apply health information in order to make judgements and take decisions in everyday life concerning health care, disease prevention and health promotion to maintain or improve quality of life during the life course.*

The public's lack of health literacy is a serious problem. Limited health literacy is associated with higher rates of hospitalization, poorer health, and higher mortality. In fact, health literacy is the strongest predictor of an individual's health status (Johnson & Case, 2012; Kickbusch et al., 2013). Furthermore, people with limited health literacy most often have lower levels of education and are older (Kickbusch et al., 2013). Health literacy is also considered an important factor in preventing cancer, due to the association between this disease and multiple behavioural risk factors.

Ideally, a health-literate person is able to seek and assess health information required to (Kickbusch et al., 2013):

- understand and carry out instructions of self-care;
- plan and achieve the lifestyle adjustments required to improve his/her health;
- make informed health-related decisions;
- know how and when to access healthcare;

- share health-promoting activities with others and address health issues in the community and society.

Considering this list of skills, we can easily conclude that no one is fully health-literate. At some point, everyone needs help understanding important health information or navigating inside the health system.

When we combine health literacy with technology use, we see profound differences between individuals and have to consider the existence of an "ehealth divide" in the population. This divide is characterized by the different possibilities to access and use health information technologies (IT) like patient portals, electronic health record systems, fitness trackers, and smartphone health apps. The ehealth divide is also related to the level of health literacy of the individual. In fact, several studies show that people with adequate health literacy are more likely to use the Internet for email, browsing the web, accessing health information, and communicating with health providers. They are also more likely to own a mobile phone or a smartphone (Bailey et al., 2015; Kontos, Blake, Chou, & Prestin, 2014; Mackert, Mabry-Flynn, Champlin, Donovan, & Pounders, 2016). Also, people with low health literacy are less likely to use health IT or perceive them as easy to use or useful (Mackert et al., 2016). Espanha et al. (2013) traced four Internet use profiles in the Portuguese population:

- Info-exclusion – this profile comprises older people (+65 years), retired from work, with low or inexistent levels of education, and low or very low income.
- No relation with Internet – this profile is mainly comprised by 45 to 64 year old individuals, with low levels of education, with insufficient foreign language knowledge, and low to medium income. Individuals with this profile use the Internet sporadically (less than once a month).
- Usual relation with Internet – this profile includes individuals with ages between 25 and 44 years, with at least mandatory education, some level of understanding of foreign languages, and medium income. Individuals in this profile use the Internet 2 to 3 times a week.
- Daily relation of Internet – this profile mainly includes younger individuals (15 to 24 years), with high levels of education and income, and classified as proficient or fluent speakers of foreign languages. Individuals in this profile use the Internet on a daily basis.

A recent analysis of the predictors of online cancer prevention information seeking behaviour corroborates these profiles, with younger age, higher education, and foreign language knowledge significantly contributing to the likelihood of an individual using the Internet as a cancer prevention source (Ginossar, 2016).

The different levels of health literacy observed across the population contribute widely to the existence of social health inequalities, i.e., differences in the prevalence and burden of illness for different population groups due to modifiable social factors (Latulippe, Hamel, & Giroux, 2017). Health IT are promising tools to reduce these inequalities by improving health care systems' efficiency and accessibility. However, they can also contribute to increase them if people have unequal access to it (Kontos et al., 2014). People without access to health IT are in the "wrong side" of the "ehealth divide". eHealth literacy, defined as the use of emerging information technologies to improve and enable health and health care, is, thus, becoming increasingly important (Schulz, Fitzpatrick, Hess, Sudbury-Riley, & Hartung, 2017; Sudbury-Riley, FitzPatrick, & Schulz, 2017). eHealth literacy combines both specific and general forms of literacy:

- Specific forms:
  - Health literacy – health literacy is a key constituent of ehealth literacy but, nevertheless, just one of seven essential literacies.
  - Computer literacy – ability to use a computer and its software to accomplish practical tasks (Haigh, 1985).
  - Science literacy – ability to know and understand scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity (National Academies of Sciences Engineering and Medicine, 2016).
- General forms:
  - Traditional literacy – ability to read and write (UNESCO, 2005).
  - Information literacy – ability to know when there is a need for information, to be able to identify, locate, evaluate, and effectively use that information for the issue or problem at hand (American Library Association's Presidential Committee on Information Literacy, 1989).
  - Media literacy – ability to access, analyse, evaluate, and produce communication in a variety of forms (Buckingham, 2003).
  - Digital competence – ability to keep abreast with the rapid changes in the area of information and communication technology (Vuorikari, Punie, Carretero, & Van Den Brande, 2016).

Thus, the concept of ehealth literacy expands from the concept of health literacy to reflect the complexity inherent to the use of health IT compared with the use of offline resources (Schulz et al., 2017). eHealth literacy is crucial in today's networked environment.

## 2.6. Mobile Health Interventions

Mobile health (mHealth) interventions refer to health interventions delivered through handheld computer devices that are intended to travel through time and space with the participant (Danaher, Brendryen, Seeley, Tyler, & Woolley, 2015). These interventions have the potential to transform healthcare through patients' empowerment (reflected in a higher quality of life), while increasing healthcare systems efficiency and sustainability (European Commission, 2014b).

mHealth interventions have emerged in part due to the ubiquity use of mobile devices and, particularly, smartphones: 89.0% of Portuguese are mobile phone users (59.0% of which are smartphones users), with little differences regarding gender, age, and income level (Google, 2016) (Figure 8). These interventions leverage on the fact that mobile phone users carry them around all the time and even keep them nearby when asleep, making it possible to deliver meaningful health information as users go about in their everyday activities (Danaher et al., 2015).

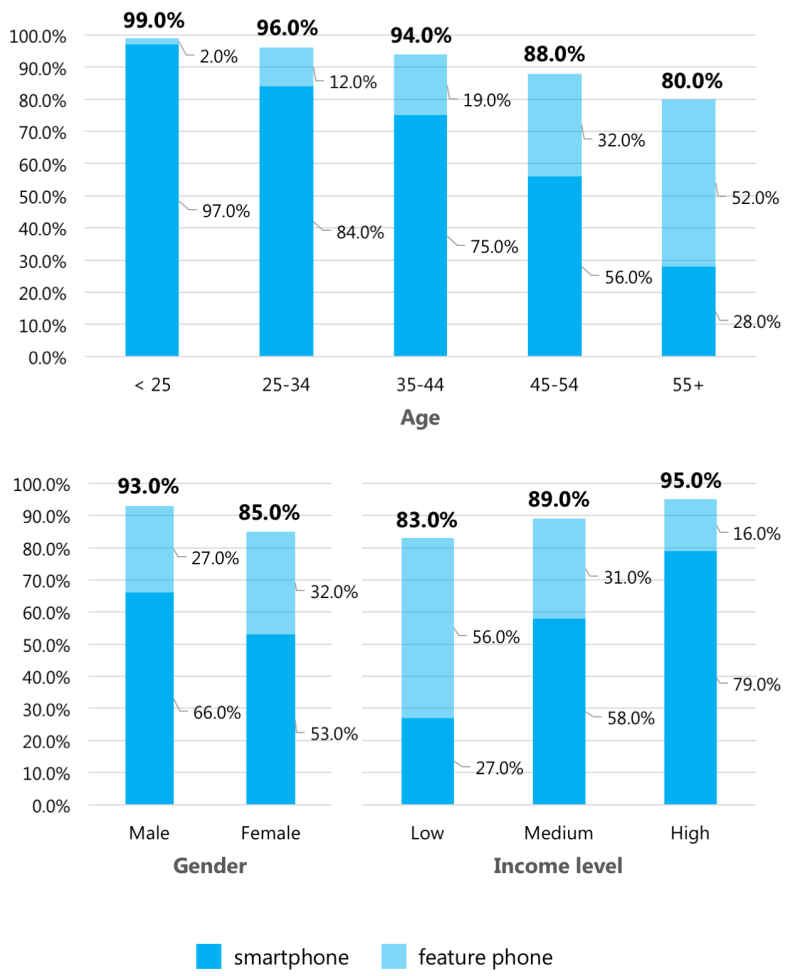



Figure 8 Mobile phone users in Portugal by age, gender and income level (data from Google, 2016).

mHealth interventions can be designed to provide *just-in-time* support and guidance when most needed (Kumar, Nilsen, Pavel, & Srivastava, 2013; McClernon & Choudhury, 2013; Riley et al., 2011; Spruijt-Metz & Nilsen, 2014). This *just-in-time* support can occur in two different ways: given their mobility and always within-reach location, mobile devices can provide immediate access to information or support when required (for instance, providing quick access to a personal list of reasons to quit to someone with a smoking urge); also, intervention content can be adapted based on data inputted by the user during the course of the intervention, providing an intervention adapted to the users' present needs (Danaher et al., 2015; Spruijt-Metz & Nilsen, 2014).

### 2.6.1. Towards a Definition of mHealth

The concept of mobility is central in the notion of participatory healthcare. This concept evolved concurrently with the technological evolution that characterized the last one hundred years. This novel paradigm began with telemedicine (in 1905, and again in 1969) and telehealth (in 1978), later giving rise to the concept of eHealth (in 1999), with mHealth (in 2003) as its subset (Bashshur, Shannon, Krupinski, & Grigsby, 2011). This timeline was made possible by several technological developments that include the Internet, the dawn of mobile phones and, of course, smartphones. Smartphones, and the wearable technology that revolves around them, embody the current stage of the evolution in mobility of and participation in healthcare. As such, the field of mHealth has seen an explosion of research in the last few years, with the number of mHealth articles indexed in Scopus exponentially growing since 2010, mainly focused on text messaging systems and mobile applications (Cameron, Ramaprasad, & Syn, 2017).

mHealth has been defined differently by different authors. Istepanian, Jovanov, and Zhang (2004, p. 405) defined it as "mobile computing, medical sensor, and communications technologies for healthcare". The WHO defined it as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" (WHO, 2011, p. 6). Bashshur and coleagues (2011) deconstruct mHealth as a component of the health IT domain. They propose four components in the mHealth domain (clinical support, health worker support, remote data collection, and helpline), and three basic dimensions (functionality, applications and technology). However, these definitions are excessively technology-driven and prove to be too narrow. They lack the ability to portray a systemic view of the information system in which the technology is embedded. In an attempt to solve this problem, Cameron and coleagues (2017) proposed an ontology of mHealth (Figure 9). This ontology

deconstructs mHealth into three dimensions:

- mHealth System – the system built around the mobile technology to manage healthcare information. This dimension is deconstructed into three sub-dimensions: Structure, Function and Semiotics;
- Stakeholders – those with a stake in the delivery/receipt of healthcare whose role includes management of healthcare information using mobile technology;
- Outcomes – the desired results of healthcare through the meaningful use of mobile technology in the management of healthcare information.

mHealth System

| Structure | | Function | | Semiotics | | Stakeholder | | Outcome | |
|---|---|---|---|---|---|---|---|---|---|
| Hardware | [for mobile] | Acquisition | [of] | Data | [by] | Healthcare | [to meaningfully manage] | Efficiency | [of/in healthcare] |
| -Sensors | | Storage | | -Static | | Providers | | -Cost | |
| -Devices | | -Encrypted | | -Streaming | | -Physicians | | -Time | |
| Software | | -Non-encrypted | | Health | | -Nurses | | -Resource | |
| -Platform | | Analysis | | Records | | -Pharmacists | | Quality | |
| -Applications | | -Quantitative | | -Current | | -Care Teams | | -Standard | |
| Networks | | -Qualitative | | -Historical | | Organizations | | -Accuracy | |
| -Local wireless | | Interpretation | | Knowledge | | -Hospitals/Clinics | | -Efficacy | |
| -Telecommunication | | -Diagnostic | | -Current | | -Governement/ | | Safety | |
| Processes | | -Predictive | | -Traditional | | Health agencies | | Parity | |
| -Manual | | -Interventional | | | | -Insurers | | | |
| -Automated | | Application | | | | General | | | |
| Policies | | -Adoptive | | | | Population | | | |
| -Privacy | | -Scholastic | | | | -Individuals | | | |
| -Regulation | | -Distributive | | | | -Families/ | | | |
| | | Deletion/Erasure | | | | Groups | | | |
| | | -Local | | | | -Communities | | | |
| | | -Systemic | | | | | | | |

Figure 9 An ontology of mHealth (Cameron et al., 2017).

The ontology encapsulates 67,200 potential components of mHealth through the concatenation of an element from each dimension with the adjacent words/phrases in each column (Cameron et al., 2017). For instance, a given mHealth application can be instantiated as:

$Software_{Application}$ [for mobile] Acquisition [of] $Data_{Streaming}$ [by] $Population_{Individuals}$ [to meaningfully manage] $Efficiency_{Resources}$ [of healthcare]

Thus, a particular mHealth research or application will instantiate only a small number of components encapsulated in the mHealth ontology. This ontology can be used as a definition of mHealth, depicting the combinatorial complexity of the domain.

### 2.6.2. Smartphones as mHealth Tools

Smartphones have been used successfully in several mHealth interventions ranging from smoking cessation, to weight loss, elderly care, and disease management (Afshin et al., 2016; Bert, Giacometti, Gualano, & Siliquini, 2014; Fiordelli, Diviani, & Schulz, 2013; Klasnja & Pratt, 2012; Mosa, Yoo, & Sheets, 2012; Silva, Rodrigues, de la Torre Díez, López-Coronado, & Saleem, 2015; Steinhubl, Muse, & Topol, 2015; Whittaker, Merry, Dorey, & Maddison, 2012). There is strong evidence that support the effectiveness of short message services (SMS) based interventions (Cole-Lewis & Kershaw, 2010; DeKoekkoek et al., 2015; Fry & Neff, 2009; A. K. Hall, Cole-Lewis, & Bernhardt, 2015; Scott-Sheldon et al., 2016). However, smartphones offer more complex and powerful capabilities that can be used to tailor and customize interventions for individuals on the basis of health needs and behavioural attributes (Fiordelli et al., 2013). The full potential of smartphones hasn´t yet been explored.

Smartphones provide several features that expand the "mHealth toolbox" beyond the use of SMS (Danaher et al., 2015). The currently available mHealth toolbox includes:

- Text messaging (SMS) – SMS can reach all mobile phones (feature phones and smartphones) irrespective of service provider and is the most common non-voice use of mobile phones. mHealth interventions can use SMS to send small pieces of health information as well as brief reminders that might have a prompting effect (Hall et al., 2015).
- Cameras – the phone camera(s) included in virtually all smartphones can be easily used for collecting health-related data throughout the day (as pictures or videos). They have been used in mHealth interventions in three primary ways: (1) to log health-related behaviours (such as food consumption) in a digital diary; (2) to provide additional health information about a specific condition (such as the appearance of a skin lesion); (3) to document relevant contextual factors that might influence disease self-management processes (Klasnja & Pratt, 2012).
- Native apps – smartphone operating systems (such as Apple's iOS or Google's Android) offer the

ability to develop special purpose apps that can run in smartphones. Researchers and commercial companies have leveraged these capabilities to build several different types of health-related apps. The number of health-related apps currently available illustrates the relative easiness of this process: there are over 165,000 apps available for download in the leading platforms' App Stores (Apple App Store and Google Play). The majority focuses on the areas of wellness, diet and exercise, with nearly a quarter focused on disease and treatment management (Aitken, 2015).

- App notifications (for native apps) – mHealth smartphone apps can proactively push intervention content to participants by displaying text notifications with alerts (sound and/or vibration). When tapped, these notifications can guide users to specific contents available within the native app. This integration is impossible with the use of SMS (Danaher et al., 2015).
- Automated sensors – there are several built-in sensors on smartphones that can be leveraged by researchers to enhance mHealth interventions, such as accelerometers, pedometers, barometers, etc. Sensors offer the promise of being able to provide the unobtrusive capture of personally relevant information that may be used to tailor the intervention to a particular moment or context. Smartphones also have the ability to connect to external devices (for example, using Bluetooth) such as blood pressure monitors, digital scales, glucose meters, smartwatches, and wristbands, further enhancing the possibilities for mHealth interventions. However, the use of built-in sensors likely increases user acceptance of mHealth interventions by freeing users from the need to keep track of, charge, and wear an additional device (Patel, Asch, & Volpp, 2015).
- Internet access – one of the most important capabilities of smartphones is their ability to connect to the Internet from nearly anywhere. This always-on capability enables real-time connection between the device and specific servers, uploading users' health data (such as glucose levels or blood pressure) and facilitating early detection of critical events. It also gives seamless access to a multitude of online resources (specific websites, social networks, videos, etc.) and makes it easier to keep intervention content up-to-date (Klasnja & Pratt, 2012).

According to Klasnja and Pratt (2012), there are five key mHealth intervention strategies using smartphones:

- Tracking health information – smartphones can be used to track health-related behaviours such as physiological and mental states, symptoms and other health relevant parameters. This data has many uses, but the process itself can provide benefits, including the increased frequency of desired behaviours and awareness of health patterns.
- Involving the healthcare team – smartphones can enable the remote monitoring of the patients' symptoms, activities, and physiological parameters enhancing the effectiveness and responsiveness

of the healthcare team to critical situations. They can also facilitate provider-patient care interactions.

- Leveraging social influence – research as shown that social networks can have a positive or negative influence on health behaviours (Christakis & Fowler, 2007, 2008). Smartphones can facilitate social support or competition among individuals with the same health goals, social support from family and friends, and can leverage on successfully accomplished health goals from peers.
- Increasing accessibility to health information – mHealth intervention content can be delivered via smartphones to individuals without any effort on their part. Thus, interventions can be "pushed" to smartphones providing reminders, health information, motivational messages, and other types of content that can help manage health and maintain persistent awareness of and commitment to personal health goals, facilitating behaviour change.
- Utilizing entertainment – mHealth interventions can leverage different forms of entertainment to engage individuals with their health goals. Research as shown that gamification, i.e., the use of game elements in non-game contexts, can have a positive impact in health and wellbeing, particularly for health behaviours (Johnson et al., 2016).

Miller (2012) compared the use of smartphones versus traditional research methods and suggested that smartphones have several advantages and disadvantages (Table 6).

Table 6 Advantages and disadvantages of smartphones as research tools (Miller, 2012).

| Main advantages | Main disadvantages |
|---|---|
| (1) Potential for global recruitment and very large samples<br>(2) High convenience, ecological validity, and unobtrusiveness for participants<br>(3) Easy video and audio capture, motion sensing, and location tracking<br>(4) Potential for high-quality video and audio display<br>(5) Potential for remote biosampling using connected wearables. | (1) Substantial study preparation work in writing, debugging, pilot testing, and field-testing the app<br>(2) Low contextual control over participants' physical and social environments during the study<br>(3) Potentially very large and complex sets of data that require sophisticated data analysis<br>(4) Ethical challenges in obtaining truly informed consent, protecting participant privacy and anonymity, and reducing liability risks |

This highlights the important role that smartphones can have in health-related research. However, there are several limitations associated with current mHealth interventions using smartphones. The first one is related to app underutilization. A study by the Institute for Healthcare

Informatics analysed more than 165,000 mHealth apps and suggested that most apps are underutilized: 36 apps account for nearly half of all downloads, while 40.0% of apps have fewer than 5,000 downloads (Aitken, 2015). Individuals face an overwhelming array of mHealth apps to choose from, with little guidance on quality or support from health organizations (Becker et al., 2014). Additionally, despite the large number of health-related apps developed so far, the majority does little more than provide information (Aitken, 2015). Likewise, it is estimated that about 75.0% of users open mHealth smartphone apps fewer than 10 times (Consumer Health Information Corporation, 2011). Several studies have also looked into who uses mHealth apps. Krebs and Duncan (2015) found that little over half of mobile phone users had downloaded a health-related app. Several studies reported that mHealth app users were more likely to be younger, with higher income, more educated, and with higher health literacy (Carroll et al., 2017; Ernsting et al., 2017; Krebs & Duncan, 2015). There seems to be an "mHealth paradox", where people that already are health aware are most likely to download and use health apps. This keeps the most needed populations out of reach and undermines one of the main attributes of mHealth: general access to healthcare. mHealth studies also report very high dropout rates and nonusage attrition (Guertler, Vandelanotte, Kirwan, & Duncan, 2015; Kim et al., 2016; McConnell et al., 2016). This can seriously undermine the study objectives and lead to an underestimate of the impact of the mHealth app in the population that uses it (Eysenbach, 2005). All these observations may reflect an early interest in the novelty of the app, with a decline in excitement as the novelty wears of.

Another issue to consider is market interposition, i.e., when technological advancements encourage society to tacitly permit self-treatment and unauthorized medical practice through consumer access and actual use (Becker et al., 2014). It remains to be seen how people actually use self-diagnosis apps, for instance. However, studies have shown that there are several potential risks in their use, mainly concerning diagnosis sensitivity and reliability, and accountability of app developers (Lupton & Jutel, 2015; Semigran, Linder, Gidengil, & Mehrotra, 2015; Wolf et al., 2013).

Researchers have also identified a gap on mHealth interventions targeting young populations (Buhi et al., 2012; Fedele, Cushing, Fritz, Amaro, & Ortega, 2017). This is surprising if we take into consideration that young people are early adopters of new technologies. It seems that researchers are overlooking a good opportunity to capitalize this natural advantage for reaching this priority population on a broad range of health behaviour issues.

There are several mHealth interventions targeting cancer with encouraging results (Davis & Oakley-Girvan, 2014; ITU, 2014). But these solutions aren't without problems. Pandey and

colleagues (2013) analysed 77 cancer-related apps and concluded that currently available smartphone apps lack scientifically supported data. The authors stated that only one-fourth of all apps were developed by healthcare agencies. There is a need to ensure that valid and relevant information reaches the consumers. The majority of cancer-related apps analysed in the study focused on general information about the disease, research and recent advances, and support for healthcare professionals and patients. General awareness of the disease accounted for about 10% of all apps. Despite its importance, cancer prevention wasn't mentioned as the main theme of any application. Furthermore, studies have shown that the majority is not informed by behaviour change theories and does not include proven behaviour change techniques (Coughlin et al., 2016). For instance, Ubhi and colleagues (2016) reported that most free smoking cessation apps available for iPhone didn´t use any behaviour change technique and that this situation didn't improve when they compared the available apps in 2012 and 2014. Coughlin and colleagues (2016) did an exploratory literature review and concluded that there isn't a sufficient ammount of well designed studies to establish the cancer prevention capabilities of smartphone apps. They also called for the need to develop culturally appropriate, tailored health messages to promote cancer knowledge and awareness. Cancer-related apps are likely useful and provide a low-cost way to disseminate cancer prevention information to the general population and to particular at-risk populations (Bert et al., 2014). However, we currently do not have strong evidence to support this assertion.

# Happy: health awareness and prevention personalized for you

# 3

This chapter describes the rationale, design, implementation, and evaluation of a cancer prevention smartphone app called Happy - health awareness and prevention personalized for you.

## 3.1. Concept

The idea for the development of Happy emerged when the researcher was trying out a smartphone app called Instant Heart Rate (Azumio, 2010). This app claims it can measure heart rate almost instantly using nothing but the smartphone camera. The discussion concerning the reliability and sensitivity of these measures is beyond the point of this observation. The app reminded him each day to monitor heart rate and the researcher found himself doing daily measures. He was performing a health procedure that used to be complicated and required specialized equipment using nothing more than his *personal* smartphone. In that moment, he realized the tremendous potential of smartphones for health interventions. Working on cancer education, the researcher immediately started thinking how he could leverage this to promote cancer prevention behaviours. The idea that started to form was to have a smartphone app that could be used as a Behaviour Change Support System (BCSS), i.e., a socio-technical information system with psychological and behavioural outcomes designed to induce, alter or reinforce attitudes, behaviours or an act of complying through persuasion (Kelders, Oinas-Kukkonen, Oörni, & Gemert, 2016), to promote healthy behaviours, thus reducing the risk of cancer. It was decided that the developing behaviour intervention would target multiple behaviours at once. Multiple behaviour changes are difficult, but research suggests that it is possible. For instance, a study by Spring and coleagues (2012) showed that targeting diet and physical activity together seems to aid in the adoption and maintenance of healthy behaviours. It is argued that these two behaviours share physiological and behavioural mechanisms that, collectively, can impact

energy balance, appetite and food choices (Mata et al., 2009). Physical activity is also recognized as a possible gateway to other health behaviour changes (Kremers, De Bruijn, Schaalma, & Brug, 2004; Mata et al., 2009). By targeting multiple behaviours at once, one can promote a general sense of health that, in turn, might prompt other healthier behaviours with great benefits in the general health status. The targeted behaviours are the ones listed in chapter 2.2 (page 12). All behaviours were included except for number 10 (Avoid exposure to know cancer-causing substances and radiation) because it was considered very specific and related to certain contexts, mainly in the workplace. Given the need to promote and maintain these behaviours over a long period of time, the app would have to be simple, easy to use, and discreet. It was also decided that the app should work on its own, without any connected device: this would instantly make it user-friendlier.

FBM was chosen as a theoretical framework and the smartphone app was to be considered a persuasive technology. Thus, the PSD framework was used to inform app development.

Another point that was taken into consideration was the language of the app. It was decided to write it in Portuguese because it was meant to target the national population. This was seen as an opportunity since very few health apps are written in Portuguese.

## 3.2. Target Population

The target population of Happy is comprised of healthy Portuguese young adults, with ages between 18 and 40 years. The choice of a young population was based upon five different reasons:

- Cancer prevention should start at an early stage of life (reducing exposure time to risk factors) (Colditz et al., 2012);
- Individuals in this age range typically take control of their own behaviour (as opposed to younger individuals);
- Nearly all individuals in this age range own at least one mobile device and are very tech-savvy (Google, 2016). By targeting this population we can capitalize on this natural advantage;
- Given the incidence of cancer in Portugal, it is very likely that individuals in this stage of life have come across some cancer case(s) in their family or close relations. Thus, they most likely are in the Purposive-placid stage of the cancer care continuum. By providing a smartphone app that guides the user by specific and personally relevant cancer-related contents, we can leverage on the needs of the population and increase cancer knowledge and awareness;

- There is an identified gap on mHealth interventions targeting young populations (Fedele et al., 2017).

## 3.3. Study I: Requirement Analysis

This section describes the first research step towards the development of Happy. This study sought to explore the views and experiences of healthy young adults concerning the fundamental features of a cancer prevention smartphone app that seeks behaviour change. Study I results are mentioned in Paper I, and fully explored in Paper II.

### 3.3.1. Methods

This study was conducted in two sequential steps: as a first step, we conducted focus groups with healthy young adults that explored: (1) prior experiences with health-related apps, (2) points of view concerning currently available health-related apps, (3) points of view concerning desired features in a health promotion app, and (4) opinions on what influences long term usage of health promotion apps. The second step was based on the focus groups analysis and led to the design and application of an online survey to a larger sample of healthy Portuguese young adults. The results from the two steps were confronted and resulted on a guideline set for the design and development of a cancer prevention app.

*Participants*

Focus group participants were recruited via e-mail. Two mailing lists were used: one from University of Aveiro and another from Ipatimup (Institute of Molecular Pathology and Immunology of the University of Porto). Two hundred and twelve volunteers responded to the e-mail. The selection criteria were: (a) being a smartphone user; (b) age between 18 and 35 years old; and (c) availability to participate on focus group time schedule. Sixteen participants met the above criteria.

Online survey respondents were recruited via e-mail and through the social network Facebook®. The same mailing lists were used, but the e-mails of the focus groups participants were excluded. Respondents reached the survey's website by clicking in a link in the received e-mail or in the Facebook® post. A total of 1,693 questionnaires were collected and filtered using the same selection criteria as above (smartphone users with age between 18 and 35 years old), resulting in 798 valid questionnaires.

All participants in the study provided informed consent to participate in the study.

*Procedure*

Three focus groups (with 6, 5 and 5 participants, respectively) were conducted between December 2013 and January 2014. The same interview schedule was used in all focus group (Supplementary file 1). The discussion began with a more general question to get participants talking about previous experiences (if any) with health-related apps. In order to encourage discussion and opinions, a series of slides illustrating different health-related apps was used. The apps were organized according to the following features: (1) tailored information, (2) behaviour tracking, (3) on-the-go information, (4) reminder use, (5) health goal setting, (6) graphic depiction of health indicators, (7) motivation, (8) social sharing, and (9) contextual information acquisition. The participants were encouraged to express their opinion highlighting which apps would they use and why, what problems did they envision and what features were lacking in these examples. The focus groups were 70–90 min long. Two researchers were present in all sessions. One assumed the moderator role, facilitating the discussion and presenting the materials, and the other the assistant role, taking field notes.

Based on the focus groups analysis, an online survey was designed (Supplementary file 2). The online survey was made available during March 2014, in a dedicated website, and had a total of 24 questions distributed in four different pages (6 items per page). It took 10–15 min to complete. A total of 1,693 questionnaires were collected and filtered using the selection criteria, resulting in 798 valid questionnaires.

*Data analysis*

The focus groups were filmed and the content was transcribed. The transcripts were then analysed using inductive thematic analysis (Bardin, 2011; Coutinho, 2011). After initial coding, highlighting relevant discussion themes, all text segments were iteratively analysed. Themes were added or merged until they effectively represented all text segments and captured the essence of every focus group discussion. The transcript analysis and coding was done using WebQDA (Neri de Souza, Costa, & Moreira, 2011).

Data from the online survey was analysed using IBM SPSS Statistics, version 21. Data distribution was strongly asymmetrical (significantly different from a normal distribution), thus an Independent Samples Mann-Whitney U Test was used to test differences between genders. All p-values are presented with Holm-Bonferroni correction.

### 3.3.2. Results

All participants (focus group and online survey) answered the survey concerning health and lifestyle and smartphone user experience (Table 7).

Table 7 Sociodemographic characteristics, self-reported baseline behaviour and smartphone user experience of study participants (n=814).

| | Participants origin | | |
|---|---|---|---|
| | Focus groups (n=16) | Online survey (n=798) | Total (n=814) |
| **Sociodemographic characteristics** | | | |
| Gender, n (%) | | | |
| Female | 10 (62.5) | 511 (64.0) | 521 (64.0) |
| Male | 6 (37.5) | 272 (34.1) | 278 (34.2) |
| No answer | 0 (0.0) | 15 (1.9) | 15 (1.8) |
| Age, mean (SD) | 24.5 (2.9) | 23.8 (4.6) | 23.8 (4.6) |
| Education level, n (%) | | | |
| College degree | 16 (100) | 612 (76.7) | 628 (77.1) |
| No college degree | 0 (0.0) | 180 (22.6) | 180 (22.1) |
| No answer | 0 (0.0) | 6 (0.8) | 6 (0.7) |
| **Health and lifestyle** | | | |
| Physical exercise (weekly average), n (%) | | | |
| ≥2 hours [a] | 6 (37.5) | 234 (29.3) | 240 (29.5) |
| 1 to 2 hours | 3 (18.8) | 153 (19.2) | 156 (19.2) |
| <1 hour | 5 (31.3) | 273 (34.2) | 278 (34.2) |
| None | 2 (12.5) | 137 (17.2) | 139 (17.1) |
| No answer | 0 (0.0) | 1 (0.1) | 1 (0.1) |
| Fruit and vegetable (daily average), n (%) | | | |
| ≥5 servings [a] | 0 (0.0) | 34 (4.3) | 34 (4.2) |
| 3 to 4 servings | 7 (43.7) | 211 (26.4) | 218 (26.8) |
| 1 to 2 servings | 9 (56.3) | 506 (63.4) | 515 (63.3) |
| None | 0 (0.0) | 45 (5.6) | 45 (5.5) |
| No answer | 0 (0.0) | 2 (0.3) | 2 (0.2) |
| Tobacco consumption, n (%) | | | |
| Smoker | 2 (12.5) | 152 (19.0) | 154 (18.9) |
| Former smoker | 2 (12.5) | 90 (11.3) | 92 (11.3) |
| Non smoker [a] | 12 (75.0) | 552 (69.7) | 564 (69.3) |
| No answer | 0 (0.0) | 4 (0.5) | 4 (0.5) |
| Alcohol consumption (daily average), n (%) | | | |
| >2 drinks | 0 (0.0) | 3 (0.4) | 3 (0.4) |
| 1 to 2 drinks | 2 (12.5) | 169 (21.1) | 171 (21.0) |
| None [a] | 14 (87.5) | 623 (78.1) | 637 (78.3) |
| No answer | 0 (0.0) | 3 (0.4) | 3 (0.4) |
| Body mass index (BMI), n (%) | | | |
| High | 1 (6.3) | 203 (25.4) | 204 (25.1) |
| Normal [a] | 15 (93.8) | 545 (68.3) | 560 (68.8) |
| Low | 0 (0.0) | 50 (6.3) | 50 (6.1) |

[a] values compliant with cancer prevention guidelines (Schüz et al., 2015).

Table 7 (continued) Sociodemographic characteristics, self-reported baseline behaviour and smartphone user experience of study participants (n=814).

| | Participants origin | | |
|---|---|---|---|
| | Focus groups (n=16) | Online survey (n=798) | Total (n=814) |
| Smartphone user experience | | | |
| Smartphone type, n (%) | | | |
| Android | 13 (81.3) | 592 (74.2) | 605 (74.3) |
| iPhone | 3 (18.8) | 121 (15.2) | 124 (15.2) |
| Other (windows phone, blackberry, etc.) | 0 (0.0) | 65 (8.1) | 65 (8.0) |
| Don't know/No answer | 0 (0.0) | 20 (2.5) | 20 (2.5) |
| Smartphone ownership time, n (%) | | | |
| >1 year | 7 (43.8) | 516 (64.7) | 523 (64.3) |
| 6 months to 1 year | 6 (37.5) | 130 (16.3) | 136 (16.7) |
| < 6months | 3 (18.8) | 152 (19) | 155 (19.0) |
| No answer | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Smartphone use (daily average), n (%) | | | |
| >2 hours | 7 (43.8) | 265 (33.2) | 272 (33.4) |
| 1 to 2 hours | 2 (12.5) | 195 (24.4) | 197 (24.2) |
| <1 hour | 7 (43.8) | 333 (41.8) | 340 (41.8) |
| No answer | 0 (0.0) | 5 (0.6) | 5 (0.6) |
| Used smartphone to monitor, n (%): | | | |
| Tobacco consumption | 1 (6.3) | 14 (1.8) | 15 (1.8) |
| Alcohol consumption | 0 (0.0) | 4 (0.5) | 4 (0.5) |
| Body weight | 4 (25.0) | 125 (15.7) | 129 (15.8) |
| Diet | 0 (0.0) | 100 (12.5) | 100 (12.3) |
| Physical exercise | 7 (43.8) | 256 (32.1) | 263 (32.3) |
| Other health issues (headaches, moods, etc.) | 4 (25.0) | 184 (23.1) | 188 (23.1) |

Analysing the participant's reported behaviour, it is possible to perceive that the great majority doesn't comply with cancer prevention guidelines. This is true for fruit and vegetable consumption (merely 34 participants, 4.1%, are compliant with the guidelines), physical exercise (only 240 participants, 29.4%, workout more than 2 h per week), BMI (204 participants, 25.0%, reported being overweight or obese), and tobacco and alcohol consumption (174 participants, 21.3%, drink, and 154 participants, 18.9%, smoke).

Concerning smartphone user experience, the majority uses their smartphone more than 1h per day (468 participants, 57.6%) and owns a smartphone for more than a year (523 participants, 64.2%). Many participants (350 participants, 42.9%) have used their smartphone to monitor health-related behaviours such as tobacco consumption (15 participants, 1.8%), alcohol consumption (4 participants, 0.5%), body weight (129 participants, 15.8%), diet (100 participants, 12.2%), physical exercise (263 participants, 32.3%) and other health issues (188 participants, 23.1%).

*Desired features in a cancer prevention app*

During the focus group discussions, four app features emerged as the most promising for a cancer prevention smartphone app: health behaviour tracking, health goal setting, tailored information, and reminders.

Behaviour tracking was viewed as a very interesting feature.

> *A person is able to track and see how we are everyday and I think that's an advantage because we can see if we exceeded something or not and that's going to influence our habits.* (Participant B, FG#1)

Participants emphasized the fact that being able to track our behaviour allows us to pinpoint our mistakes and that seeing an improvement might serve as a motivation to keep going. However, due to the nature of some health data, tracking might be problematic.

> *It's very hard because it needs a high amount of honesty from that person and I think that you know you're smoking, you're hurting yourself and I don't know if you want to… right? Be confronted with that on the screen.* (Participant E, FG#3)

Several participants emphasized the importance of graphic depictions of the tracked behaviours.

> *I love graphs in apps. To see what we had, in the past, and what we will have in the future.* (Participant D, FG#1)

> *One thing that's important is statistics. A person inputs data and then sees how it behaved during a month (…) this is important too, a person should have access to the inputted data.* (Participant C, FG#2)

Goal setting was also viewed as an important way to stay motivated.

> *People like to have things to accomplish, goals to achieve. And if the app doesn't have a goal people will… and it has to be interactive and simple.* (Participant B, FG#2)

In fact, several participants stated that goal setting, associated with a reward system, might boost motivation.

> *Participant A: I quitted smoking about 3 months ago and the one thing that helped me in the apps I used were the rewards that are nothing… might not be regarded as special. Those things that… those milestones that show up in your phone and say "congratulations". That might seem stupid but it helped…*
> *Participant E: It's not stupid. It's positive reinforcement. It's setting a goal and*

*human beings work like that: as long as we are focused and rewarded for what we do, we will do it with pleasure. That's why things seem easier.*
(FG#2)

On the other hand, it was also mentioned that not reaching the proposed goals might have a negative impact on behaviour.

The idea of tailoring information according to the user's profile emerged several times in the focus group discussions. This necessity is tightly connected with the nature of health information. Excess of information was viewed as something that could impair user's understanding and lead to confusion, particularly concerning cancer.

> *Not a generic thing. Like, a person has bad eating habits, downloads some app that's going to suggest thousands of healthy things. Even if that person doesn't need them. Instead of just giving the same suggestions to all users, try to figure out how the person is, it's profile, and then use this information to create tailored suggestions.* (Participant F, FG#1)

The focus group participants also viewed the use of reminders as very useful for behaviour change.

> *When I think about prevention and health the first thing that comes to mind is our eating habits. An app that, I don't know… for instance, uses reminders, that's also very important. Remind us to drink water or eat fruit.* (Participant A, FG#1)

However, some participants emphasized the necessity of triggering reminders at the right time and others considered that an excess of reminders could be counterproductive and could lead the user to deactivate this feature. Thus, this feature should be used with caution and only in relevant contexts.

In terms of desired features, the online survey respondents tended to agree with the focus group participants (Figure 10).

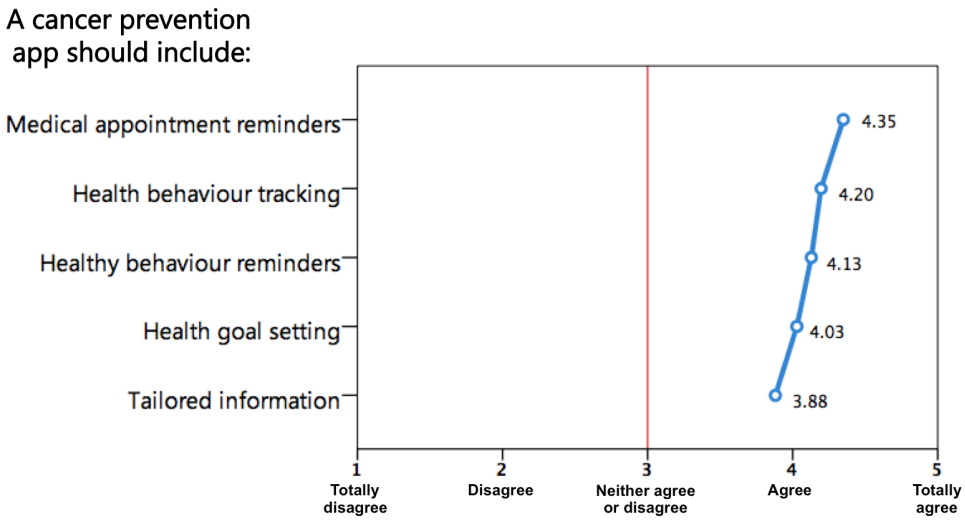



Figure 10 Online survey results on features to include on a cancer prevention smartphone app.

*Personal health data storing and sharing*

Many focus group participants highlighted the importance of privacy and safety of data stored in a health-related app. They stressed the sensitiveness of health information and expressed concerns about the potential misuse by third party organizations.

> *Everything that can be used against us regarding our health habits probably will be in the future. Anything they can grab, that can screw us, they will use it. "Oh, you said in the app that you smoke 3 cigarettes a day, sorry but your insurance isn't 60€ but 75€ because you have a 2.75% higher probability of having lung cancer. That will cost us X more so your insurance will be heavier. It's like when you have an accident with your car, they raise your insurance.* (Participant A, FG#3)

The storage location of health data was also a point of discussion.

> *One thing is to follow ourselves. Another thing is to have "our friends from NSA" following us 24/7. And that links to the question of where the data is saved. One thing is keeping it on the phone and being able to delete it. A different thing is keeping it on the other side, in the cloud. Because there you can delete it, what you see, but you won't really delete it. It's like Facebook chat, you delete it but it isn't deleted.* (Participant B, FG#1)

Although these points were consensual, the majority of participants showed some tolerance to personal information sharing. They were willing to share some information as long as they controlled what was shared.

> *Participant A: This monitors all your life, all your life. From the moment you get up*

*until you go to bed.*
*Participant E: If you want to use your smartphone you have to… right? I think…*
*Participant B: Yes, it's almost like a privacy concession that people want or not.*
*Participant E: It's a concession because otherwise you won't do anything*
(FG#3)

*Participant F: Yes, privacy is always important.*
*Participant B: That's what we were saying: what to share. We never want to share everything.*
(FG#1)

The focus group participants also considered that sharing personal information could be beneficial in specific contexts.

> *Why not share, smokers that is, the gradual reduction that they have achieved. Maybe sharing that in a "just smokers" network motivated people, seeing that. "That colleague was able to reduce several packs of cigarettes in a week", something like that.* (Participant C, FG#1)

Sharing information with friends for competition purposes was viewed as potentially motivating.

> *Maybe with friends it will work pretty well, competition. See who gets more. See who does better.* (Participant E, FG#2)

The online respondents tended to agree with the focus groups participants regarding health data storing and sharing (Figure 11).

Among online respondents there were significant statistical differences between genders regarding "Competing with my friends is motivating" ($p<0.001$ and mean difference=0.644), "I would share personal health data to compare myself with others" ($p<0.001$ and mean difference=0.407), "I would only use a health promotion app if it didn't share my health and personal data with anyone" ($p<0.001$ and mean difference=0.315), and "I would share personal health data with others that have the same issue" ($p=0.044$ and mean difference=0.216).

Both genders agreed that sharing health information with others could be beneficial and are willing to do so, although they stated that they would only use a health promotion app if it didn't share any personal information. Contrary to what was stated on the focus groups, online survey respondents were not sympathetic with information sharing for comparison purposes. This is more noticeable in the female gender as they tend to disagree more with these statements. Also, female respondents didn't see competition with friends as very motivating.

Regarding the storage of data, most respondents didn't oppose to having their data stored in a server.

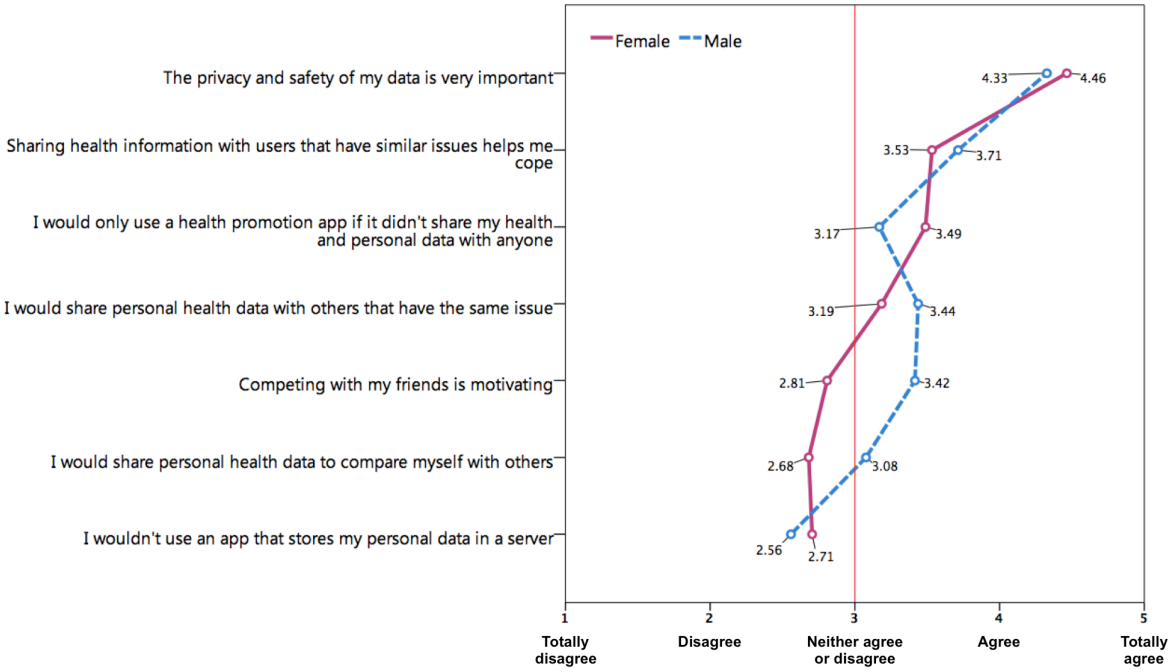



Figure 11 Online survey results on personal health data storing and sharing, by gender.

*Important dimensions for long-term use*

Focus groups participants stressed the importance of easiness of use and of the user interface for long-term app usage.

> *I think that, the more information you have to input, less likely it will be to use the app for a long period of time. The first time we will like it and do it, the second also, the third one… right?* (Participant C, FG#2)

> *Participant D: the easiness of… I don't know the word, it's not handling but, you know.*
> *Moderator: the usability?*
> *Participant D: that's it.*
> *Participant E: I agree. A thing that you have to click and it's done, I think…*
> *Participant A: it has to be pretty and functional*
> (FG#3)

Peer influence was also highlighted as a very important factor, as was the need to efficiently manage the phone's resources (battery and memory).

*I think the group of friends is important. I think that, I might even delete the app the next day but if someone tells me that that is awesome I will download it.* (Participant E, FG#3)

*It has to manage battery use well. There are awesome apps, like this one (Moves app), and a person at the end of the day has already low battery, nowadays no one has a phone with a battery that lasts more than two days, and with this (Moves app) not even a day.* (Participant B, FG#1)

Online respondents tended to agree with the focus groups participants but added other dimensions for long-term app usage (Figure 12) concerning the quality of health information (validation, updated information, tailoring and detail), behaviour tracking, healthy challenges promotion and use of reminders.

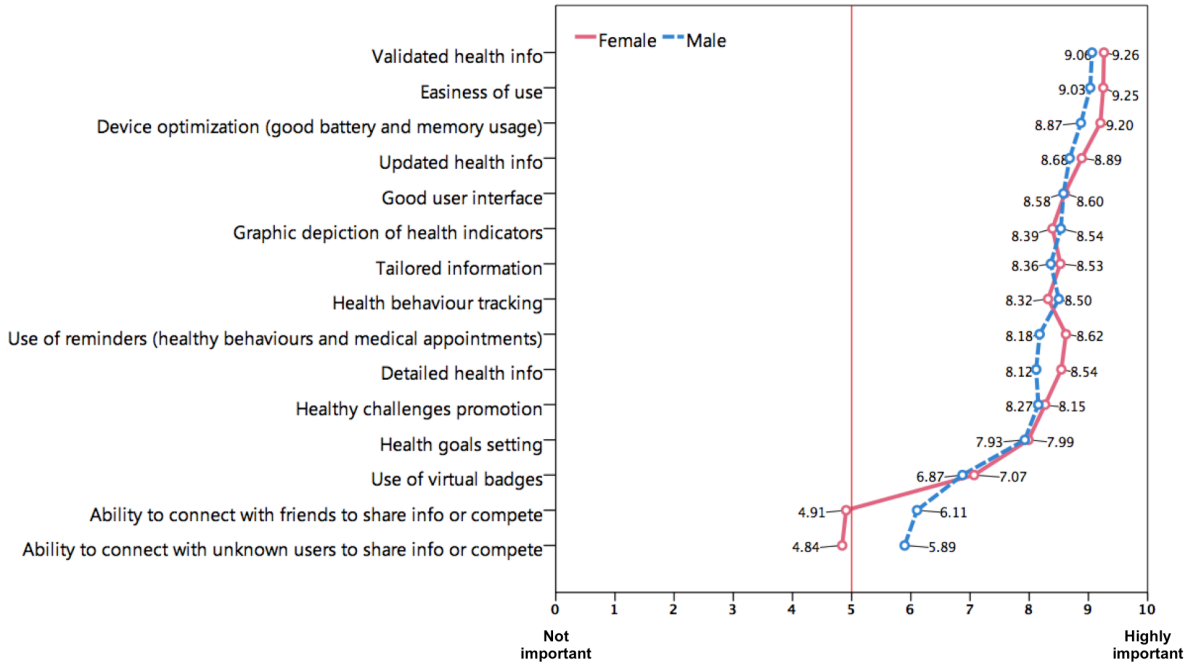



Figure 12 Online survey results on the relative importance of dimensions for long-term app usage, by gender.

There were significant statistical differences between genders regarding the following features: "Ability to connect with friends to share info or compete" ($p<0.001$ and mean difference=1.141), "Ability to connect with unknown users to share info or compete" ($p<0.001$ and mean difference=0.954), "Detailed health info" ($p<0.001$ and mean difference=0.486), "Use of reminders (concerning healthy behaviours and medical appointments)" ($p<0.001$ and mean difference=0.399), "Device optimization (good battery and memory usage)" ($p<0.001$ and mean difference=0.339), "Validated health info" ($p<0.001$ and mean difference=0.257), "Updated

health info" (p=0.013 and mean difference=0.265) and "Easiness of use" (p=0.013 and mean difference=0.224). Although the difference between genders was significant regarding "Healthy challenges promotion" (p=0.044), the mean difference was very small (0.138).

Again, respondents didn't see the ability to connect with friends or other users as a very important factor for long-term app use. This was particularly true for female respondents.

The analysis of the results allowed the definition of a guideline set for the development of a cancer prevention smartphone app (Table 8):

Table 8 Guidelines for the development of a cancer prevention smartphone app.

| | Guidelines | Dimensions |
|---|---|---|
| User experience | App has to be light, simple to use and behaviour tracking should be passive or based upon low burden inputs. | Easiness of use<br>User interface<br>Device resource management<br>Data input |
| Motivation | App has to be engaging and provide tools to enhance users' motivation.<br>Gamification features aren't considered important. | Behaviour tracking<br>Healthy challenges promotion<br>Health goal setting |
| Usefulness | App has to have useful tools that help users make healthier choices and gain insight on their behaviour. | Use of reminders<br>Behaviour tracking<br>Healthy challenges promotion |
| App content | App content must be validated and up to date.<br>Health information provided should be tailored to the users current health status. | Quality and pertinence of content |
| Social sharing | App can have social features but they should be optional and user controlled. | Information sharing |
| Privacy & Safety | App has to be safe to use and preserve users' privacy using secure connections. | Safety<br>Security<br>Data storage |

The guidelines highlight the focus groups and online survey results and are linked to design and development dimensions. Each dimension provides a possible solution to address the corresponding guideline.

## 3.4. App Development: Prototype

This section describes the features of the prototyped app. The prototype is described with some detail in Paper I, and Paper III. The first version was developed between March and May 2014 (Figure 13) by a group of four students in the context of the Project UC from the graduation course New Communication Technologies at University of Aveiro.

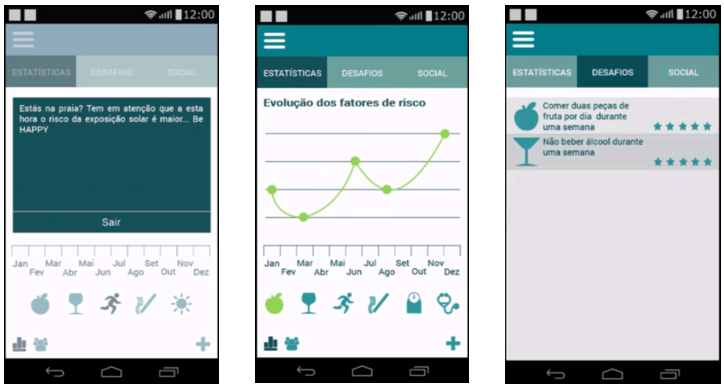



Figure 13 Screenshots from the first version of the prototype.

However, this prototype had several problems in feature implementation that deterred it from being field-tested and deemed it unfeasible. A functional app prototype (second version) was developed with a company called hellodev (https://hellodev.us) between February and July 2015, and was supported by the Calouste Gulbenkian Foundation through project HYPE (Healthy Youth through Prevention Education).

Happy aims to be a simple and easy to use cancer prevention smartphone app that can be used as a BCSS to promote healthy behaviours, thus reducing the risk of cancer. App development took into account the resulting guidelines of Study I, and also information extracted from specialized literature (Ahtinen et al., 2009; Consolvo et al., 2008; Consolvo, Klasnja, McDonald, & Landay, 2012; Dennison, Morrison, Conway, & Yardley, 2013; Hebden, Cook, van der Ploeg, & Allman-Farinelli, 2012; Mosa et al., 2012; Rabin & Bock, 2011). The functional prototype of Happy included the following features: Behaviour assessment, Behaviour tracking, Happy Score, Messages, and Statistics.

*Behaviour assessment*

When users access Happy for the first time, they are required to answer a behaviour assessment questionnaire. The questionnaire has 22 composite questions, and collects user information, biometric data, diet, physical activity, alcohol and tobacco consumption, ultraviolet radiation (UV) exposure, vaccination, exams, and behaviour barriers and intake contexts. The extracted data from the questionnaire is included in the user profile as *variables* (Figure 14).

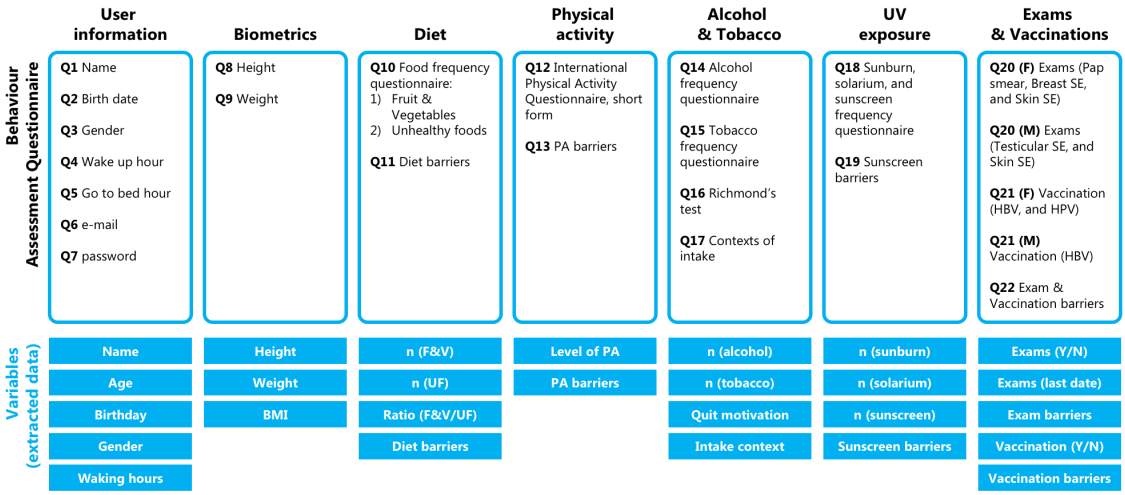



Figure 14 Overview of the behaviour assessment questionnaire and user profile variables inferred from extracted data (F&V – fruits and vegetables; UF – unhealthy foods; PA – physical activity; SE – self-exam; F – female; M – male).

Users answer the questionnaire by tapping and swiping through lists of items or values (Figure 15). This method was chosen because it is familiar to smartphone users, and has a smaller user burden when compared to other alternatives like text input (Consolvo et al., 2012). Likewise, we preferably used item frequency questionnaires where users can select the items they want from a list of possibilities. This method was chosen because it can reduce the recall bias (Smyth, Webb, & Oikaya, 2007).

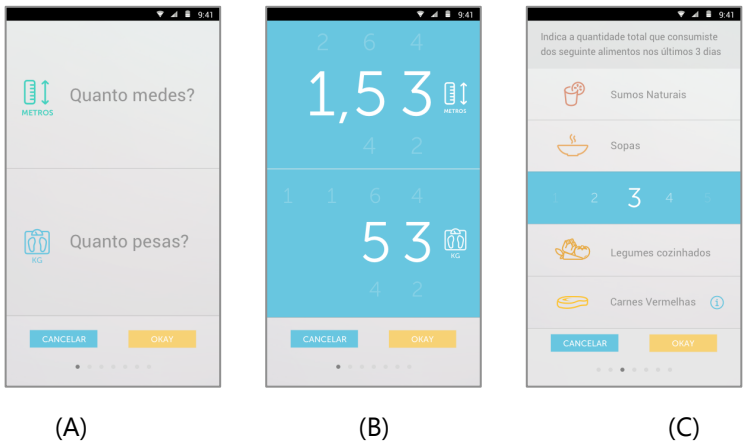



Figure 15 Screenshots from the behaviour assessment questionnaire. Users select items by tapping on them (A) and change values by swiping up and down (B) or left and right (C).

To assess physical activity, we used the International Physical Activity Questionnaire, short form (Craig et al., 2003). This questionnaire was considered reliable to monitor physical activity

and inactivity in many different settings. We opted not to use any automated mean to capture activity data using the smartphone's sensors because they can only detect a narrow range of activities and often fail to detect them, leading to user disappointment. Also, the continuous use of these sensors largely contributes to battery depletion, increasing the likelihood of users uninstalling the app (Consolvo et al., 2012). Richmond's test (Richmond, Kehoe, & Webster, 1993) was used to assess smokers' motivation to quit. This item was included so that we could differentiate between smoker profiles and target them differently according to their initial motivation to quit smoking. We also included questions regarding behaviour barriers. Barrier identification was considered important because, according to FBM, we can raise an individual's ability to perform a given behaviour by simplifying the behaviour. This can be achieved by addressing the specific behaviour barriers that are relevant to the individual. The listed barriers for each behaviour were obtained from a scoping review of the scientific literature performed by the researcher concerning:

- Diet (Biloukha & Utermohlen, 2001; Deshpande, Basil, & Basil, 2009; Gough & Conner, 2006; Hollywood et al., 2013; Lappalainen et al., 1997; Silliman, Rodas-Fortier, & Neyman, 2004; Stevenson, Doherty, Barnett, Muldoon, & Trew, 2007; Yeh et al., 2008);
- Physical exercise (Aaltonen et al., 2012; Adachi-Mejia et al., 2010; Allender, Cowburn, & Foster, 2006; Arzu, Tuzun, & Eker, 2006; Grubbs & Carter, 2002; Leyk et al., 2012; Lovell, Ansari, & Parker, 2010; Myers & Roth, 1997; Silliman et al., 2004);
- Alcohol consumption (Marlatt & Witkiewitz, 2002; Wild, Hinson, Cunningham, & Bacchiochi, 2001);
- Tobacco consumption (Ho, 1998; Siqueira, Rolnitzky, & Rickert, 2001);
- Sunscreen use and skin self-exam (Baum & Cohen, 1998; Berndt et al., 2011; Boggild & From, 2003; Calder & Aitken, 2008; Day, Wilson, Hutchinson, & Roberts, 2013; Garside, Pearson, & Moxham, 2010; Hillhouse, Adler, Drinnon, & Turrisi, 1997; Peacey, Steptoe, Sanderman, & Wardle, 2006);
- Pap smear (Abotchie & Shokar, 2009; Bukowska-Durawa & Luszczynska, 2014; Rutten et al., 2004; Tilson et al., 2004);
- Breast and testicular self-exams (Al-Dubai et al., 2012; Katz, Meyers, & Walls, 1995; Prestwich et al., 2006);
- And vaccination (Dillard & Spear, 2010; Gerend, Shepherd, & Shepherd, 2013; Marlow, Waller, & Wardle, 2009; Rambout, Tashkandi, Hopkins, & Tricco, 2014; Ratanasiripong, 2012).

All assessed behaviours were self-reported. This choice was based on the assertion that self-report is a cost-effective and valid mean of collecting personal information, despite the inherent

limitations (Smyth et al., 2007). In fact, it has been shown that continuous assessment of health data by self-reporting can be as reliable as clinical assessments (Brener, Billy, & Grady, 2003; Caplan et al., 2003; Dahl, Hassing, Fransson, & Pedersen, 2010; H. I. Hall et al., 2004; Lykins, Pavlik, & Andrykowski, 2007).

The behaviour assessment questionnaire allows the definition of individual user profiles and determines the current putative level of cancer prevention, called *Happy Score* in the context of the app.

*Behaviour tracking*

Behaviour tracking during app use is done using Ecological Momentary Assessment (Moskowitz & Young, 2006; Smyth & Stone, 2003) and relies upon low burden inputs. Each day, 30 minutes before self-reported bedtime, users are prompted to answer one behaviour question, randomly assigned from the behaviour assessment questionnaire that are relevant to the user. The random assignment of questions is conditioned, i.e., all relevant questions are asked to the user before a repeated question can occur.

Users can track their behaviour by answering behaviour questions that are sent to them periodically by the app or by deliberately entering behaviour data by tapping the button "+" on the app's home screen (Figure 17). Thus, users can still record relevant behaviour data even if that isn't requested by the app at the end of the day.

These behaviour assessments are used to update the user profile over time and collect the data that is used to provide feedback to users in the form of graphical statistics.

*Happy Score*

Happy Score (HSc) summarizes the information about user's behaviours associated with cancer risk/prevention. This score is calculated by simply adding up the points obtained for all self-reported behaviours (Figure 16). The points attributed to each behaviour were weighted according to available scientific evidence (Bjartveit & Tverdal, 2005; Doll & Peto, 1981; Ott, Ullrich, Mascarenhas, & Stevens, 2011; Parkin, Boyd, & Walker, 2011). The resulting score ranges from 0 to 150: the highest the displayed number, the better the overall behaviour in terms of cancer prevention. Note that the score ranges from 0 to 150, having the commonly used 0 to 100 been deliberately avoided to prevent misunderstandings: if the score ranged from 0 to 100 it could be mistaken as a percentage of protection against cancer; thus 100 would mean 100%

protection, a vision that is misleading as we can lower our personal risk of cancer but we can't eliminate it completely by having a healthier life.

HSc integrates information about all the user's cancer risk/prevention behaviours and illustrates the overall user's status in a way that is useful for monitoring behavioural changes and for comparisons between different users. It conveys the idea that *any* change is important for cancer prevention. It includes continuous variables, such as number of cigarettes or portions of fruit and vegetables (that provide potential changes everyday), and one-time behaviours such as HPV vaccination.

| Description and range | Points |
|---|---|
| Number of portions of fruit and vegetables consumed per day. Range: 0 to ≥5 portions. | 0 to 20 |
| Number of portions of unhealthy foods consumed per day (red meat, processed meat, and fatty foods). From >3 to 0 portions. | 0 to 10 |
| Ratio between portions of fruit and vegetables and portions of unhealthy foods (Cut point: 0.9). | 0 to 8 |
| Physical activity level as measured by the International Physical Activity Questionnaire, short form. From low to high. | 0 to 5 |
| Cervix cancer screening (Pap smear) enrolment. Only applies to female. From "no screening" to "currently screened". | 0 to 10 |
| Skin, breast (female) and testicular (male) self-exams performed. From "no self-exam" to "all self-exams performed". | 0 to 30 |
| From "no vaccination" to "HBV and HPV vaccination" (Female) or "HBV vaccination" (Male) | 0 to 20 |
| Number of sunburns last week. From >1 to 0. | 0 to 2 |
| Body mass index calculated using height and current weight. From obesity to normal weight. | 0 to 15 |
| Number of alcoholic drinks consumed per day. From >1 to 0 drinks (Female); >2 to 0 drinks (Male). | 0 to 5 |
| Number of smoked cigarettes per day. From >25 to 0 cigarettes. | 0 to 35 |

Figure 16 Contribution of behavioural factors and indexes to HSc calculation.

HSc is represented on the home page of the app, allowing users to self-monitor their behaviour in a glanceable way (Figure 17). This strategy has proven to be effective in influencing health behaviours in other contexts (Helfer & Shultz, 2014).

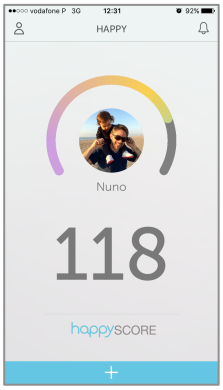



Figure 17 Screenshot from the home page of Happy (HSc = 118).

Any update to the user profile, entered by answering a behaviour question prompted by the app or by deliberately inputting behaviour data, will recalculate the HSc accordingly. This provides a real-time assessment of the behaviour by establishing a link between the reported behaviour and the level of cancer prevention, a very intense and personal experience.

*Messages*

According to FBM, messages can be good triggers of behaviour change (Fogg, 2003, 2007a, 2007b, 2011; Lee, Koopmeiners, Rhee, Raveis, & Ahluwalia, 2014; Stanford Persuasive Tech Lab, 2010).

Happy sends one message per day within the self-reported waking hours of the user via app notifications. A total of 1,120 messages were developed following CDC's guidelines to writing for social media (CDC, 2012): give the most important information first; limit the use of jargon, technical, or scientific language; write in active voice; keep messages short; write in a friendly but professional tone; choose words with one definition or connotation; use measurements that are familiar to your audience; choose familiar terms, and use them consistently; limit the use of acronyms; use numbers when they help you make your point; consider using alternatives to words expressing mathematical concepts, such as risk, normal, and range, if those words do not have meaning to your audience. All reported behaviours that don't comply with cancer prevention guidelines, are targeted by the app.

Happy was developed to enable message tailoring. Tailoring is defined as "creating communications in which information about a given individual is used to determine what specific content he or she will receive, the contexts or frames surrounding the content, by whom

it will be presented and even through which channels it will be delivered" (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008, p. 454). Message tailoring takes into account the users' profile and context (using the smartphones' clock, calendar, and GPS, along with World Weather Online and Google Maps Application-Programing Interfaces, API, the app is able to collect meaningful information concerning location, time of day, week and month, air temperature, UV index, and weather conditions). Each message is assigned a *trigger context* that determines the conditions needed to send it to the user (Figure 18). The goal is to deliver the right message to the right user in the right moment. When a user is located in a target location, for instance, the message sent to her will take this in consideration, along with specific profile features, increasing the relevance and adequacy of the message content to the user. The effort of tailoring messages to the users' profile and context is important because it allows the delivery of cancer prevention messages with less redundant information, that are more likely to be remembered and processed by the receiver (Campbell et al., 2009; Gerend, Shepherd, & Lustria, 2013; Hawkins et al., 2008; Kreuter & Wray, 2003; Rimer & Kreuter, 2006).

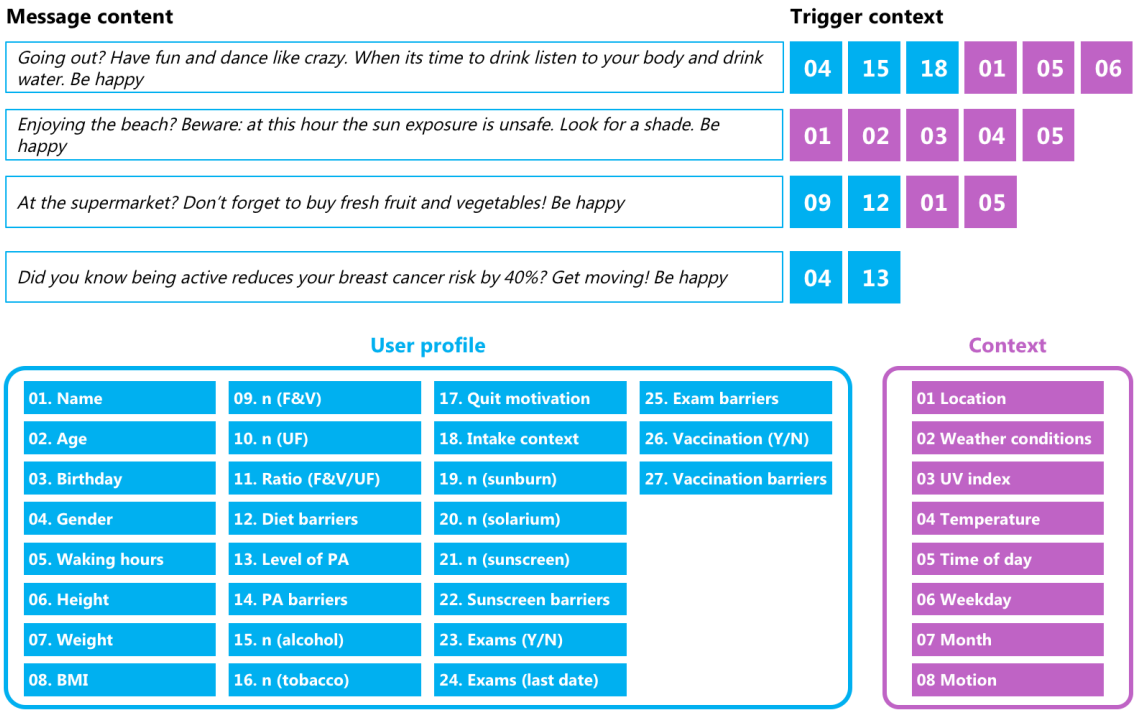



Figure 18 App's message tailoring system. Note that some messages rely exclusively on user profile variables and others target all users in specific contexts. Most messages rely on both user profile and context variables.

*Statistics*

All behaviour tracking data is processed by the app and presented as graphic feedback to the user in the statistics section (Figure 19). It is mainly a self-assessment and motivational tool.

Graphic feedback was chosen because graphs can help users understand patterns in their data and might facilitate behaviour changes (Consolvo et al., 2012). Furthermore, it enables the communication of a large amount of information in a compact representation, suitable for mobile device displays.

Graphs displayed in the app are interactive, allowing users to access additional information by taping points on the graph and by swiping left or right to explore changes through time. Each graph is built using the available behaviour data. For instance, from time to time, users are prompted to input amounts of fruits and vegetables consumed that day. As users input more data, the correspondent graph will start to take form, allowing users to track this behaviour through time. One main disadvantage of this approach is the role of missing data. Since the app doesn't know whether data is missing or the behaviour was not performed, it assigns a value of zero to the periods of missing data. Thus, the resulting graphs might obscure trends and potential relationships, undermining the main reason to provide behaviour feedback to users.


Figure 19 Screenshot from the statistics section of Happy.

The general architecture of the prototype app (Figure 20) consists of the sensors embedded in the smartphone; the smartphone; a server (that acts simultaneously as a web server and a data repository); a message database; and World Weather Online, and Google Maps services. The smartphone's embedded sensors detect and feed data (GPS coordinates, device movement, date and time) to Happy. Then, the app processes this data using the World Weather Online and Google Maps API to generate significant contextual data (weather conditions and location). The smartphone transmits the data to the remote server where it is bundled with the user profile (previously stored in the server). This data set is then used to search the message database and select the message that is best suited to the user profile and current context. The selected message (tailored message) is then sent to the smartphone and presented to the user in the

application as an app notification.

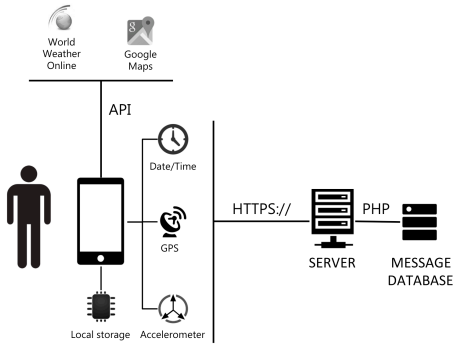



Figure 20 General architecture of the prototype app.

Behaviour data entered by users is sent to the server where it is registered and used to recalculate HSc and statistics. These values are then sent to the smartphone and presented graphically to the user. All entered data is stored in the server and mapped into the user profile, allowing effective tailoring of the subsequent messages sent to the user. Hypertext Transfer Protocol Secure (HTTPS) is used in all data transmission between the smartphone and the server, which means that the smartphone must have an Internet connection service such as General Packet Radio Service (GPRS), 3rd generation (3G), 4th generation (4G) or a wireless local area network (Wi-Fi). If the smartphone is temporarily disconnected from the Internet, all entered data will be stored locally and sent to the server when the connection is restored, updating all data values. Happy runs on Android OS and iOS, the two most commonly used smartphone platforms.

### 3.4.1. Theoretical framework of the prototype

Happy uses FBM as a theoretical framework, focused on the persuasive power of message triggers. In light of this model, messages included in the app were designed as sparks (motivational messages), facilitators (suggestions to facilitate specific behaviours), or signals (reminders to perform specific behaviours) (Table 9).

Table 9 Examples of message type according to FBM.

| Message type | Target behaviour | Message content |
|---|---|---|
| Spark | HPV vaccination | *A little sting today might save you a big anguish tomorrow. Get the HPV shot. Be happy* |
| Facilitator | Decrease tobacco consumption | *Distract yourself during a craving with physical activity. Research shows it can help you stay smoke free and improve your mood. Be happy* |
| Signal | Increase physical activity level | It's a nice day outside! How about calling a friend and go for a walk? Be happy |

To analyse the persuasive methods implemented on the app prototype, we applied the PSD framework to classify its features and functionalities (Table 10):

Table 10 Persuasive analysis of the app prototype using the PSD framework.

| PSD framework | | Happy prototype features and functionalities |
|---|---|---|
| Category | Principle | |
| **Primary task support** | Reduction | Behaviour data input is simple and quick.<br>Several messages are designed to simplify target behaviours (facilitators).<br>HSc provides a simple and useful way to assess users' behaviour in real time. |
| | Tunnelling | The baseline behaviour assessment is structured in a way that guides users through all behaviours and makes them reflect upon each one, providing an excellent way to self-assess the behaviour choices that users do everyday. |
| | Tailoring | All messages sent to users are tailored to the users' profile and context. |
| | Personalization | The app's home page (Figure 17) is designed to show the users profile picture associated with their personal name and HSc, providing the link between the person and the value presented on screen.<br>Several messages address the users by name. |
| | Self-monitoring | Users are able to track behaviours and monitor their evolution towards health goals.<br>HSc provides a simple and useful way to assess their behaviour in real time. |
| | Simulation | HSc updates in real time allowing users to see the effect of their current behaviour in their level of cancer prevention. |
| | Rehearsal | N/A |
| **Dialogue support** | Praise | N/A |
| | Rewards | N/A |
| | Reminders | Users receive tailored reminders to perform certain health behaviours such as skin self-exams. |
| | Suggestion | Users receive messages that will suggest health behaviours when it's more appropriate in terms of context. For instance, if a user is at the beach and the UV index is higher than 8, the user might receive a message warning about the danger and suggesting the search of a shadow. |
| | Similarity | The app's home page (Figure 17) is designed to show the users profile picture associated with their personal name and HSc, providing the link between the person and the value presented on screen. |
| | Liking | The User Interface (UI) was designed to be visually attractive and very graphic. |
| | Social role | N/A |
| **System Credibility Support** | Trustworthiness | All information provided to users is based on international cancer prevention guidelines. |
| | Expertise | The scientific team works in a major Portuguese cancer research centre and in an important University. |
| | Surface credibility | UI has a professional look designed to enhance credibility. The app is endorsed by one of the major Portuguese cancer research centre. |
| | Real-world feel | The scientific team works in a major Portuguese cancer research centre and in an important University. |
| | Authority | Several messages have OMS (and other health authorities) endorsement. |
| | Third-party endorsements | N/A |
| | Verifiability | Many messages have a reference that is easily verifiable by the users. |

Note that the app prototype doesn't have any feature or functionality covering the "Social Support" category of the PSD framework. It is also worth mentioning that Happy uses a *pure form* of persuasion, since it relies only in verbal and non-verbal symbols and allows the

voluntary participation of users in the persuasion process (Oinas-Kukkonen, 2013).

## 3.5. Study II: Usability Test

This section describes the usability tests performed with the prototyped app. Study II was performed to test Happy's ability to be used by real users in non-controlled contexts. This study is mentioned in Paper III.

### 3.5.1. Methods

This study sought to test the app prototype's ability to be used in real-life settings.

*Participants*

Volunteers were recruited by personal invitation. The selection criteria included: (a) being an iOS or Android smartphone user; (b) age between 18 and 35 years old; and (c) availability to participate in the study. Ten participants met the above criteria and performed the requested usability tests.

*Procedure*

Each participant was asked to perform seven specific tasks in the app. The researcher's smartphone was used to complete these tasks. The Think Aloud Method (Lewis & Rieman, 1993) was used to further extract information from the users' performance. After the usability tests, all participants answered a usability questionnaire (Supplementary file 3). This questionnaire was adapted from a usability and feasibility study of a social mHealth application for physical activity (Al Ayubi, Parmanto, Branch, & Ding, 2014).

*Data analysis*

The researcher observed and took field notes on all the performed tests. The field notes were then analysed and all extracted data was compiled into performance and error reporting tables. Data from the usability questionnaire was analysed using IBM SPSS Statistics, version 21.

### 3.5.2. Results

Table 11 summarizes the demographic and smartphone user experience data of the study participants.

Table 11 Sociodemographic characteristics and smartphone user experience of study participants.

| | | Total (n=10) |
|---|---|---|
| Sociodemographic characteristics | | |
| Gender, n (%) | | |
| | Female | 5 (50.0) |
| | Male | 5 (50.0) |
| | No answer | 0 (0.0) |
| Age, mean (SD) | | 23.8 (4.6) |
| Education level, n (%) | | |
| | College degree | 10 (100.0) |
| | No college degree | 0 (0.0) |
| | No answer | 0 (0.0) |
| Smartphone user experience | | |
| Smartphone type, n (%) | | |
| | Android | 6 (60.0) |
| | iPhone | 4 (40.0) |
| | Other (windows phone, blackberry, etc.) | 0 (0.0) |
| | Don't know/No answer | 0 (0.0) |
| Smartphone ownership time, n (%) | | |
| | >1 year | 9 (90.0) |
| | 6 months to 1 year | 1 (10.0) |
| | < 6months | 0 (0.0) |
| | No answer | 0 (0.0) |
| Smartphone use (daily average), n (%) | | |
| | >2 hours | 6 (60.0) |
| | 1 to 2 hours | 3 (30.0) |
| | <1 hour | 1 (10.0) |
| | No answer | 0 (0.0) |

Eight users were able to successfully complete all requested tasks; two were unable to complete one task. Furthermore, several errors occurred during task performance (Figure 21).

| | | User #1 | User #2 | User #3 | User #4 | User #5 | User #6 | User #7 | User #8 | User #9 | User #10 | Errors | Completion rate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Task #1 | Register in the app | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 100% |
| Task #2 | Answer behaviour assessment | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 0 | 6 | 100% |
| Task #3 | Register 30 min of intensive physical activity in the app | 1 | ✖ | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 4 | 90% |
| Task #4 | Access statistics | ✖ | 2 | 2 | 0 | 1 | 4 | 2 | 2 | 2 | 3 | 18 | 90% |
| Task #5 | Access previous data entries | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 4 | 100% |
| Task #6 | Access notifications | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100% |
| Task #7 | Logout from the app | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 100% |

Figure 21 Usability test results.

Three usability problems were identified during test performance:

- **Problem #01:** users couldn't easily access statistics. All but one participant had difficulties accessing the statistics section (task #4).

  **Solution to problem #01:** provide, on first use, a visual hint to let users know how to access the statistics.
- **Problem #02:** users didn't identify the statistics access window. Many users had difficulties identifying the statistics access window, even when they tapped the access button.

  **Solution to problem #02:** place a title saying "Statistics" on top of the statistics access window.

- **Problem #03:** users mistakenly assumed wrong time units – several users had problems answering the behaviour assessment questionnaire because they assumed that time input was in minutes.

  **Solution to problem #03:** use "hh:mm" in the input window as a visual hint to guide users to the right time units.

The proposed solutions were embedded on the prototype to tackle these problems. Overall, participants gave positive evaluations to all usability factors, except app expectations (Table 12). All participants stated that they were satisfied with the quality of the app, that it was easy and simple to use, and that the organization of information was clear. However, the majority expected more features in the app (60.0%).

Table 12 Usability evaluation (n=10).

| Usability factors | Agree or Strongly agree | |
|---|---|---|
| | n | % |
| I like the interface of this app | 9 | 90.0 |
| The app's interface is pleasant | 8 | 80.0 |
| It was easy to learn how to use the app | 8 | 80.0 |
| It was easy and simple to use the app | 10 | 100.0 |
| The organization of information was clear | 10 | 100.0 |
| It was easy to navigate to find what I need | 8 | 80.0 |
| It was easy to obtain what I need | 9 | 90.0 |
| Whenever I made a mistake using the app, I could recover easily and quickly | 8 | 80.0 |
| This app has all the features I expected it to have | 4 | 40.0 |
| The app gave error messages that clearly told me how to fix problems | 6 | 60.0 |
| Overall, I am satisfied with the quality of the app | 10 | 100.0 |

## 3.6. Study III: Pilot Study

This section describes the pilot study performed with the app prototype. The purpose of this study was to field-test Happy. Study III results are mentioned in Paper III and fully explored in Paper V.

### 3.6.1. Methods

This study sought to field-test Happy in real-life settings. Participants downloaded and used the app on their personal smartphones for 28 consecutive days (4 weeks). At the end of this period, they answered an online questionnaire and some participants were interviewed.

*Participants*

Participants were recruited via e-mail and Facebook. The recruitment e-mail was sent to a mailing list from University of Aveiro (n=2,558) and the study announcement was posted on the official Ipatimup Facebook page. Voluntary participants were required to answer an online survey. The survey was available online for two weeks. The selection criteria were: (a) being a smartphone user; (b) age between 18 and 35 years old; and (c) ability to download and register in the app. Thirty two participants met the above criteria. All participants provided informed consent to participate in the study.

*Procedure*

Participants were informed that the app would send one message per day and would prompt them to answer a behaviour question at the end of each day. A small visual guide was provided via e-mail to illustrate the app functionalities along with a contact they could use for technical assistance. Participants were instructed to use the app for 28 consecutive days (4 weeks) and were required to answer an online questionnaire at the end of this period (Supplementary File 4). The questionnaire was designed to assess usability, feasibility, message receptivity, and perceived impact of the app. At the end of this process, ten participants agreed to take part in in-depth semi-structured interviews to further explore these topics. The same interview schedule was used in all interviews (Supplementary File 5).

*Outcome measures*

The study considered the following outcomes:

- **Usability:** usability was evaluated from data provided on the online questionnaire. Several usability factors were assessed: learnability, efficiency, memorability, error recovery, navigation, and subjective satisfaction. The assessment tool used in the questionnaire was adapted from a usability and feasibility study of a social mHealth application for physical activity (Al Ayubi et al., 2014).
- **Feasibility:** feasibility was evaluated from data collected at the interviews and directly from Happy. Participants' motivation and user experience with Happy and user-system interactions were assessed regarding feasibility.
- **Message receptivity:** Message receptivity was evaluated from data provided on the online questionnaire and at the interviews. The assessment tool used in the questionnaire was adapted from a study on the usage of SMS to address HIV knowledge, risk reduction, social support, and patient involvement (Uhrig et al., 2012).
- **Perceived impact of Happy:** Perceived impact was evaluated from the data provided on the online questionnaire and at the interviews. The questionnaire was adapted from the Mobile Application Rating Scale (Stoyanov, Psych, Hides, Kavanagh, & Zelenko, 2015). Behavioural data collected in the app was also used to assess perceived impact. HSc was used as an indicator of change along with data from individual behaviours. Users were required to answer one single question per day (regarding one single behaviour), randomly assigned from the whole behaviour assessment questionnaire, and could also deliberately report behaviours on demand. Thus, it was not possible to ensure the assessment of all behaviours everyday. This could create over or underrepresentation of individual behaviours influencing HSc overall measure. To minimize this bias, all collected data was computed and week averages per participant were calculated. Differences between initial and subsequent HSc values were computed for all users to show trends in cancer prevention behaviours.

*Data analysis*

Descriptive statistics and exploratory data analysis was performed. Week comparisons of all behaviour data collected in the app were done using repeated measures ANOVA test. All statistical analysis was done using IBM SPSS Statistics, version 22.

Interviews were audio recorded and the content was transcribed. The transcripts were then analysed using inductive thematic analysis (Bardin, 2011; Coutinho, 2011). After initial coding, highlighting relevant themes, all text segments were iteratively analysed. Themes were added or merged until they effectively represented all text segments and captured the essence of every interview. The transcript analysis and coding was done using the software NVIVO, version 11.

### 3.6.2. Results

Table 13 summarizes the sociodemographic data of the participants, along with the self-reported baseline behaviour.

Table 13 Sociodemographic characteristics and self-reported behaviours of study participants.

| | | Total (n=32) |
|---|---|---|
| Sociodemographic characteristics | | |
| Gender, n (%) | Female | 17 (53.1) |
| | Male | 15 (46.9) |
| Age, mean (SD) | | 25.6 (4.8) |
| Smartphone type, n (%) | Android | 18 (56.3) |
| | iPhone | 14 (43.8) |
| Self-reported behaviour (baseline) | | |
| Level of Physical Activity, n (%) | High | 7 (21.9) |
| | Moderate | 4 (12.5) |
| | Low | 21 (65.6) |
| Fruit and vegetables (daily average), n (%) | ≥5 servings | 11 (34.4) |
| | 3 to 4 servings | 9 (28.1) |
| | 1 to 2 servings | 10 (31.2) |
| | None | 2 (6.3) |
| Tobacco consumption (daily average), n (%) | >10 cigarettes | 1 (3.1) |
| | 1 to 10 cigarettes | 14 (43.8) |
| | Non smoker | 17 (53.1) |
| Alcohol consumption (daily average), n (%) | >2 drinks | 0 (0.0) |
| | 1 to 2 drinks | 15 (46.9) |
| | None | 17 (53.1) |
| Body mass index (BMI), n (%) | Obese | 4 (12.5) |
| | Overweight | 6 (18.8) |
| | Normal weight | 22 (68.8) |
| Sunburn in the previous year, n (%) | Yes | 4 (12.5) |
| | No | 28 (87.5) |
| Performed skin self-exam, n (%) | Yes | 6 (18.8) |
| | No | 26 (81.2) |
| Compliance with cervix cancer screening guidelines (n=17), n (%) | Yes | 11 (64.7) |
| | No | 6 (35.3) |
| Performed breast self-exam (n=17), n (%) | Yes | 14 (82.4) |
| | No | 3 (17.6) |
| Performed testicular self-exam (n=15), n (%) | Yes | 3 (20.0) |
| | No | 12 (80.0) |
| HPV vaccination (n=17), n (%) | Yes | 9 (52.9) |
| | No | 6 (35.3) |
| | Don't know | 2 (11.8) |
| HBV vaccination, n (%) | Yes | 23 (71.9) |
| | No | 5 (15.6) |
| | Don't know | 4 (12.5) |

*Usability*

Participants gave positive evaluations to almost all usability factors, except error recovery and app expectations (Table 14).

Table 14 Usability evaluation (n=32).

| Usability factors | Agree or Strongly agree n | Agree or Strongly agree % | Illustrative participant quotations |
|---|---|---|---|
| I like the interface of this app | 30 | 93.8 | Participant 01: *Pretty interesting and useful.* |
| The app's interface is pleasant | 28 | 87.5 | |
| It was easy to learn how to use the app | 26 | 81.3 | Participant 05: *A simple and intuitive app, despite having some flaws when synchronizing information.* |
| It was easy and simple to use the app | 26 | 81.3 | |
| The organization of information was clear | 24 | 75.0 | Participant 08: *Overall, I felt it was easy to interact with the menus and to input data in the app.* |
| It was easy to navigate to find what I need | 23 | 71.9 | |
| It was easy to obtain what I need | 17 | 53.1 | Participant 22: *I think the concept is pretty interesting, and a good project to develop. While the app reminded me everyday to answer the questionnaire, I sometimes ended up forgetting, because I didn't have internet or for other reasons.* |
| Whenever I made a mistake using the app, I could recover easily and quickly | 14 | 43.8 | |
| This app has all the features I expected it to have | 11 | 34.4 | |
| The app gave error messages that clearly told me how to fix problems | 9 | 28.1 | |
| Overall, I am satisfied with the quality of the app | 20 | 62.5 | |

Overall, the majority of participants stated that they were satisfied with the quality of the app (62.5%). Participants liked the interface of the app (93.8%) and agreed it is pleasant (87.5%) and easy to use (81.3%). However, the majority disagreed about effectiveness of error recovery system (56.2%) and expected more features (65.6%). During the interviews, participants mentioned features that they would like to see added to the app. The most mentioned (9 out of 10 interviewees) were challenges and social features:

> *I think it's a way of creating groups of people that have the same goal and don't know how to get there. It's easier in a group, like an exercise group, or a diet group, it's always easier to do it like that than alone. So I like it.* (Interviewee #05)

> *I think that having challenges and this type of interaction between users is the right way for the success of the app.* (Interviewee #02)

However, some interviewees (3 out of 10) declined to share sensitive information in a social network:

> *Imagine that my value [Happy Score] is not good, I'm not gonna want to share it! I know this is prevention but still...* (Interviewee #09)

One interviewee also suggested that the app should be connected to other apps on the smartphone:

> *[App] should connect to other apps such as the calendar because people are lazy, when I read a message suggesting to setup an alarm to remind me the next breast self-exam, I didn't do it, but if it had a button "add this to your calendar?", I would go for it.* (Interviewee #09)

Most participants (81.2%) affirmed they would use the app for a longer period of time (Table 15) and almost all (90.6%) would recommend it to others (Table 16).

Table 15 Reported willingness to continue using Happy (n=32).

| How much longer would you use this app? | n | % |
|---|---|---|
| None | 6 | 18.8 |
| Up to 6 months | 16 | 50.0 |
| 6 to 12 months | 6 | 18.8 |
| 1 to 2 years | 1 | 3.1 |
| 2 or more years | 3 | 9.4 |

Table 16 Reported willingness to recommend app to others (n=32).

| Would you recommend this app to other people? | n | % |
|---|---|---|
| No, I would not recommend this app to anyone | 3 | 9.4 |
| Yes, I would recommend this app to several people | 21 | 65.6 |
| Yes, I would recommend this app to everyone | 8 | 25.0 |

*Feasibility*

On average, during the 28-day trial period, there were 13 (40.6%) active users per day. Participants were prompted by the app to answer a behaviour question at the end of each day (30 minutes before self-reported bedtime). On average, each user entered behaviour data in 12 different days (41.0% of the app prompts). The least active user only entered data on 2 occasions and the most active user entered data on 26 different occasions. In 56.0% of the occasions, participants answered more than one question per day (above requested behaviour). The dropout rate was high, with only 6 users (19.0%) completing the 28-day trial period of the

app (Figure 22).

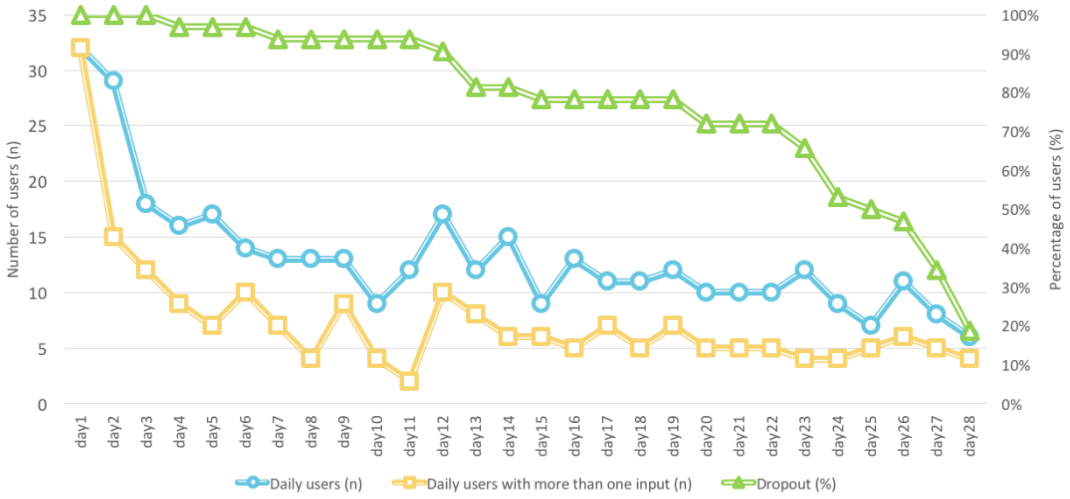



Figure 22 Daily users, daily users with more than one input, and dropout curve during the field test.

During the interviews, all participants (10 out of 10) expressed willingness to receive this type of intervention through their personal phones.

> *A smartphone is something that is always with us and is easily accessible. So, if there is something that reminds us… and maybe in decision making: "am I going to exercise today?" maybe that's what's missing. I think so, I think so. Smartphone is a good method.* (Interviewee #03)

As for the user experience with Happy, one interviewee expressed it as a very positive one, stating that it was not immediately associated with cancer.

> *For me, this app, I rarely associate it with cancer. In the app when we… the app is called Happy, when we enter it has a Happyscore, it has my name on it, it… and it's got nothing visually that associates it with cancer, so I'm gonna use it because it induces healthy lifestyles, period.* (Interviewee #05)

Several interviewees (8 out of 10) felt motivated to use the app, especially because it raises awareness.

> *It's interesting to have an app where we can register [our behaviour] daily* (Interviewee #04)

> *I think it's a good way to be constantly aware of this question of cancer prevention* (Interviewee #06)

However, some interviewees (4 out of 10) stated that the app has to be more interactive to be effective.

> *In terms of concept I think it is interesting but there was something missing…* (Interviewee #02)
>
> *If it always stays the same I think I will not use it for long and will consequently delete it.* (Interviewee #09)

*Message receptivity*

Overall, participants were very receptive to the messages (Table 17).

Table 17 Evaluation of message receptivity items (n=32).

| Item | Agree or Strongly agree | |
|---|---|---|
| | n | % |
| The messages were easy to understand | 27 | 84.4 |
| I trusted the information in the messages | 26 | 81.3 |
| The messages gave me good advice | 24 | 75.0 |
| I learned something new from the messages | 21 | 65.6 |
| The messages said something important to me | 20 | 62.5 |
| The messages made me question my current behaviour | 19 | 59.4 |
| The messages grabbed my attention | 19 | 59.4 |
| The messages told me something I didn't already know about cancer prevention | 18 | 56.3 |
| I learned about services or resources available to me from the messages | 18 | 56.3 |
| The messages motivated me to be involved in my health care | 15 | 46.9 |
| The messages motivated me to change my behaviour | 8 | 25.0 |
| I felt like the messages were designed for me | 6 | 18.8 |
| The messages promoted behaviours that are difficult for me to do | 4 | 12.5 |
| The messages contradicted what I know about cancer prevention | 1 | 3.1 |
| The messages were confusing | 0 | 0.0 |
| Overall, I liked the messages | 22 | 68.8 |

The majority of participants agreed that the messages were easy to understand (84.4%), gave good advices (75.0%), provided new and meaningful information (65.6% and 62.5%, respectively), and grabbed reader's attention (59.4%). This was also suggested in the interviews (8 out of 10 interviewees):

> *[Messages] are simple and I think that in this type of thing, the simpler, the better.*

*In other words, something that isn't coded with many technical terms, something relaxed and that can be easily read because sometimes we are with our phone but our head is in another place and I think that, I don't know, in terms of style I think that, yeah, they are good.* (Interviewee #06)

*Overall I think that all of them make sense and are interesting. And the way they are written also has… they are easy to read.* (Interviewee #07)

On the other hand, only a small portion of participants felt that the messages were designed for them (18.8%) and were motivated by the messages to change their behaviour (25.0%).

*Perceived impact of Happy*

The majority of participants agreed that the app could have a real impact in cancer prevention (Table 18).

Table 18 Perceived impact of Happy (n=32).

| Perceived impact | Agree or Strongly agree | |
|---|---|---|
| | n | % |
| This app is likely to increase awareness about cancer prevention | 28 | 87.5 |
| This app is likely to increase knowledge about cancer prevention | 27 | 84.4 |
| This app is likely to change attitudes towards cancer prevention | 25 | 78.1 |
| This app is likely to increase motivation to change cancer prevention behaviours | 22 | 68.8 |
| The use of this app is likely to encourage help seeking for cancer prevention (seek the doctor, for instance) | 20 | 62.5 |
| The use of this app is likely to increase cancer prevention behaviours | 23 | 71.9 |

Several interviewees (8 out of 10) highlighted the app features that might increase behaviour awareness and could lead to behaviour change. The identified functionalities include:

- the presence of the HSc represented on the landing page;

  *We saw when we said we ate "bad" foods (fried food and such), and we lowered our score, it was… we thought "right, I shouldn't have eaten that" or "I should have eaten a healthier food". The fact that we have a score and we see the effect of that score in our behaviour ends up motivating us to have a better score.* (Interviewee #01)

- the behaviour assessment questionnaire;

  *When I started using the app, at least when I started inserting the values of what I ate, pastries, etc., etc., I started thinking "I eat lots of junk food" and that I think is*

> *something that helps a lot, people become aware of what they eat during the day, or smoke, or drink and maybe that type of sensi… of, it's not sensitizing it's… rethinking our routines, maybe it will lead to positive results, and so I think it could fulfil its goal.* (Interviewee #02)

- and the messages.

> *I think it has lots of potential… I did many of the things that the app, the messages that the app sent, because they were so simple it was easy.* (Interviewee #05)

However, some interviewees (3 out of 10) consider that the impact that the app might have could wear off with time and is dependent of the user profile.

> *Maybe in an initial point because afterwards people end up looking at it like a routine app and it loses impact. I felt it, it had more impact the first time I answered the questionnaire and then, as I answered it over time, it didn't have the same impact.* (Interviewee #03)

> *Well, it always depends how we take it. It's like all apps, be it physical exercise or whatever. We have to feel motivated to take it, to take the suggestions seriously and do it, but yes, the suggestions would come up and, ok, it can, for someone that is focused and wants to take it seriously, I think its good.* (Interviewee #04)

Self-reported behaviour data showed an improvement trend in some cancer prevention behaviours (Table 19).

Table 19 Average change by behaviour (baseline values and weekly averages) (n=32).

| Self-reported behaviour | Baseline | Week1 | Week2 | Week3 | Week4 |
|---|---|---|---|---|---|
| BMI, Mean (SD) | 23.8 (1.8) | 23.8 (1.8) | 23.8 (1.8) | 23.9 (1.8) | 24.2 (2.1) |
| Fruit and vegetables (daily average), Mean (SD) | 4.0 (3.1) | 3.6 (2.4) | 3.6 (2.7) | 3.8 (3.1) | 4.8 (4.7) |
| Level of Physical Activity, Median | Low | Moderate | High | High | Moderate |
| Enrolled cervix cancer screening (n=17), n (%) | 11 (64.7) | 11 (64.7) | 11 (64.7) | 11 (64.7) | 11 (64.7) |
| Performed breast self-exam (n=17), n (%) | 15 (88.2) | 15 (88.2) | 15 (88.2) | 15 (88.2) | 15 (88.2) |
| Performed skin self-exam (n=32), n (%) | 6 (18.8) | 9 (28.1) | 9 (28.1) | 11 (34.4) | 13 (40.6) |
| Performed testicular self-exam (n=15), n (%) | 3 (20.0) | 4 (26.7) | 5 (33.3) | 5 (33.3) | 5 (33.3) |
| HPV vaccination (n=17), n (%) | 9 (52.9) | 11 (64.7) | 11 (64.7) | 12 (70.6) | 12 (70.6) |
| HBV vaccination (n=32), n (%) | 23 (71.8) | 26 (81.2) | 26 (81.2) | 26 (81.2) | 26 (81.2) |
| Tobacco (daily average), Mean (SD) | 5.5 (3.5) | 5.8 (4.0) | 9.0 (8.5) | 5.0 (4.2) | 2.5 (0.7) |
| Alcohol (daily average), Mean (SD) | 0.7 (0.5) | 0.3 (0.5) | 0.3 (0.4) | 0.5 (0.5) | 0.3 (0.4) |

Overall, tobacco and alcohol consumption decreased, while fruit and vegetable consumption and the level of physical activity increased. Some participants performed the suggested skin and testicular self-exams (7 and 2, respectively) and 2 female participants declared being vaccinated

against HPV. There was an increase in BMI. None of these changes were statistically significant.

In terms of overall cancer prevention, average HSc improved during the 28-trial by 7 points (Figure 23).

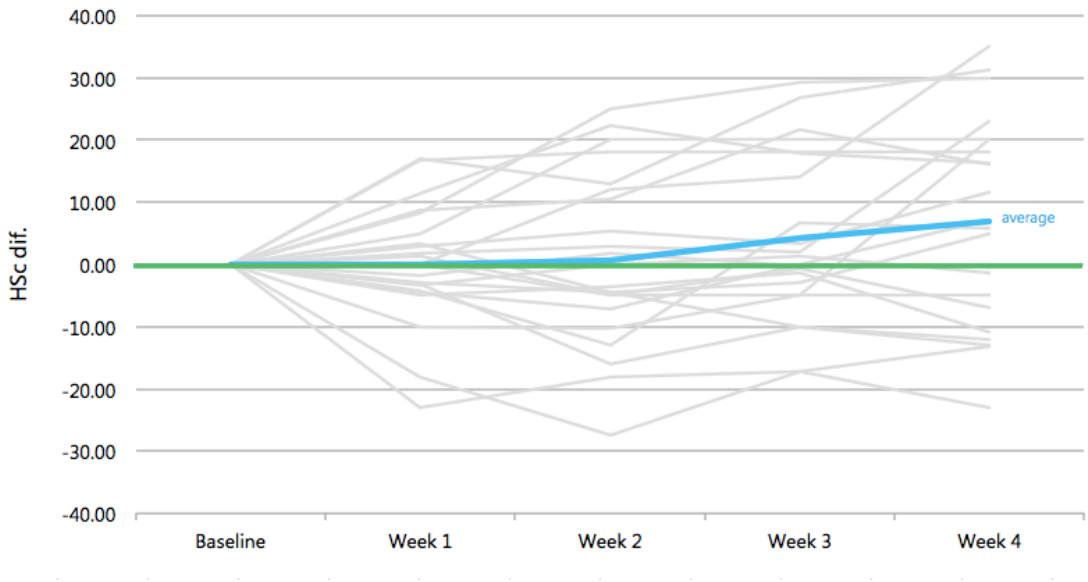



Figure 23 Changes in users' HSc during the 28-day trial. Each grey line represents a diferent user. The blue line depicts the average HSc difference for the whole group of users.

A repeated measures ANOVA analysis showed that the change in HSc was not statistical significant (p=0.069), although the trend shows a consistent increase after week 1.

## 3.7. App Development: Full App

Full app development occurred between February and July 2016. Results from Study III were used to refine and further develop the app. There was an identified need to enhance user engagement and many pilot study participants expressed they wanted a way to identify the behaviours that needed to improve. To tackle these issues, the following features were added: Glanceable data, Social, Challenges, and Virtual badges.

*Glanceable data*

The glanceable data screen was added to the app to give users a quick way to assess which behaviours needed improvement (Figure 24). It conveys qualitative information regarding the target behaviours of the app, allowing users to easily identify their personal strong and weak points in terms of cancer prevention.

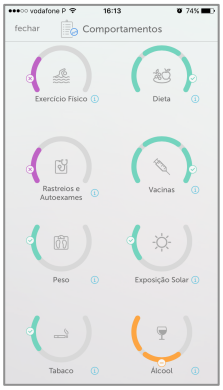



Figure 24 Screenshot from the glanceable data screen of Happy.

All behaviours are displayed in a three-point scale: "bad" (distant from cancer prevention guidelines), "more or less" (non compliant but close to cancer prevention guidelines), and "good" (compliant with cancer prevention guidelines) (Table 20).

Table 20 Qualitative assessment levels of all target behaviours in Happy.

| Behaviours | | Bad (✕) | More or less (-) | Good (✓) |
|---|---|---|---|---|
| Alcohol consumption (n) | Men | n>2 | 1<n≤2 | n=0 |
| | Women | n>1 | n=1 | n=0 |
| Tobacco consumption (n) | | n>10 | 0<n≤10 | n=0 |
| BMI | | Obese | Under or Overweight | Normal weight |
| Level of Physical Activity | | Low | Moderate | High |
| Diet (F&V and UF) | | F&V<2 OR [2≤F&V<4 AND ARG≥2] | 2≤F&V<4 OR [F&V≥5 AND UF≥2] | F&V≥5 AND UF<2 |
| Exams | | All exams="No" | ≥1 exams="Yes" | All exams="Yes" |
| UV exposure | | Sunburn="Yes" AND Solarium="Yes" AND Sunscreen="No" | Sunburn="Yes" OR Solarium="Yes" OR Sunscreen="No" | Sunburn="No" AND Solarium="No" AND Sunscreen="Yes" |
| Vaccines | Men | HBV="No" | ---------- | HBV="Yes" |
| | Women | HBV="No" AND HPV="No" | HBV="Yes" OR HPV="Yes" | HBV="Yes" AND HPV="Yes" |

The glanceable data screen divides the target behaviours into two categories: the ones that we want to increase (the four behaviours shown on top in Figure 24) and the ones we want to decrease (the four on the bottom in Figure 24). Each category is oriented and displayed in a way that tries to convey this message. For instance, as can be observed in Figure 24, the "good"

level of diet is represented by a totally filled green graph. The "good" level of tobacco consumption, however, is represented symmetrically: the graph is upside down and green colour only fills the first space. In each case, the graph is complemented by a "✓", pervading the idea of "good". These visual solutions were introduced to ensure that the message is clear. For instance, a totally filled green graph in tobacco consumption could suggest the idea that tobacco consumption was high and "good", providing a mixed message.

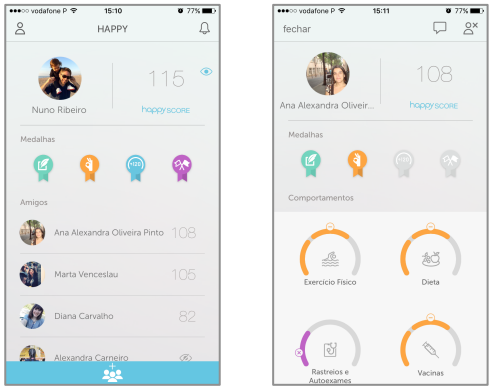
The glanceable data screen complements the statistics section, providing a different, quickly available, level of behaviour analysis. Moreover, each behaviour represented in the screen has an information button that, when tapped, provides the cancer prevention guideline to the user, reinforcing the prevention message of the app. Furthermore, like all other app sections, this screen is tailored to the user, i.e., only the relevant behaviours are displayed.

*Social*

Social section displays all users that are added to the user's social network. This feature is designed to boost online support and competition between users. Users access this section by swiping right from the home screen. All users' friends that use the app are sorted by HSc and displayed in a "scoreboard" (Figure 25A). Thus, users can compare themselves with others and see each other's HSc. By tapping a friend, users can see the breakdown of the HSc by target behaviour, providing an overview of the friends' behaviour (Figure 25B). Users can also communicate with friends inside the app, facilitating online support.

In order to leverage existing online social interactions, Happy was integrated with the most widely used social networking system: Facebook ("Facebook statistics," 2015). This was done using Facebook's open API that allows access to functions for online interaction to third party applications.

This feature was implemented taking into account the guidelines for the development of a cancer prevention smartphone app (Table 8). Thus, it is optional: users can opt-in to share and see other users' HSc.




(A) (B)

Figure 25 Screenshots from the social section. Users see their friends sorted by HSc (A) and can access the friends' page by tapping on them (B).

*Challenges*

Challenges are healthy tasks meant to further engage users with the app. They are designed to give small achievable goals to boost users' motivation and help them reach desired behaviours. Each challenge lasts 24h. Users are assigned to specific challenges and can change them by tapping a button. Only challenges that target relevant behaviours are presented to each user. When users accept a challenge, they receive a motivational message. Twenty-four hours later, they are prompted to say if they completed the challenge. If they answer "Yes", they receive a praise message and get a virtual badge. If they answer "No" they receive a message that motivates them to try again. This feature was implemented based on the suggestions from pilot study participants and on the findings of previous research. For instance, Johnson and colleagues (2016) found that gamification can have a positive impact in health behaviours.

*Virtual badges*

A virtual badge is awarded to users when they successfully complete challenges; track behaviours in consecutive days; have a HSc higher than 120 after adding behaviour data; and meet health behaviour guidelines. Users can access the virtual badges by swiping left from the home screen (Figure 26).


Figure 26 Screenshot from the virtual badges section.

The virtual badges are cumulative and users can see their friends' virtual badges in the social section, enhancing competition. When users reach a milestone, i.e., a certain amount of badges, they receive a praise message. Just like the challenges, these gamification elements were embedded in the app to increase user engagement and boost motivation.

The general architecture of the full app is based on the prototype app's architecture, with added elements: Facebook's API is used to manage all social interactions between the user and his peers and a challenges database was added to the server (Figure 27).

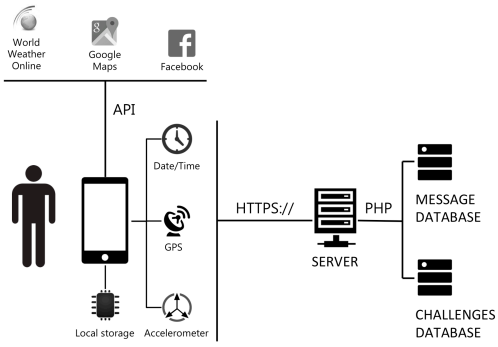
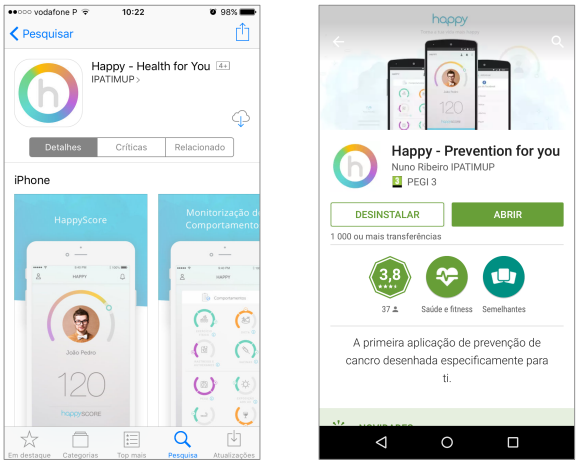



Figure 27 General architecture of the full app.

Parallel to the app, several communication elements were created with the purpose of app promotion including a dedicated website (http://happy-app.eu) (Figure 28), images and information for the Apple App Store and Google Play Store (Figure 29), and a bookmarker (Figure 30). The bookmarker contains two QR codes that allow immediate access to the app for both smartphone platforms (Android and iOS) and was distributed in several events since the app was launched.


Figure 28 Happy's dedicated website.




(A) (B)

Figure 29 Screenshots from Apple App store (A) and Google Play store (B).


Figure 30 Happy's bookmarker.

### 3.7.1. Theoretical framework of the full app

To analyse the persuasive methods implemented on the full app, we once again applied the PSD framework to classify its features and functionalities (Table 21):

Table 21 Persuasive analysis of the full app using the PSD framework (differences between this and the prototype app's analysis are highlighted in blue).

| PSD framework | | Happy prototype features and functionalities |
|---|---|---|
| **Category** | **Principle** | |
| **Primary task support** | Reduction | Behaviour data input is simple and quick.<br>Several messages are designed to simplify target behaviours (facilitators).<br>HSc provides a simple and useful way to assess users' behaviour in real time. |
| | Tunnelling | The baseline behaviour assessment is structured in a way that guides users through all behaviours and makes them reflect upon each one, providing an excellent way to self-assess the behaviour choices that users do everyday. |
| | Tailoring | All messages sent to users are tailored to the users' profile and context. |
| | Personalization | The app's home page (Figure 17) is designed to show the users profile picture associated with their personal name and HSc, providing the link between the person and the value presented on screen.<br>Several messages address the users by name. |
| | Self-monitoring | Users are able to track behaviours and monitor their evolution towards health goals.<br>HSc provides a simple and useful way to assess their behaviour in real time.<br>Glanceable data screen provides a quick way to assess behaviour and pinpoint where the user can make improvements. |
| | Simulation | HSc updates in real time allowing users to see the effect of their current behaviour in their level of cancer prevention. |
| | Rehearsal | N/A |
| **Dialogue support** | Praise | A praise message is displayed when users reach a milestone in terms of health behaviour or successfully complete a challenge. |
| | Rewards | Virtual badges are rewarded to users when they successfully:<br>- complete challenges;<br>- track behaviours in consecutive days;<br>- have a HSc higher than 120 after adding behaviour data;<br>- meet health behaviour guidelines. |
| | Reminders | Users receive tailored reminders to perform certain health behaviours such as skin self-exams. |
| | Suggestion | Users receive messages that will suggest health behaviours when it's more appropriate in terms of context. For instance, if a user is at the beach and the UV index is higher than 8, the user might receive a message warning about the danger and suggesting the search of a shadow. |
| | Similarity | The app's home page (Figure 17) is designed to show the users profile picture associated with their personal name and HSc, providing the link between the person and the value presented on screen. |
| | Liking | The UI was designed to be visually attractive and very graphic. |
| | Social role | N/A |

Table 21 (continued) Persuasive analysis of the full app using the PSD framework (differences between this and the prototype app's analysis are highlighted in blue).

| PSD framework | | Happy prototype features and functionalities |
|---|---|---|
| **Category** | **Principle** | |
| **System Credibility Support** | Trustworthiness | All information provided to users is based on international cancer prevention guidelines. |
| | Expertise | The scientific team works in a major Portuguese cancer research centre and in an important University.<br>The app's dedicated website gives access to the names, pictures, short bio and contacts of the scientific team behind the app. |
| | Surface credibility | UI has a professional look designed to enhance credibility. The app is endorsed by one of the major Portuguese cancer research centre. |
| | Real-world feel | The scientific team works in a major Portuguese cancer research centre and in an important University.<br>The app's dedicated website gives access to the names, pictures, short bio and contacts of the scientific team behind the app. |
| | Authority | Several messages have OMS (and other health authorities) endorsement. |
| | Third-party endorsements | N/A |
| | Verifiability | Many messages have a reference that is easily verifiable by the users. |
| **Social Support** | Social learning | Users can compare themselves with others and see each other's HSc.<br>Users can see the number of rewarded badges that represent their performance in terms of target health behaviours. |
| | Social comparison | |
| | Normative influence | Happy allows users to see all their Facebook friends that are using the app. Users can see other users' achievements in terms of health behaviours. |
| | Social facilitation | Happy allows users to see all their Facebook friends that are using the app.<br>By tapping on a friend, users can see the breakdown of the HSc by target behaviour, providing an overview of the friends' behaviour. |
| | Cooperation | Users can support each other by using the app as a communication channel. This communication can be used to leverage behaviours and to cooperate with peers towards a similar health goal. |
| | Competition | Users can compare themselves with others and see each other's HSc.<br>All users' friends are sorted by HSc and displayed in a "scoreboard".<br>Users can see the number of rewarded badges that represent their performance in terms of target health behaviours. |
| | Recognition | All users' friends are sorted by HSc and displayed in a "scoreboard". The user with the highest HSc appears at the top of the "scoreboard", providing peer recognition. |

As can be seen in Table 21, the full app has features that cover the four categories of the PSD framework: Primary Task Support, Dialogue Support, System Credibility Support, and Social Support.

## 3.8. Study IV: Observational Study

This section describes the first study performed with the app after it was released. The purpose of Study IV was to: (1) examine user participation and engagement with the app in real-life settings, (2) analyse the reasons and sociodemographic- and engagement-related determinants of nonusage attrition, and (3) assess changes in the users' cancer prevention behaviours.

### 3.8.1. Methods

This study sought to analyse all user-generated data collected through the app between September 2016 and April 2017.

*Participants*

The smartphone app was made available in September 2016, and prospective participants downloaded the free app from the Apple App Store and Google Play Store between September 2016 and April 2017. All participants provided informed consent through the smartphone and gave permission for sharing telephone data with the researchers. The University of Aveiro's Ethics Committee approved this study (Supplementary File 6).

*Outcome measures*

The study considered the following outcomes:

- **Participation, demographics, and baseline behaviour assessment:** number of app downloads and number of registered users were recorded. Date of birth and gender were assessed when users registered in the app. Users later received a survey via email allowing the collection of education data. Registered users were then required to answer a baseline behaviour assessment. The assessed behaviours include diet, physical activity, weight, alcohol and tobacco consumption, UV radiation exposure, vaccination, screenings and self-exams.
- **Engagement parameters:** engagement with the app was defined as the duration and frequency of involvement with the app. Three measures of engagement were used: (1) the duration of app use, calculated as the number of calendar days from the first to the last time behavioural data was logged, (2) the total number of days behavioural data was recorded in the app and uploaded to the system server, and (3) number of completed challenges within the app. The combination of the first two measures informs on how "intensively" the app was used by users. For instance, users could have logged data in two different occasions during a 20-day period (low level of interaction) or logged data everyday in a 15-day period (high level of interaction).
- **Nonusage attrition:** duration of app use was also applied as an indicator of nonusage attrition. Participants were coded as "nonusage attrition observed" when they did not log any behaviour data for at least 30 days (i.e., there was ≥30 days between their last data log and the end of the observation period). All other users were coded as "nonusage attrition not observed". All users coded "nonusage attrition observed" received a link to a dropout questionnaire via email (Supplementary File 7) at the end of the observation period. The online questionnaire was

made available during June 2017, in a dedicated website. It took less than 10 minutes to complete.

- **Behavioural data:** all behavioural data logged in the app was analysed. HSc was used as an overall measure of the users' cancer prevention level. The first four months of data logged by each user were used in this analysis. All collected data was computed and monthly averages were calculated. Differences between initial and subsequent HSc values were computed for all users to show trends in cancer prevention behaviours.

*Data analysis*

Descriptive statistics and exploratory data analysis was performed. Survival analysis was used to examine differences in nonusage attrition between groups. Nonusage attrition was examined over the first 3 months after app registration and was limited to a subsample of users (n=3,068) who were potentially using the app for at least 3 months (90 days). This was done to ensure that all participants had the same chance to use the app. This means that users were included even if they logged data for a single day. The duration of app use was used as the time variable. The event variable was coded as specified in the outcome measures section with 1="nonusage attrition observed" and 0="nonusage attrition not observed". Predictors of nonusage attrition (sociodemographics, engagement parameters, and baseline HSc) were examined using Cox proportional hazard regression. Hazard ratios, representing relative risks of attrition, were calculated. Kaplan-Meier survival curves with the proportion of users "surviving" (i.e., still using the app) over time and quartiles of survival time were estimated for each user group. Comparisons of HSc data collected in the app were done using repeated measures ANOVA test. All statistical analysis was done using IBM SPSS Statistics, version 22.

Answers to the open ended questions on the dropout questionnaire were analysed using inductive thematic analysis (Bardin, 2011; Coutinho, 2011). After initial coding, highlighting relevant themes, all text segments were iteratively analysed. Themes were added or merged until they effectively represented all text segments and captured the essence of every answer. The text analysis and coding was done using the software NVIVO, version 11.

### 3.8.2. Results

*Participation, demographics, and baseline behaviour assessment*

From launch to the time of the data freeze for this study (September 2016 to April 2017) Happy was downloaded 4,691 times (data derived from iTunes Connect and Google Play

Developer Console). However, only 3,326 (70.9%) users completed the registration in the app. Likewise, only 599 (18.0%) users answered the survey sent by email and, thus, provided education data. Table 22 summarizes the sociodemographic data of the app users, along with the self-reported baseline behaviour.

Table 22 Sociodemographic characteristics and self-reported behaviours of app users.

| | | Total (n=3,326) |
|---|---|---|
| Sociodemographic characteristics | | |
| Gender, n (%) | Female | 1,988 (59.8) |
| | Male | 1,338 (40.2) |
| Age, mean (SD) | | 32.7 (11.1) |
| Education level (n=599), n (%) | Undergraduate | 115 (19.2) |
| | Graduate | 484 (80.8) |
| Self-reported behaviour (baseline) | | |
| Level of Physical Activity, n (%) | High | 475 (14.3) |
| | Moderate | 509 (15.3) |
| | Low | 783 (23.5) |
| | No response | 1,559 (46.9) |
| Fruit and vegetables (daily average), n (%) | ≥5 servings | 1,127 (33.9) |
| | 3 to 4 servings | 932 (28.0) |
| | 1 to 2 servings | 776 (23.3) |
| | None | 62 (1.9) |
| | No response | 429 (12.9) |
| Tobacco consumption, n (%) | >10 cigarettes | 156 (4.7) |
| | 1 to 10 cigarettes | 376 (11.3) |
| | Non smoker | 2,794 (84.0) |
| Motivation to quit smoking (n=532), n (%) | High | 18 (0.5) |
| | Moderate | 93 (2.8) |
| | Low | 421 (12.7) |
| Alcohol consumption (daily average), n (%) | >2 drinks | 138 (4.1) |
| | 1 to 2 drinks | 866 (26.1) |
| | None | 76 (2.3) |
| | No response | 2,246 (67.5) |
| Body mass index (BMI), n (%) | Obese | 203 (6.1) |
| | Overweight | 582 (17.5) |
| | Normal weight | 1,834 (55.1) |
| | Underweight | 274 (8.2) |
| | No response | 433 (13.0) |
| Sunburn in the previous year, n (%) | Yes | 631 (19.0) |
| | No | 2,400 (72.2) |
| | No response | 295 (8.9) |
| Performed skin self-exam, n (%) | Yes | 876 (26.3) |
| | No | 1,832 (55.1) |
| | No response | 618 (18.6) |
| Performed pap smear (n=1,988), n (%) | Yes | 1,093 (55.0) |
| | No | 511 (25.7) |
| | No response | 384 (19.3) |

Table 22 (continued) Sociodemographic characteristics and self-reported behaviours of app users.

| | | Total (n=3,326) |
|---|---|---|
| Self-reported behaviour (baseline) | | |
| Performed breast self-exam (n=1,988), n (%) | Yes | 945 (47.5) |
| | No | 696 (35.0) |
| | No response | 347 (17.4) |
| Performed testicular self-exam (n=1,388), n (%) | Yes | 355 (25.6) |
| | No | 689 (49.6) |
| | No response | 344 (24.8) |
| HPV vaccination (n=1,988), n (%) | Yes | 918 (46.2) |
| | No | 573 (28.8) |
| | Don't know | 317 (15.9) |
| | No response | 180 (9.1) |
| HBV vaccination, n (%) | Yes | 1,967 (59.1) |
| | No | 360 (10.8) |
| | Don't know | 681 (20.5) |
| | No response | 318 (9.6) |

When users answered the baseline behaviour questionnaire, they were asked what were the main barriers for all reported behaviours that didn't fulfil the corresponding cancer prevention guideline. Table 23 summarizes the top five identified barriers by behaviour and Table 24 identifies the main contexts of tobacco and alcohol consumption:

Table 23 Top five identified barriers by behaviour.

| Behavioural barriers | | n | % |
|---|---|---|---|
| Fruit and vegetable | | | |
| | Doesn't decide what eats | 632 | 26.8 |
| | Eats mostly out | 418 | 17.7 |
| | Too much work preparing | 405 | 17.1 |
| | Don't know how to cook with vegetables | 237 | 10.0 |
| | Costly | 199 | 8.4 |
| Physical activity | | | |
| | No one to workout with | 415 | 24.2 |
| | Lack of willpower | 361 | 21.1 |
| | Weather conditions | 251 | 14.6 |
| | Health issues | 224 | 13.1 |
| | No time | 191 | 11.1 |
| Sunscreen use | | | |
| | Forget to apply it | 2062 | 85.1 |
| | Want to get a tan | 176 | 7.3 |
| | Doesn't believe it is effective | 107 | 4.4 |
| | Forget it at home | 36 | 1.5 |
| | Costly | 22 | 0.9 |
| Skin self-exam | | | |
| | Don't know how | 904 | 55.7 |
| | Don't know what to search for | 314 | 19.3 |
| | Forget to do it | 98 | 6.0 |
| | Afraid to find something | 37 | 2.3 |
| | Don't have time | 34 | 2.1 |

Table 23 (continued) Top five identified barriers by behaviour.

| Behavioural barriers | | n | % |
|---|---|---|---|
| Breast self-exam | | | |
| | Don't know how | 186 | 33.8 |
| | Don't know what to search for | 94 | 17.1 |
| | Forget to do it | 46 | 8.4 |
| | Afraid to find something | 39 | 7.1 |
| | Don't have time | 16 | 2.9 |
| Testicular self-exam | | | |
| | Don't know how | 350 | 54.8 |
| | Don't know what to search for | 136 | 21.3 |
| | Forget to do it | 30 | 4.7 |
| | Don't have time | 19 | 3.0 |
| | Afraid to find something | 18 | 2.8 |
| Cervix cancer screening | | | |
| | Don't know purpose of exam | 47 | 16.5 |
| | Lack of time | 28 | 9.8 |
| | Ashamed to do it | 27 | 9.5 |
| | Don't know where to do it | 25 | 8.8 |
| | Afraid it will hurt | 20 | 7.0 |

Table 24 Main contexts of tobacco and alcohol consumption.

| Context of consumption | | n | % |
|---|---|---|---|
| Tobacco | | | |
| | Drinking coffee, tea, alcohol | 355 | 19.1 |
| | Take a break | 230 | 12.4 |
| | Being around smokers | 241 | 12.9 |
| | Stress | 179 | 9.6 |
| | Feeling bored | 124 | 6.7 |
| Alcohol | | | |
| | Social events | 497 | 42.0 |
| | Going out | 262 | 22.2 |
| | Eating at restaurants | 142 | 12.0 |
| | Eating at home | 92 | 7.8 |
| | Being with friends | 65 | 5.5 |

*Engagement parameters*

Overall, users utilized the app between 1 and 237 days (mean 30.8 days, SD 51.9) with 8.2% (273 out of 3,326) participating at least in 1 challenge. Users logged behavioural data 7.6 days (range 1-193 days), on average, with only 23.4% (779 out of 3,326) of users logging data 10 times or more. With increasing length of app usage, the number of behavioural data logged and challenges done per week decreased (Table 25). For example, users that utilized the app between 2 and 3 months (61-91 days) logged, on average, 1.3 times a week, whereas users with between 1 and 2 weeks (8-14 days) of app use logged 3.3 times a week, on average.

Table 25 Mean engagement parameters for different enrolment lengths. All users that logged behavioural data were included (n=3,140).

| Length of app usage | n | Days of app usage | Behavioural data logged (days) | | Challenges | |
|---|---|---|---|---|---|---|
| | | Mean (SD) | Mean (SD) | Mean/week (SD) | Mean (SD) | Mean/week (SD) |
| ≤ 1 week (1-7 days) | 1,611 | 2.4 (1.8) | 1.9 (1.2) | 6.2 (1.4) | 1.4 (1.3) | 2.6 (2.8) |
| 1-2 weeks (8-14 days) | 283 | 10.6 (2.0) | 5.0 (2.6) | 3.3 (1.6) | 1.9 (1.2) | 1.4 (0.8) |
| 2-3 weeks (15-21 days) | 195 | 17.8 (2.0) | 5.8 (3.8) | 2.3 (1.4) | 2.9 (3.2) | 1.2 (1.3) |
| 3-4 weeks (22-29 days) | 156 | 25.5 (2.4) | 8.8 (5.7) | 2.4 (1.5) | 2.2 (1.9) | 0.6 (0.5) |
| 1-2 months (30-60 days) | 338 | 42.2 (9.1) | 10.4 (8.4) | 1.8 (1.4) | 3.9 (4.2) | 0.7 (0.8) |
| 2-3 months (61-91 days) | 169 | 75.9 (9.1) | 14.5 (13.4) | 1.3 (1.2) | 2.9 (2.5) | 0.3 (0.2) |
| 3-4 months (92-122 days) | 104 | 105.6 (9.7) | 17.7 (18.3) | 1.2 (1.2) | 3.5 (5.4) | 0.2 (0.4) |
| 4-5 months (123-152 days) | 98 | 137.6 (7.9) | 27.1 (32.0) | 1.4 (1.6) | 5.3 (6.0) | 0.3 (0.3) |
| 5-6 months (153-182 days) | 68 | 168.5 (9.2) | 26.0 (25.5) | 1.1 (1.1) | 8.7 (12.6) | 0.4 (0.5) |
| 6-7 months (183-212 days) | 65 | 200.3 (8.9) | 35.1 (38.1) | 1.2 (1.3) | 3.2 (4.2) | 0.1 (0.1) |
| 7-8 months (213-237 days) | 53 | 226.1 (7.3) | 49.3 (53.5) | 1.5 (1.6) | 7.9 (12.5) | 0.2 (0.4) |

*Nonusage attrition*

The following results are based on a subsample (n=3,068) only including users who registered in the app 3 or more months prior to the end of the observation period (30 April 2017). Sociodemographics, engagement parameters, and baseline HSc were analysed as potential predictors of nonusage attrition in the subsample (Table 26).

In the univariate analysis, having a degree (hazard ratio=0.746, 95% CI 0.605-0.919, p=0.006), being of higher age (hazard ratio=0.981, 95% CI 0.978-0.984, p<0.001), using the challenges section of the app (hazard ratio=0.587, 95% CI 0.514-0.669, p<0.001), and having a higher baseline HSc (hazard ratio=0.993, 95% CI 0.992-0.995, p<0.001) reduced the risk of attrition. An increase on the number of logs per week increased the risk of attrition by 50% (hazard ratio=1.554, 95% CI 1.524-1.583, p<0.001). Results from the multivariate analysis showed a similar pattern (Table 26) except that graduate users did not differ significantly from undergraduate users (hazard ratio=0.820, 95% CI 0.661-1.017, p=0.070) when controlling for other variables in the analysis.

Table 26 Univariate and multivariate Cox regression analysis: association of nonusage attrition risk with sociodemographics, engagement parameters, and baseline HSc in the subsample of users (n=3,068).

| Dependent variables | Univariate Hazard ratio (SE), 95% CI | p | Multivariate Hazard ratio (SE), 95% CI | p |
|---|---|---|---|---|
| Gender | | | | |
| Female | Reference | | Reference | |
| Male | 0.936 (0.38), 0.869-1.007 | 0.077 | 0.136 (0.104), 0.926-1.393 | 0.222 |
| Education | | | | |
| Undergraduate | Reference | | Reference | |
| Graduate | 0.746 (0.107), 0.605-0.919 | 0.006 | 0.820 (0.110), 0.661-1.017 | 0.070 |
| Age | 0.981 (0.002), 0.978-0.984 | <0.001 | 0.977 (0.006), 0.964-0.989 | <0.001 |
| Mean logs/week | 1.554 (0.010), 1.524-1.583 | <0.001 | 1.566 (0.024), 1.496-1.640 | <0.001 |
| Challenges | | | | |
| No | Reference | | Reference | |
| Yes | 0.587 (0.067), 0.514-0.669 | <0.001 | 0.471 (0.131), 0.346-0.609 | <0.001 |
| Baseline HSc | 0.993 (0.001), 0.992-0.995 | <0.001 | 0.990 (0.002), 0.986-0.995 | <0.001 |

Using the challenges section of the app had the highest effect on attrition reduction in both analyses. To better describe this effect, a Kaplan-Meier survival curve was plotted with two user groups (used the challenges app section vs. didn't use the challenges app section) based on the duration of usage (Figure 31).

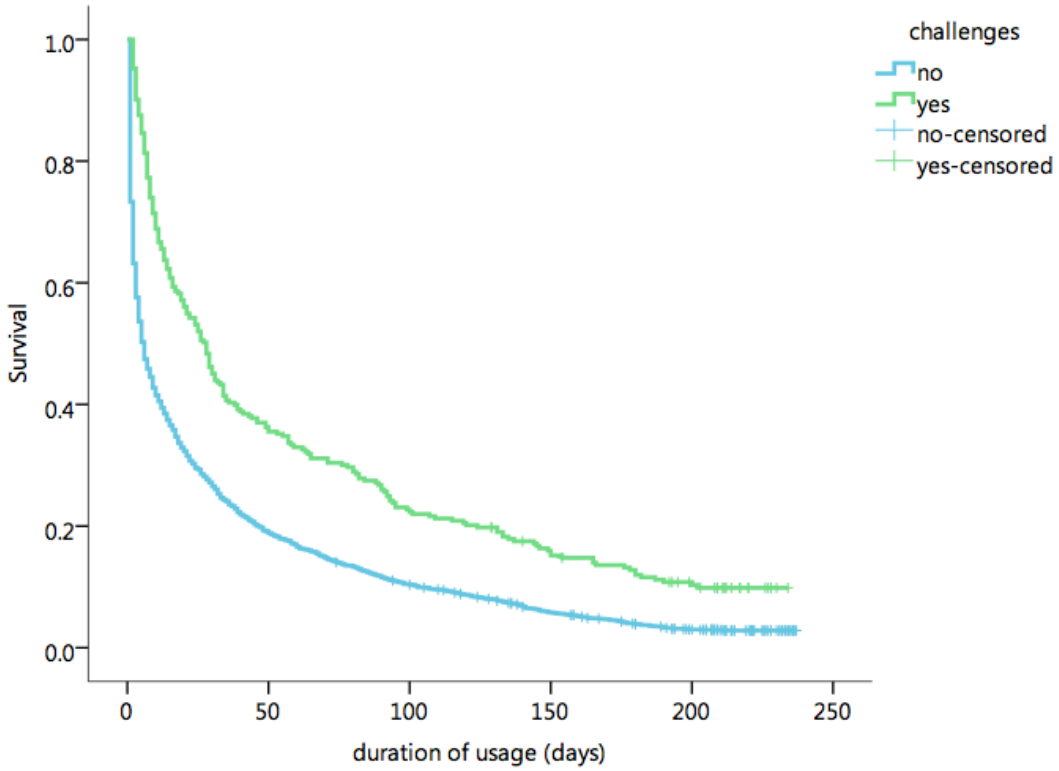



Figure 31 Nonusage attrition curve for user groups (used challenges section vs. didn't use challenges section) in the subsample of users (n=3,068).

The log-rank test showed that the survivor functions were significantly different across groups ($\chi 2\ 2=70.049$, $p<0.001$). Estimated app usage also differed between groups (Table 27).

Table 27 Survival time by group in the subsample of users (n=3,068).

| User group | Percentage of users still using app[a] | | |
|---|---|---|---|
| | 75% | 50% | 25% |
| Used challenges | 8 days | 28 days | 92 days |
| Didn't use challenges | 1 day | 6 days | 33 days |
| All users | 2 days | 7 days | 36 days |

[a] Table indicates at what point in time (days) 75%, 50%, and 25% of users were still using the app for the different user groups

Estimated median lifetime usage (time after which 50% stopped logging behavioural data) was 7 days for all groups combined. For all groups combined, 25% (767/3,068) were still logging steps after 36 days. Among the users that used challenges, these estimates greatly increased: 25% (68/273) were still logging data after 92 days.

All users that stopped using the app for more than 30 days at the end of the observation period (n=3,164) received an email with a link to a dropout questionnaire. A total of 212 users (6.7%) accessed the questionnaire but only 57 (1.8%) answered it. The main reasons to stop using the app are presented in Table 28.

Table 28 Dropout reasons (n=57).

| Dropout reasons | n | % | Illustrative quotations |
|---|---|---|---|
| Other expectations | 14 | 24.6 | *Not what I was expecting.* |
| Workload and time required | 10 | 17.5 | *Lack of time to dedicate to the app.* |
| Technical issues | 9 | 15.8 | *Lack of storage capacity on my iPhone.* |
| Forgetfulness | 5 | 8.8 | *Forgot that I had it installed.* |
| Confidence in own knowledge | 4 | 7.0 | *I already do what the app tells me to do.* |
| Competing interests | 4 | 7.0 | *It was one app among many that I use throughout the day.* |
| Personal reasons | 3 | 5.3 | *I'm older than the target population of the app.* |
| Lack of familiarity with system | 2 | 3.5 | *I lack a general interest in technologies, not specifically this app.* |
| Satisfaction with obtained results | 2 | 3.5 | *Once I've learned in the app what I should do, there was no need to use it.* |
| External events | 2 | 3.5 | *Prolonged voyage to another country with a different context from Portugal.* |
| Usability and interface issues | 1 | 1.8 | *Didn't understand how to use the app.* |
| Apathy towards cancer education | 1 | 1.8 | *Because I didn't change my habits and the score would remain the same.* |

*Behavioural data*

Analysis of logged behavioural data showed a positive trend in several cancer prevention behaviours that translated in an average 4 point increase in HSc (Figure 32).

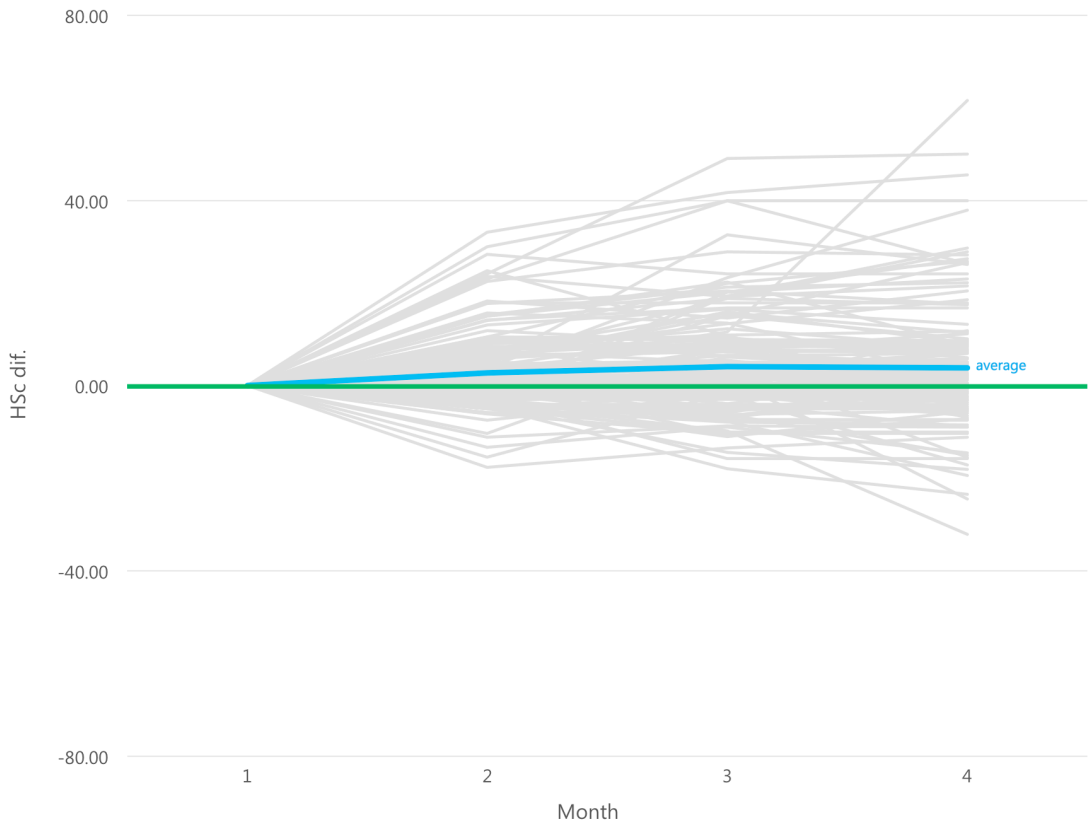



Figure 32 Changes in users' HSc during the first four months of app use. Each grey line represents a diferent user. The blue line depicts the average HSc difference for the whole group of users.

A repeated measures ANOVA analysis showed that the change in HSc was statistical significant ($p<0.001$).

## 3.9. Study V: Quasi-Experimental Study

This section describes a 6-month quasi-experimental study performed with the app after it was released. The purpose of Study V was to assess the effectiveness of Happy in terms of behaviour change and cancer prevention knowledge. Partial results of this study are explored in Paper IV.

### 3.9.1. Methods

A three-arm quasi-experimental design was used with baseline, 3 month, and 6 month assessments. All elements in the intervention groups used the smartphone app Happy, whereas the elements of the control group didn't.

*Participants*

All app users received an email with a link to an online questionnaire (Supplementary File 8) in the day of registration (beginning of the study). Only users that registered between September and October 2016 (n=2,717) were considered for the purposes of this study, given the time needed to complete the study (6 months) and the time of data freeze (30 April 2017). App users that answered the questionnaire and had more than 18 years were included in the intervention group. The same email was sent to a mailing list from University of Aveiro (n=2,558). Every individual that answered the questionnaire, had a smartphone and had more than 18 years was included in the control group. Three and six months later, all study participants received a new email requiring them to answer the same online questionnaire. At the end of the study, all data logged by elements of the intervention group was analysed. Duration of app use, calculated as the number of calendar days from the first to the last time behavioural data was logged, was used to sort app users in two different intervention groups. Users were classified as "low users" if they had less than 30 days of app use and "high users" if they had 30 or more days of app use. The University of Aveiro's Ethics Committee approved this study (Supplementary File 6).

*Outcome measures*

The study considered the following outcomes:

- **Cancer prevention knowledge:** cancer prevention knowledge was evaluated from data provided on the online questionnaire at each assessment (baseline, 3 month, and 6 month). Participants answered 15 multiple-choice questions concerning several dimensions of cancer prevention (risk factors, epidemiology and behaviour guidelines). Results of each assessment are presented as percentages of correct answers.
- **Cancer prevention behaviour:** cancer prevention behaviour was evaluated from data provided on the online questionnaire at each assessment (baseline, 3 month, and 6 month). Participants answered the same questions included in the app's behaviour assessment questionnaire. Number of complied cancer prevention guidelines (please see 2.2. Preventability

of Cancer) was used as an overall measure of the study participants' cancer prevention level. Given the different number of guidelines available for women and man (11 and 9, respectively), percentages were calculated to allow comparison.

*Data analysis*

Descriptive statistics was performed. Comparisons of cancer prevention knowledge and behavioural data collected in the study were done using repeated measures ANOVA test. All statistical analysis was done using IBM SPSS Statistics, version 22.

### 3.9.2. Results

*Participants*

As shown in Figure 33, a total of 2,771 and 2,558 participants were eligible for the intervention and control groups, respectively. Of these, 523 (16.1%) and 103 (4.0%) answered the baseline questionnaire. Between the 3 month and 6 month assessments, 497 (95.0%) and 47 (45.6%) didn't answer the questionnaire and, thus, were lost to follow-up in the intervention and control groups respectively. At the end of the study, 12 and 13 app users were assigned to the low users and high users groups, respectively. One participant was excluded from the control group because she downloaded the intervention app.

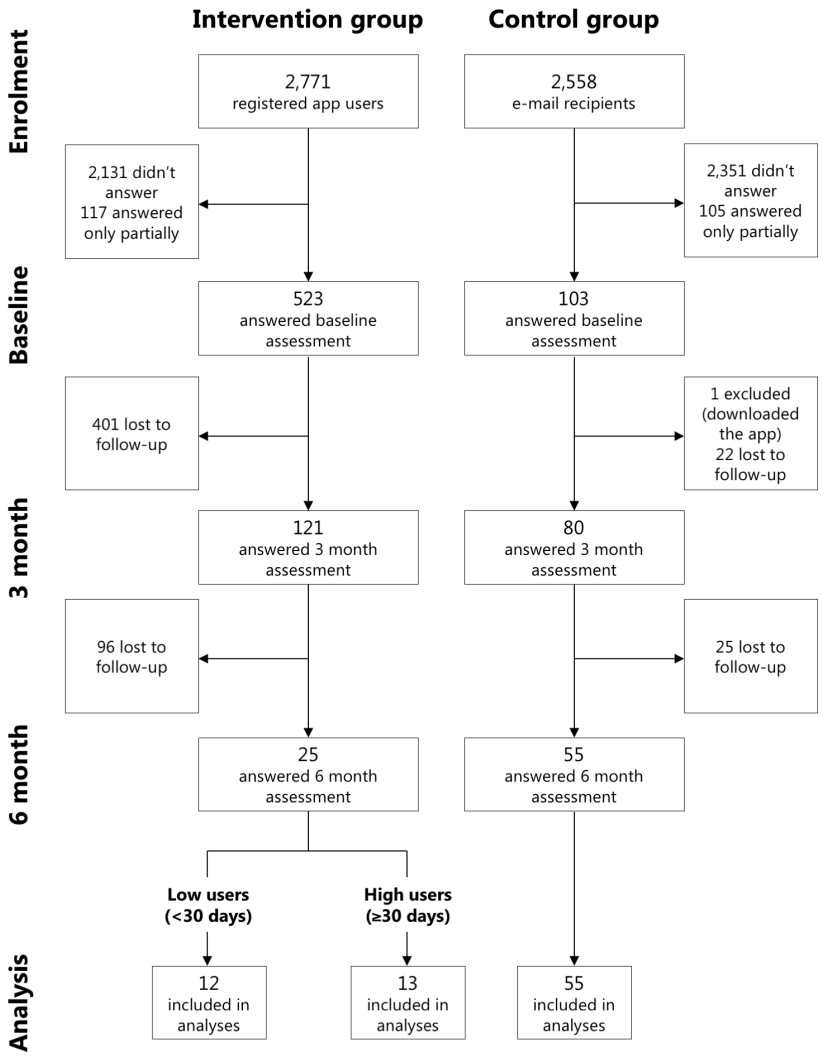



Figure 33 Study enrolment overview.

Participant characteristics are presented in Table 29. Participants were predominantly 18 to 25 years old (45.0%), female (77.5%), and had a college degree (85.0%).

Table 29 Sociodemographic characteristics of study participants.

| | All (n=80) | Intervention group: low users (n=12) | Intervention group: high users (n=13) | Control group (n=55) |
|---|---|---|---|---|
| Gender, n (%) | | | | |
| Female | 62 (77.5) | 10 (83.3) | 9 (69.2) | 43 (78.2) |
| Male | 18 (22.5) | 2 (16.7) | 4 (30.8) | 12 (21.8) |
| Age, n (%) | | | | |
| 18-25 years | 36 (45.0) | 3 (25.0) | 2 (15.4) | 31 (56.4) |
| 26-30 years | 19 (23.8) | 3 (25.0) | 1 (7.7) | 15 (27.3) |
| 31-40 years | 25 (31.3) | 6 (50.0) | 10 (76.9) | 9 (16.4) |
| Education, n (%) | | | | |
| Undergraduate | 12 (15.0) | 0 (0.0) | 2 (15.4) | 10 (18.2) |
| Graduate | 68 (85.0) | 12 (100.0) | 11 (84.6) | 45 (81.5) |

*Cancer prevention knowledge*

Figure 34 shows the baseline, 3 month, and 6 month knowledge assessment results:

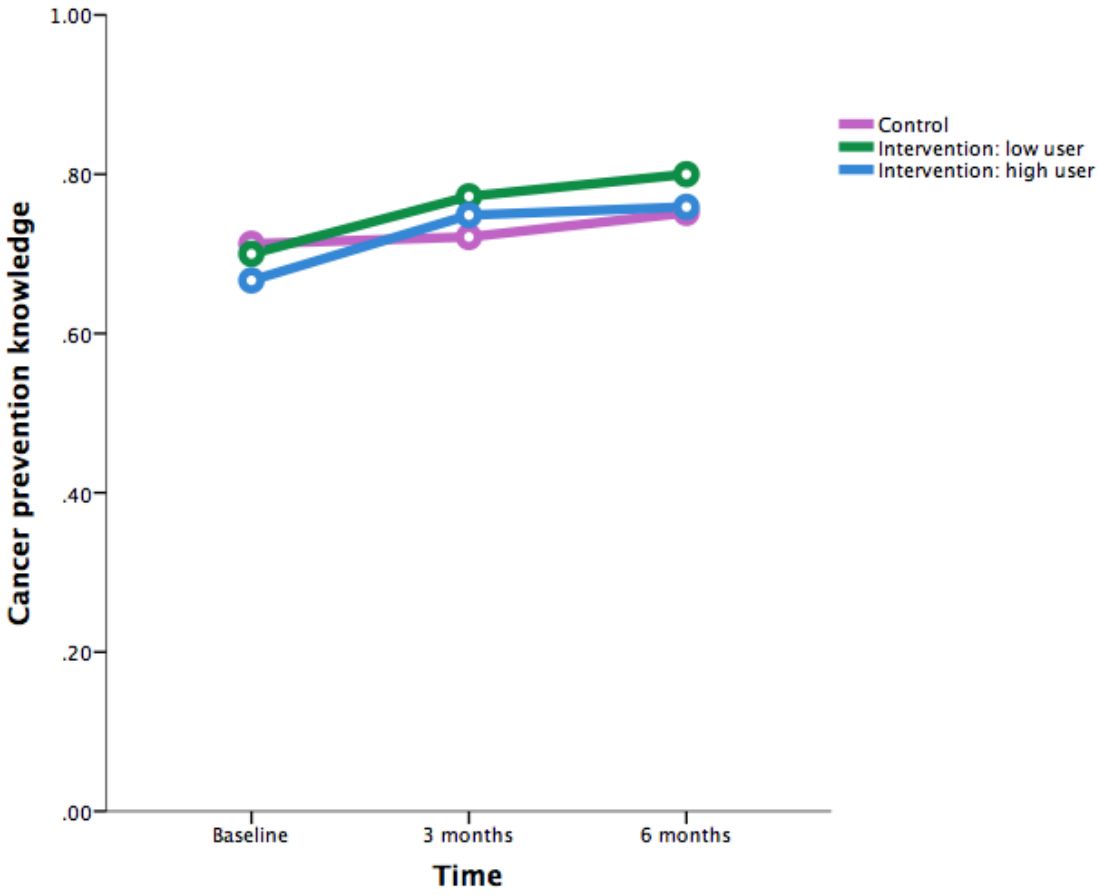



Figure 34 Cancer prevention knowledge assessment results.

The intervention group observed an increase in knowledge from baseline to the 6 month assessment, with a mean 10 point increase (from 0.70 at baseline to 0.80 at 6 months) in the low users, and a mean 9 point increase (from 0.67 at baseline to 0.76 at 6 months) in the high users. The control group observed a mean 4 point increase (from 0.71 at baseline to 0.75 at 6 months). However, a repeated measures ANOVA analysis showed that the observed differences between groups were not statistically significant (p =0.092).

*Cancer prevention behaviour*

Figure 35 shows the baseline, 3 month, and 6 month behaviour assessment results:

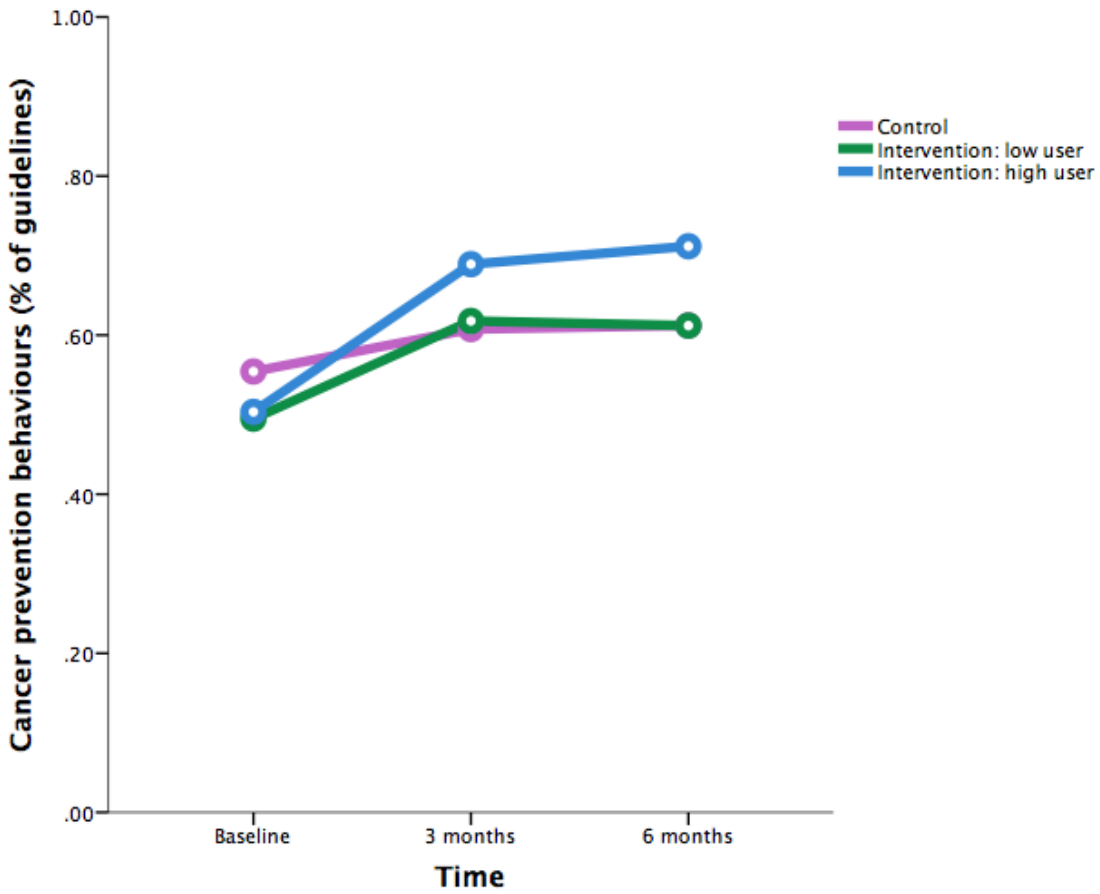



Figure 35 Cancer prevention behaviour assessment results.

In terms of behaviour, the intervention group observed a significant increase in the percentage of complied cancer prevention guidelines. This was more evident in high users, with a mean increase of 21 points (from 0.50 at baseline to 0.71 at 6 months) than in low users, with a mean increase of 12 points (from 0.49 at baseline to 0.61 at 6 months). The control group also observed an increase, by a mean of 6 points (from 0.55 at baseline to 0.61 at 6 months). A repeated measures ANOVA analysis showed that the observed differences between groups were statistically significant (p =0.011).

## 3.10. Discussion

The main purpose of this work was to research and develop a cancer prevention strategy, using smartphones, capable of supporting behaviour change in a young adult population. Several studies were performed and led to the development of a cancer prevention smartphone

app, tested in real-life contexts. Several points from this work should be highlighted and require further discussion.

The target population of this cancer prevention project were healthy Portuguese young adults, with ages between 18 and 40 years. During this work, several questionnaires were applied to this population, allowing us to characterize them in terms of cancer prevention behaviours. The majority has a low level of physical activity, and consumes less than 5 daily portions of fruit and vegetables. Nearly a quarter of them smokes tobacco and/or drinks alcohol, and is above normal weight. In terms of secondary prevention, half of all female participants hasn't performed a pap smear and/or a breast self-exam, putting them at a higher risk of cervical and breast cancer, two common forms of cancer in women (Torre et al., 2015). Likewise, the majority of male participants had never performed a testicular self-exam, a simple and quick way to detect the most frequent cancer in young men in western populations (Van Hemelrijck, Shanmugalingam, Soultati, Chowdhury, & Rudman, 2013). Also, many participants had at least one sunburn in the year before answering the questionnaire and only about a quarter had performed a skin self-exam, undermining the possibility of preventing the most common form of cancer (non-melanoma skin cancer) (Day et al., 2013). This confirms previous observations concerning this population's lack of cancer awareness (Katz et al., 1995; Sherman & Lane, 2014). Healthy Portuguese young adults have to improve their behaviour if they want to stay healthy in the future. This scenario stresses the need to design cancer prevention interventions that could reverse these numbers.

Study I revealed that many participants had already used their smartphone to monitor health-related behaviours (Table 11). Study III results also indicated that participants were willing to have a cancer prevention app installed in their own smartphones and to receive messages that promote prevention behaviours. This shows that young adults are receptive to the idea of using health-related apps in their daily lives and reinforces the belief that a cancer prevention intervention delivered by smartphone is adequate for this population. The number of app downloads registered from launch (September 2016) to April 2017 corroborates this view: almost 5,000 downloads in 7 months is impressive, especially if we take into account that the app was only available in the Portuguese market and almost half of all health-related apps don't reach this number (Aitken, 2015).

Data from Study IV (Table 22) shows that the population using Happy is similar to other mhealth app user populations (Carroll et al., 2017; Ernsting et al., 2017; Krebs & Duncan, 2015), and that the app reached the intended population: young adults that currently don't comply

with cancer prevention guidelines. It is also worth noting that, among users that smoked, the motivation to quit was, overall, low. It is reasonable to think that these users would never download a quit smoking app. However, by downloading this app, they were exposed to health messages motivating them to quit smoking, providing a good opportunity for them to change this harmful behaviour. This underlines the importance of multiple behaviour interventions as opposed to single behaviour interventions. Likewise, analysing the reported barriers and contexts of behaviours (Table 23 and Table 24), we can verify that the most cited barriers are related to lack of knowledge, forgetfulness, and social barriers. Interventions delivered by smartphone (such as the one developed in this work) can tackle these barriers by providing information, reminding users, and intervening in typical social contexts by using geolocation.

Study I explored the views and experiences of healthy Portuguese young adults concerning the essential features a cancer prevention smartphone app that seeks behaviour change should have. Overall, the results were concurrent with other studies (Ahtinen et al., 2009; Consolvo et al., 2012; Dennison et al., 2013; Rabin & Bock, 2011). However, there are some specificities that should be explored more thoroughly. Study participants identified four main features that should be included in a cancer prevention smartphone app: health behaviour tracking, health goal setting, reminders and tailored information. The first two were seen as more engaging and motivating and could be the core features to support behaviour change. It was implied by several participants that seeing how we behave could be a call to action for most people and lead to the desired behaviour change. Likewise, most participants considered that having goals to achieve was an important motivational factor and a feature that should be included. This has also been reported in previous studies (Ahtinen et al., 2009; Consolvo et al., 2012; Dennison et al., 2013). The ability to set reminders was viewed as a very important feature, mainly to remind scheduled medical appointments but also to remind to comply with healthy guidelines (eat more fruit, for example). This feature was also highlighted in another study (Ramanathan, Swendeman, Comulada, Estrin, & Rotheram-Borus, 2013). Finally, study participants noted the importance of tailoring health information provided to the user. Several participants highlighted this feature as a way to help users understand what they have to do without being overwhelmed by too much information. This feature was stressed as essential when it concerns cancer, as there are many misconceptions and myths surrounding this disease (Burak & Boone, 2008). Regarding information sharing, focus group participants showed some openness as long as this was user controlled and only in specific contexts, like between users with similar problems or with friends for competition purposes. However, online respondents seemed less keen on

sharing information, despite recognising its value – the majority agreed that sharing information with similar users would help them cope. This tendency was particularly apparent in female respondents and regarding information sharing for competition or comparison purposes. Also, some concerns were raised regarding privacy and safety of health information. This attitude towards information safety and sharing via social networks was also seen before (Dennison et al., 2013). This seems to indicate that, although social sharing can be present in a cancer prevention app, it should always be optional and user controlled and it shouldn't be the main focus of the app.

As for long-term use of health apps, Study I results seem to show that, if a user perceives the cancer prevention app as useful, with a good user experience, and having an increased value to them (mainly due to the type of information it contains), they will be more likely to use it for a long period of time. This is an important finding because if we want them to change behaviour in a consistent and sustained way, we have to find ways to engage users for a long period of time. It is also in accordance with a study that analysed factors influencing the continued use of health apps (Cho, 2016).

Study I also showed that features associated with gamification (use of virtual badges, competition with others), designed to increase motivation and to further engage users with apps, don't seem to be important dimensions for long-term use of health related apps. However, Study IV results point to a different direction: using the challenges section of the app was associated with a lower risk of user attrition. This seems to show that the *intent* to use an app and the *actual use* of the app are two different experiences that might not fully coincide. This highlights the need for studies that analyse the use of smartphone apps in real-life settings and go beyond intents of use or pilot study participation.

Study I allowed the definition of a guideline set for the development of a cancer prevention smartphone app (Table 8). This guideline set was the basis of the work that led to the development of Happy's prototype. Several volunteers tested the app prototype by performing the usability tests (Study II) and participating in the pilot study (Study III). These studies allowed the identification of some usability and technical issues in the prototype. For instance, only 18.8% of the pilot study participants felt like the messages were designed for them (Table 17). This seemed to indicate that the tailoring process wasn't effective. A closer look into the tailoring algorithm identified a technical issue that might explain that result. Due to problems associated with geolocation, most of the messages sent by the app during the pilot study missed the context of the user. Thus, participants received general messages mostly about

cancer prevention and cancer risk factors that are relevant to them but didn't consider it as sufficiently tailored messages. The tailoring algorithm was later improved in the full app to ensure that message tailoring effectively occurred.

Study III showed that the app was easy to use and can be easily accepted by users. The overall experience with the app was considered positive. However, there was the need to improve several things in the prototype app, mainly in error recovery features. Also, the majority of participants expected more features in the app indicating that the prototype version required more development to add new functionalities. During the interviews, several study III participants suggested adding challenges and social features to the app. These suggestions were taken into account and the proposed features were integrated in the app's full version.

Happy was designed for daily use with one message and one behaviour question sent to participants everyday as push notifications. This app relied on a continuous, yet low burden, use. However, results from Study III showed that the dropout rate was high, with only 6 users (19.0%) completing the full trial period, and that users logged data, on average, in just 12 different occasions during the 28-day trial. Such trend was also consistent in interview recruitment, with only 10 pilot study participants opting-in on the interview. User engagement was also low when we consider Study IV results. On average, users logged data in 7.6 days (range 1-193 days), with only 23.4% (779 out of 3,326) of users logging data 10 times or more. Results also show that, the longer the users utilized the app, the less they engaged with it each week. This has been reported in previous studies and seems to be a side effect of using health-related apps in real-life settings (Consumer Health Information Corporation, 2011; Guertler et al., 2015; Kim et al., 2016; McConnell et al., 2016). This has been described as the "Law of attrition" and is one of the fundamental methodological challenges in the evaluation of mhealth applications (Eysenbach, 2005). Unlike drug trials, where the intervention is "prescribed" to patients, in studies involving health information technology usage is at the discretion of the participant and he/she can easily discontinue usage. In mhealth longitudinal studies such as the ones performed in this work, where the intervention is neither mandatory nor critical for the participants' health, trial participants will most certainly be lost and might reduce the intervention group to a small amount of participants. Several factors have been proposed that might influence nonusage and dropout attrition in mhealth interventions such as inappropriate information (leading to unrealistic expectations), ease of enrolment and drop out, usability and interface issues, lack of personal contact, workload and time required, competing interests, among others (Eysenbach, 2005). Results from the dropout questionnaire (Table 28) showed that the dropout reasons

advanced by study participants are in line with the factors proposed by Eysenbach (2005). Factors related to the ease of dropout (participants could stop using the app at any time) and the lack of personal contact between researcher and study participants (recruitment was done online and all contacts, if any, occurred through e-mail), despite not being mentioned by questionnaire respondents, should also be considered as possible explanations for the observed dropout rates. Another point to consider is the different shape of the dropout curves from Study III (Figure 22) and Study IV (Figure 31). Study III curve is flatter, gradually decreasing towards the end of the study. Study IV curve, on the other hand, is "L-shaped" depicting a rapid decrease of app use after the first day. These differences have also been observed in other studies (Christensen, Griffiths, Korten, Brittliffe, & Groves, 2004) and relate to the type of environment in which the studies are conducted. In this sense, Study III had a more "formal" structure, with some contacts occurring between researcher and study participants during the recruitment stage and at the start of the trial, whereas Study IV was totally "open", with participants spontaneously enrolling in the intervention by downloading and using the app. This led to a substantial number of users that were curious in seeing how the app worked but weren't willing to invest time with it and, thus, for whom the intervention isn't suitable.

Study IV allowed the identification of several parameters that reduced the risk of attrition. Being older, having a higher HSc at baseline assessment, and using the challenges section of the app were associated with a lower risk of attrition. Using the challenges section of the app had the highest effect on attrition reduction (Figure 31), increasing by more than 3 fold the amount of time spent using the app (Table 27). This result corroborates the findings of other studies regarding gamification effects (Hamari, Koivisto, & Sarsa, 2014; Johnson et al., 2016; Muntean, 2011) but contradicts Study I findings. Study I participants considered gamification features as non-important for long-term use of health related apps, but data from the Study IV shows quite the opposite. Previous studies have also reported the null effects of gamification. For instance, a study by Zuckerman and Gal-Oz (2014) showed that the use of virtual rewards didn't improve the effectiveness of a smartphone app for physical activity promotion. Further investigations should be performed to better understand the role of gamification in long-term user engagement.

Results from Studies III-V suggest that Happy is an effective way to promote cancer prevention. Study III participants highlighted in the interviews the HSc represented on the landing page, the behaviour assessment questionnaire, and the tailored messages as the main functionalities that might contribute to this goal. Thus, results seem to indicate that these features can be successfully used in the promotion of cancer prevention behaviours. In fact, the

majority of Study III participants agreed that the app might increase cancer awareness and knowledge, and even motivate users to change behaviours (Table 18). This is corroborated by the behavioural data collected. Average HSc increased by 7 points during the 28-day trial (Study III) and by 4 points during the first 4 months of usage (Study IV).

Another point that deserves further consideration is related to how users changed behaviour during app use. Analysing Figure 23 and Figure 32, we can easily identify users that rapidly increased their HSc and others that decreased it, almost symmetrically. Thus, we can consider that the app had different effects in different types of users and did not lead to a behaviour improvement in all cases. This seems to show that certain types of users are more receptive to this type of approach. Further investigations should be performed to characterize these user profiles and the app should focus on the more receptive profile to enhance the observed effects in behaviour change.

Study V results showed a significant increase in cancer prevention behaviours in the experimental group compared to the control group. It also showed that high users (users with 30 or more days of app usage) outperformed low users (users with less than 30 days of app usage), indicating the effect of app use on behaviour. The timespan of Study V also allows us to conclude that this wasn't a short-term effect.

Study V results also showed that cancer prevention knowledge increased in both experimental groups but didn't differ significantly from the control group. This is not entirely surprising given that Happy wasn't primarily a cancer information app. Information was delivered to users in small pieces (in the form of short messages) and seamlessly dispersed within the app, with the specific goal of persuading users to perform the target behaviours. The knowledge increase observed in the experimental group was probably due to the use of tailoring. As described, users received messages that were tailored to their profile and physical context. This allowed the delivery of relevant cancer prevention messages that are more likely to be remembered and processed by the receiver, thus contributing to knowledge increase.

Despite the positive impact of Happy found in Study V, it is worth noting that the implementation of the study was suboptimal. Over 90% of the intervention group and almost half of the control group were lost to follow-up, leaving a final sample of 25 and 55 individuals, respectively. Thus, results from this study shouldn't be generalized to the whole study population. Nonetheless, these results provide strong evidence of Happy's persuasive power and effectiveness as a BCSS that can be merged into the users' daily routine. They also

emphasize the need for a continuous use of the app, highlighting the importance of long-term user engagement.

Happy seems to be an effective cancer prevention app. If we consider that this app was designed to be very simple, sending one single tailored message per day and providing instant feedback to users' reported behaviours, the results are quite impressive. It shows that health-related apps can be effective without burdening users with too much information or too many calls to action. It also provides some support to FBM as a theoretical framework. The goal of this thesis was not to test whether the behaviour model had a good predictive value but to use it as a conceptual guide in the design choices that inevitably have to be made when designing a smartphone app. By enhancing the persuasiveness of the smartphone app and designing tailored messages as behaviour triggers we ended up with a cancer prevention smartphone app that works as an effective BCSS.

# 4 Conclusions

This thesis has presented five distinct studies related to the iterative process that led to the development of a cancer prevention smartphone app called Happy. The first study provided vital information for the design of a cancer prevention app and allowed the development of the prototype app. The prototype was then validated in the second and third studies with elements of the target population. These studies showed that the app was usable and easily accepted by users. They also highlighted the need for improvements and allowed the identification of some technical issues. These were tackled, and the solutions were embedded in the full app. The full app was then used in two more studies that looked into the context of usage in real-life settings and assessed the effectiveness of the app. The work performed in this thesis allowed the fulfilment of the research objectives as follows:

- *Determine the fundamental features of a cancer prevention smartphone app designed to support behaviour change in a young adult population*

Study I allowed the definition of a guideline set for the development of a cancer prevention smartphone app (Table 8). The proposed guideline set translates the knowledge gained from the performed study and can be a very useful tool for the development of health-related apps focused on behaviour change and cancer prevention.

- *Define effective communication strategies, using smartphones, to prompt healthy behaviours on users*

App development and Study II and III results allowed the definition of several communication strategies that effectively prompt healthy behaviours on users. These include the messages sent to users everyday by the app, the presence of the HSc represented on the landing page, and the behaviour assessment questionnaire. These strategies were tested and validated in Study III.

- *Prototype and develop a cancer prevention smartphone app*

  A cancer prevention smartphone app called Happy was developed through an iterative process from requirement analysis, to prototype, to full version. The app is currently available for download in the Apple App Store and Google Play Store.

- *Validate the cancer prevention smartphone app in a young adult population*

  Happy was validated in studies III, IV and V. The validation process provided insights into the receptiveness of the population to this type of apps, and how the app is used in real-life settings.

- *Understand how a cancer prevention smartphone app is used in real-life settings*

  Study IV provided several insights on how a cancer prevention app is used in real-life settings. These insights are very useful because they provide data for research on app use, and allow the definition of realistic goals in similar projects.

- *Understand the role of sociodemographic- and engagement-related determinants in smartphone app use*

  Study IV provided some results concerning the determinants in app use. These results seem to point out the important role that gamification features might have in long-term user engagement. This contradicted the prospective results from Study I, highlighting the importance of triangulation in research.

- *Analyse the effectiveness of the cancer prevention application, considering both cancer prevention knowledge and behaviour change*

  Study V tested the effectiveness of Happy in terms of cancer prevention knowledge and behaviour. Cancer prevention behaviour significantly increased in the experimental group, providing strong evidence of the effectiveness of the app as a BCSS.

The research performed in this thesis had an exploratory nature. It relied in several theoretical principles emerging from research fields like cancer prevention, behaviour change, and mhealth to develop a "prototype solution" for cancer prevention education. The research journey allowed many learning opportunities and led to several important findings:

- In general, healthy young adults don't comply with cancer prevention guidelines. This is true for protective behaviours like having a healthy diet or performing self-exams, as well as for risky behaviours like smoking and drinking alcohol.
- Healthy young adults are already using health-related apps and are willing to use a cancer prevention app on their own smartphones, opening the door for the implementation of cancer prevention interventions via smartphone.
- Cancer prevention apps should be designed to be useful, with a good user experience, and with increased value to the user (mainly due to the quality of cancer information it provides).
- This type of app attracts many "curious users" leading to high dropout rates and nonusage attrition. This user behaviour is similar to the one reported in other studies (for instance, Guertler et al., 2015; Kim et al., 2016; McConnell et al., 2016) and appears to be a side effect of using health-related apps in real-life settings.
- Long-term user engagement is needed to effectively persuade users to adopt cancer prevention behaviours.
- User engagement is affected by many factors such as education level and age of users. In the case of Happy, adherence to the challenges section of the app had the highest effect on attrition reduction. This emphasizes the importance that gamification features can have in user engagement.
- Happy proved to be effective as a behaviour change support system that can merge into the users' daily routine and seamlessly persuade him/her to adopt cancer prevention behaviours.
- A relatively simple app that sends one tailored message per day and provides instant behaviour feedback can have a powerful effect in users, persuading them to change behaviours towards cancer prevention.

These findings provide support to the feasibility and potential impact of cancer prevention interventions delivered by smartphone. Furthermore, they point out the importance of user engagement for the success of this type of behaviour change intervention. If we want users to change behaviour in a consistent and sustained way, we have to find ways to engage them with the app for a long period of time.

It is worth mentioning that the findings discussed in this thesis are not limited to the use of smartphones. Technology will continue to evolve and the field of mhealth will certainly see some dramatic changes in the near future. Nonetheless, the concepts and guidelines that emerged from this work and led to the development of the smartphone app Happy can be used in other technological settings and, thus, continue to be valid when we consider new types of mobile devices.

## 4.1. Contributions to the field

Mobile health is a relatively new research field that has developed rapidly in the last few years. Many studies start to emerge exploring new concepts and ideas about the use of mobile devices in health-related areas. This is an inherent characteristic of a young research field that is taking the first steps towards general principles and theories that apply to a larger set of conditions. This thesis is one more step towards this purpose.

This work applied several questionnaires that allowed the characterization of young adult's cancer prevention behaviour. Despite not being a major objective of this work, it provided behaviour data that allows us to assert that young adults generally don't comply with cancer prevention guidelines. This emphasises the importance of designing interventions targeting this population.

The field of cancer prevention has been relatively unexplored in mhealth, particularly using a multiple behaviour approach. Many researchers choose to focus on a single behaviour, neglecting the interactions that exist between different behaviours and treating the individual as a set of independent actions. This work took a different approach on behaviour change, taking into account that cancer prevention relies on numerous types of behaviours, rendered in several guidelines. Thus, the multiple behaviour approach described here provides a different point of view that adds up to other studies, enriching the empirical research done in this research field.

Likewise, most behaviour change interventions have focused on populations that are older or affected by disease. By targeting a healthy young adult population, this work also contributes to the field by providing a proof-of-concept regarding the openness of the population to receive behaviour change interventions via such personal devices as smartphones.

This thesis used FBM as a framework, expanding the theoretical approach beyond "classical" behaviour change theories. In the context of this work, FBM proved to be very useful, providing the theoretical background that informed the design of the cancer prevention smartphone app. Testing different theories and models might lead to new ideas and concepts that, in turn, can be used in novel approaches. This expands the research field and is, therefore, one more contribution of this work.

Happy's development took into account the views and experiences of healthy young adults concerning the fundamental features of a cancer prevention smartphone app that seeks behaviour change and led to the definition of a guideline set for the development of a cancer

prevention smartphone app. This guideline set is a major theoretical contribution of this thesis for the research field.

Smartphone app markets, such as Apple App Store and Google Play, are full of health-related apps. However, very few app evaluations appear in scientific literature, and, conversely, very few smartphone apps developed by researchers have been released to the general public. Likewise, studies conducted in randomized controlled trial (RCT) settings often have poor external validity and generalizability, deeming the real-life applicability of the interventions as uncertain (Neville, O'Hara, & Milat, 2009). Hence, to determine the true societal impact of smartphone apps, work should focus on how to reach the real target populations and not merely volunteers of RCT studies or convenience samples. This work was performed with these considerations in sight: the developed app was validated by the target population in several research steps and the effectiveness of Happy was assessed in real-life settings. The last two studies were performed in a non-controlled environment, enhancing the ecological validity of results (and naturally compromising some internal validity). The analysis of user participation and engagement with the app provided evidence of how this type of apps are effectively used and contributed to answer questions regarding real-life applicability.

Perhaps the major contribution of this thesis is the cancer prevention smartphone app. It is the first of its kind developed in Portugal specifically targeting multiple behaviours and a young population. Happy is freely available to all smartphone owners and proved to be a very useful cancer prevention tool. It is worth mentioning that the main value of this app goes beyond cancer prevention. The same system can be used in other health education/health promotion contexts with few changes to the core features. The database of health messages and challenges was developed as an open repository, allowing the implementation of changes in a quick and easy way. This allows the development of new sets of messages targeting other behaviours, perhaps behaviours that are relevant to other diseases. Also, the system is web-based, allowing it to be adapted to other mobile devices with little development effort.

## 4.2. Future Work

As was mentioned in the introduction, the work described in this thesis should be viewed as a first development cycle towards an innovative solution to a very complex problem. Several suggestions for further research emerge from the studies.

First of all, Happy's effectiveness should be confirmed in more controlled settings. A truly experimental design study, such as a RCT, should be implemented to assess the effects of using

this cancer prevention smartphone app. This would allow a closer comparison between different groups and would increase the internal validity of results. Also, the use of controlled settings would probably lower the nonusage attrition rate, since participants would likely be more motivated and committed to this type of study because of the formal structure and selection processes involved (Eysenbach, 2005).

A major problem identified in this work was the prevalence of high dropout rates. This is clearly identified in the scientific literature (Consumer Health Information Corporation, 2011; Eysenbach, 2005; Guertler et al., 2015; Kim et al., 2016; McConnell et al., 2016) and was observed in all field studies performed in this thesis. User engagement is pivotal for behaviour change interventions and it is essential to find ways to increase it to assure the intervention's success. Study IV hinted that the use of gamification could be a solution, confirming previous research and contradicting findings from Study I. A paradigmatic example found in the literature is the case of the game Pokémon Go. A recent study showed that this game significantly increased users' physical activity over a period of at least 30 days reaching low activity populations that normally wouldn't be using physical activity apps (Althoff, White, & Horvitz, 2016). However, there are many doubts concerning the long-term effects of this app, as the novelty wears off. The question remains unanswered: how can we effectively engage users for long periods of time to sustain behaviour change?

Studies III and IV allowed the identification of several user profiles that reacted differently to the cancer prevention intervention by improving, not changing or even worsening their behaviour. A possible research direction would be to focus on the characterization of these profiles and adapting the app to target the more receptive users in a way that further enhances its effectiveness as a BCSS. On the other hand, the less receptive users should be studied to clearly understand what didn't work for them. This data would allow the development of a different app that might improve the observed results in this sub-population.

This thesis provided evidence that supports the important role that digital media solutions can have in health education. The development of new solutions could offer a means to provide continuity from formal to informal educational contexts, eliminating barriers in the learning process and contributing to create new modalities that enhance learning experiences in health education. Cancer education in particular can seriously benefit from the use of digital media solutions. As such, research should continue exploring new ways to leverage digital technologies for the purposes of cancer prevention, pervading the general population with the notion that cancer is a word, not a sentence.

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# B


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# Appendixes

# A

## Paper I

Ribeiro, N., Moreira, L., Almeida, A. M. P., & Santos-Silva, F. (2016). Smartphones: Innovative Tools in Cancer Prevention. In M. M. Cruz-Cunha, I. M. Miranda, R. Martinho, & R. Rijo (Eds.), *Encyclopedia of E-Health and Telemedicine* (pp. 1041–1058). IGI Global. http://doi.org/10.4018/978-1-4666-9978-6.ch081

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# Smartphones:
## Innovative Tools in Cancer Prevention

N

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## INTRODUCTION

This chapter explores the potential of smartphones on cancer prevention. The acceptability of mobile health (mhealth) technologies as promoters of behavior change and the identification of desired features necessary to prototype a cancer prevention app were assessed in a target population.

It is estimated that, by the year 2030, cancer will affect more than 26 million people worldwide and over 17 million will die from this disease (IARC, 2008; Jemal, Bray, Ferlay, Ward, & Forman, 2011). More than half of cancer cases are due to unhealthy behavioral options (Colditz & Wei, 2012); if everyone adopt a healthier lifestyle, cancer incidence would fall dramatically (Colditz & Wei, 2012; Colditz, Wolin, & Gehlert, 2012). Research has shown that there is a link between knowledge and the adoption of healthy behaviors (Hawkins, Berkowitz, & Peipins, 2010; Keeney, McKenna, Fleming, & McIlfatrick, 2010; Niederdeppe & Levy, 2007). Still, exceptions remain, being smokers the most paradigmatic example: despite all the warnings and campaigns designed to promote smoking cessation, many people continue to smoke (International Union Against Cancer, 2004). Information campaigns are needed to increase cancer awareness but they simply are not enough to promote behavior change.

## BACKGROUND

mHealth can be defined as all "medical and public health practice supported by mobile devices" (WHO, 2011, p. 6). mHealth solutions currently being developed could transform healthcare through patients' empowerment (reflected in a higher quality of life), while increasing healthcare systems efficiency and sustainability (European Commission, 2014). Presently, mHealth is being applied in most areas of medicine and healthcare, having made important contributions to research on cardiology, diabetes, obesity, smoking cessation, elderly care, and chronic diseases (Silva, Rodrigues, de la Torre Díez, López-Coronado, & Saleem, 2015; Steinhubl, Muse, & Topol, 2015). mHealth interventions can be used globally to target specific behaviors and prevent major diseases. For instance, the "Be He@lthy Be Mobile"

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initiative uses mobile phones to tackle non-communicable diseases with nationwide interventions (e.g. mTobaccoCessation in Costa Rica or mCervicalCancer in Zambia) (ITU, 2014). mHealth has already generated much public interest: by the end of 2010, mHealth applications counted more than 200 million downloads and about 70% of worldwide citizens were interested in at least one mhealth application. This has led to a rapid expansion of available mhealth applications (there are more than 400,000 available in the U.S. Apple App Store alone) (Silva et al., 2015). But problems have arisen concerning the security, reliability, and quality of service of these applications. Several studies have already pointed out the need to regulate these applications in order to prevent potential hazards (Steinhubl et al., 2015).

## CANCER PREVENTION USING SMARTPHONES

Population-wide measures targeting behaviors like inadequate sun exposure, smoking, excessive alcohol use, eating a poor diet, and physical inactivity could reduce overall cancer incidence in fifty per cent (Stein & Colditz, 2004). The European Code Against Cancer (Boyle et al., 2003) defines the following guidelines: (1) Do not smoke; (2) Avoid obesity; (3) Undertake some brisk physical activity every day; (4) Increase daily intake of vegetables and fruits (at least five servings per day); (5) Limit alcohol consumption to one or two drinks per day (women and men, respectively); (6) Avoid excessive sun exposure; (7) Enroll in cancer screening tests (cervical, breast and colorectal screening); (8) Participate in vaccination programs against hepatitis B virus and human papilloma virus; (9) Avoid exposure to known cancer-causing substances.

Individually, everyone should follow these cancer prevention guidelines to reduce their personal risk of cancer. But behavior change is a very hard task: people have generally favorable attitudes towards healthy behaviors, but they often lack the skills needed to maintain it as part of their daily routine (Kaptein, De Ruyter, Markopoulos, & Aarts, 2012). In many cases, cancer prevention involves changing several aspects of our lifestyles. Multiple behavior changes are difficult, but research suggests that it is possible. A study by Spring et al. (2012) showed that targeting diet and physical activity together seems to aid in the adoption and maintenance of healthy behaviors. It is argued that these two behaviors share physiological and behavioral mechanisms that, collectively, can impact energy balance, appetite and food choices (Mata et al., 2009). Physical activity is also recognized as a possible gateway to other health behavior changes (Kremers, De Bruijn, Schaalma, & Brug, 2004; Mata et al., 2009). By targeting multiple behaviors at once, one can promote a general sense of health that, in turn, might prompt other healthier behaviors with great benefits in the general health status.

According to Fogg (2009), behavioral changes occur when three elements converge in a given moment: motivation, ability and triggers. If one of these three elements is missing, change will not occur. This model clearly points out that motivation alone is not enough to induce a new behavior; the target behavior has to be simple enough to be performed by that person and a trigger has to be present to remind that person to perform that behavior (Stanford Persuasive Tech Lab, 2010). Fogg (2009) defines trigger as something that tells people to perform a behavior now. An effective trigger will remind and instigate people to perform the target behavior.

Fogg Behavior Model (Figure 1) predicts an action line that depends on the motivation and ability of individuals. This line determines whether a trigger will succeed or not. When a person is highly motivated to perform a behavior, a trigger might succeed even if the behavior is hard to do. When a behavior is easy to perform, even a person with low motivation will do it if prompted by the right trigger.

*Figure 1. Fogg Behavior model*
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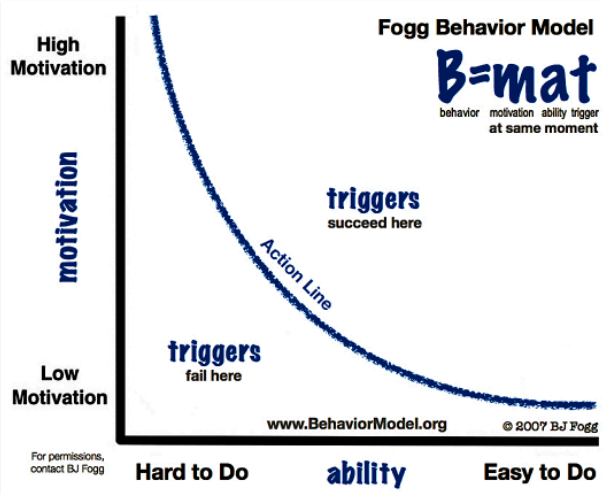



According to this model, behavior change is possible by motivating people, keeping the target behaviors simple and using the right trigger in the most appropriate moment.

Smartphones can be helpful aids in behavior change. Like all mobile phones, they are personal, portable and always connected. People carry them around and they are almost always turned on (Whittaker, Merry, Dorey, & Maddison, 2012). Smartphones are also becoming ubiquitous: it is estimated that by 2016 the number of smartphone users worldwide will surpass 2 billion and by 2018 they will represent more than half of all active mobile phone users (eMarketer, 2014). This allows extended behavior change interventions with relatively low implementation costs (Whittaker et al., 2012). Using the various built-in sensors, smartphones can "sense" time, location and even physical context in real time and induce behaviors adequate to the users immediate "needs". This presents a unique opportunity to use triggers to change, reinforce and reward the desired behaviors (Stanford Persuasive Tech Lab, 2010). Triggers can be adapted to specific moments of people's lives, merging behavior change interventions in people's routines (Fogg, 2009). Several studies have suggested that it is possible to change behavior using smartphones. They have been used successfully in several interventions ranging from smoking cessation, to weight loss and disease management (Bert, Giacometti, Gualano, & Siliquini, 2014; Fiordelli, Diviani, & Schulz, 2013; Klasnja & Pratt, 2012; Mosa, Yoo, & Sheets, 2012). Despite these encouraging results, the potential of smartphones in behavior change interventions hasn't yet been fully explored (Fiordelli et al., 2013).

There are several mhealth interventions targeting cancer with encouraging results (Davis & Oakley-girvan, 2014; ITU, 2014). But these solutions aren't without problems. A study concerning cancer-related applications (Pandey, Hasan, Dubey, & Sarangi, 2013) concluded that currently available applications lack scientifically supported data. The authors stated that only one-fourth of all applications were developed by health-care agencies. There is a need to ensure that valid and relevant information reaches the consumers and app developers should involve health-care agencies to ensure information quality. The majority of cancer-related applications analyzed in this study focused on general information about the disease, research and recent advances, and support for health-care professionals and patients. General

awareness of the disease accounted for about 10% of all analyzed applications. Cancer prevention wasn't mentioned as the main theme of any application, despite its importance.

Another issue to consider is the clinical validity of the available applications. A study looked at smartphone applications that claim to detect melanoma and found that they are mostly inaccurate (Wolf et al., 2013). This raises serious questions as reliance on these applications can potentially delay the diagnosis of melanoma and harm users. It is essential that app developers use adequate methods to evaluate and validate health applications to ensure quality and prevent harmful effects derived from the use of these mhealth solutions.

## HAPPY: HEALTH AWARENESS AND PREVENTION PERSONALIZED FOR YOU

This section will focus on the rationale, methodological process and preliminary results concerning the development of a cancer prevention mobile application named Happy - Health Awareness and Prevention Personalized for You. The main goal of Happy is to persuade users to change their behavior, making healthier choices, thus reducing their personal risk of developing several types of cancer.

### Target Population

The target population of this application is healthy Portuguese young adults, with ages between 18 and 35 years. The choice of a young population is based upon two different reasons: (1) Cancer prevention should start at an early stage of life (reducing exposure time to risk factors) (Colditz et al., 2012); (2) Almost all individuals of this population own at least one mobile device (ANACOM, 2014).

As a preliminary study designed to characterize the target population, an online survey concerning sociodemographic characteristics, health and lifestyle, and smartphone user experience was applied to a sample of the target population (n = 862) (Table 1).

Analyzing the results, it is possible to conclude that the great majority of respondents disregarded cancer prevention guidelines. This is particularly true for physical exercise (only 29.1% workout more than 2 hours per week), and fruit and vegetable consumption (only 4.2% eat 5 or more portions per day). Also, tobacco and alcohol consumption were reported by 18.7% and 21.4% of the respondents, respectively. Healthy Portuguese young adults have to improve their behavior if they want to stay healthy in the future. These results emphasize the need to design mhealth interventions that could improve this scenario and provides the best justification for the development of a cancer prevention application.

Interestingly, the majority of respondents (56.0%) use their smartphone more than one hour per day, and 52.2% used their smartphone to monitor health-related behaviors. This shows that this population is already using health-related applications and strengthens the belief that a cancer prevention application might have a widespread use. However, using smartphones to monitor diet, tobacco and alcohol consumption – three behaviors that raise the personal risk of cancer – is less common, which highlights the need of applications that effectively engage users on long-term monitoring of cancer-risk associated behaviors.

### Project Development

The development of a successful application designed to prevent cancer is a hard and complex task: several questions regarding the persuasive power of the application, usability and long-term usage emerge and must be answered to ensure that it succeeds. This iterative process involves several steps and different methods (Figure 2).

*Table 1. Results of the online survey*

| Sociodemographic Characteristics | |
|---|---|
| Gender, n (%) | |
| Female | **557** (64.6) |
| Male | **289** (33.5) |
| No answer | **16** (1.9) |
| Age, mean ± SD | **23.8** ± 4.6 |
| Education Level, n (%) | |
| College degree | **657** (76.2) |
| No college degree | **198** (23.0) |
| No answer | **7** (0.8) |
| **Health and Lifestyle** | |
| Physical exercise (weekly average), n (%) | |
| *>2 hours** | **251** (29.1) |
| 1 to 2 hours | **167** (19.4) |
| <1 hour | **296** (34.4) |
| None | **146** (16.9) |
| No answer | **2** (0.2) |
| Fruit and Vegetable Consumption (Daily Average), n (%) | |
| *≥5 portions** | **36** (4.2) |
| 3 to 4 portions | **227** (26.4) |
| 1 to 2 portions | **549** (63.7) |
| None | **46** (5.3) |
| No answer | **4** (0.4) |
| Smoking Status, n (%) | |
| Smoker | **161** (18.7) |
| Former smoker | **95** (11.0) |
| *Non smoker** | **600** (69.6) |
| No answer | **6** (0.7) |
| Alcohol Consumption (Daily Average), n (%) | |
| >2 drinks | **3** (0.3) |
| 1 to 2 drinks | **182** (21.1) |
| *None** | **673** (78.1) |

*continued in next column*

*Table 1. Continued*

| | |
|---|---|
| No answer | **4** (0.5) |
| Body Mass Index (BMI) | |
| High | **203** (23.5) |
| *Normal** | **596** (69.2) |
| Low | **51** (5.9) |
| No answer | **12** (1.4) |
| **Smartphone User Experience** | |
| Smartphone operating system, n (%) | |
| Android | **620** (71.9) |
| iOS | **127** (14.7) |
| Other | **67** (7.8) |
| Don't know/ No answer | **48** (5.6) |
| Smartphone Ownership, n (%) | |
| >1 year | **547** (63.5) |
| 6 months to 1 year | **143** (16.6) |
| < 6months | **172** (19.9) |
| Smartphone Use (Daily Average), n (%) | |
| >2 hours | **280** (32.5) |
| 1 to 2 hours | **203** (23.5) |
| <1 hour | **348** (40.3) |
| No answer | **31** (3.7) |
| Smartphone Used to Monitor Health-Related Behaviors, n (%) | |
| Yes | **450** (52.2) |
| No | **412** (47.8) |
| Monitored Health-Related Behaviors, n (%) | |
| Tobacco consumption | **17** (7.7) |
| Alcohol consumption | **6** (1.3) |
| Body weight | **135** (30.0) |
| Diet | **102** (22.6) |
| Physical exercise | **277** (61.5) |
| Other health issues (headaches, moods, …) | **199** (44.2) |

* Values compliant with cancer prevention guidelines.

*Requirement analysis:* three focus groups (n=16) were conducted to explore: 1) prior experiences with health-related applications, 2) points of view concerning currently available health-related applications, 3) desired features in a cancer prevention application, and 4) opinions on what influences long term usage of health promotion applications. Based on the focus groups analysis, a questionnaire was designed and applied online to a larger sample (n=798) of healthy Portuguese young adults. The results were analyzed and produced a set of specific guidelines that informed the design and development of the cancer prevention application.

*Figure 2. Summary of project development steps involved in the conception of Happy*

| Project steps | Purpose | Methods used |
|---|---|---|
| Requirement analysis | Inform the development of the app | Focus groups<br>Online survey |
| Prototype development | Develop a functional version of the app (prototype) | Technical development |
| Pilot study | Test recruitment, registration and data collection processes<br>Test the app (usability and functionality) | Small nonrandomized study |
| Beta version development | Improve and refine app features based on the feedback provided by the pilot study participants | Focus groups |
| Implementation | Field-test the app in a large scale intervention<br>Test the effect of the app in comparison with a control group | Quasi-experimental study |
| Evaluation of implementation impact | Determine the effect of the app on behavior change<br>Refine app development | Focus groups<br>Online survey<br>Semi-structured interviews |

- **Prototype Development:** Based on the resulting guidelines of the requirement analysis step, as well as on the scientific literature, a functional prototype of Happy was developed and is ready to be field-tested in a pilot study.
- **Pilot Study:** Happy will be tested in a pilot study. About 50 volunteers will use the application for four weeks. This step will be very important to test essential processes regarding volunteer recruitment, registration and analytical data collection. It will also be used to assess the application in terms of usability and functionality.
- **Beta Version Development:** Randomly selected pilot study participants will discuss their ideas and thoughts in four focus groups (each with 6 to 8 participants) and the results, along with the analytical data, will be used to further develop the cancer prevention application. This version of the application will have to be fully functional and robust enough so that it can be used for a whole year by a large group of volunteers (n>100).
- **Implementation:** A quasi-experimental study with one control group and two experimental groups (each with a minimum of 30 participants) will be implemented to field-test the cancer prevention application. The use of two experimental groups is justified by the need to study the role of social support in behavior change. Therefore, the first experimental group will use a restricted version of the application while the second experimental group will have access to the full version of the application. The control group won't have access to the application but will have access to another application designed specifically to report their health-related behavior. All participants

will be asked to periodically report their health-related behavior (alcohol consumption, physical activity level, skin and breast self-examination, etc.). This periodical input will be essential to pinpoint the exact moments and causes of behavior change. This large-scale intervention will last a full year in order to see long-term usage (and dropout) rates of the application and to allow participants enough time to change behavior. It will also allow the analysis of participant's behavior in summer months, critical for skin cancer prevention.

- **Evaluation:** The final step will allow the in-depth analysis of the implementation results. Four focus groups will be conducted, each with 6 to 8 participants. Randomly selected participants from the quasi-experimental study will form the focus groups, essential to provide the feedback needed to complete the development of the cancer prevention application. Semi-structured interviews to selected participants of the study (high and low achievers) will be conducted to further analyze the advantages and weaknesses of the application in terms of behavior change capabilities.

This project is under development and currently entering the third step (pilot study). The two completed steps will now be described in detail:

## Requirement Analysis

Three focus groups with 16 healthy young adults (potential end users of the application) were conducted between December 2013 and January 2014. Participants were encouraged to share prior experiences, points of view and opinions about currently available health-related applications. Desired features in a cancer prevention application, personal health data storing and sharing and important factors for long-term app usage emerged as the recurrent themes on the focus groups discussions (Table 2).

Based on the focus groups results, a questionnaire was designed and applied online to a larger sample of healthy young adults (potential end users of the application). The online survey was available during March 2014. A total of 798 valid questionnaires (out of 1693) were collected. The data was analyzed and confronted with the focus groups results.

Concerning the desired features in a cancer prevention application, the respondents of the online survey tended to agree with the focus group participants (Figure 3).

Regarding personal health data storing and sharing, online respondents also tended to agree with the focus groups participants (Figure 4). They agreed that sharing health information with other users that have similar issues could help them cope with the situation and thus they would share information, although they stated that they would not share any personal info with others. However, contrary to what was stated on the focus groups, sharing information for comparison purposes was ill viewed by respondents. This is more noticeable in the female gender as they tend to disagree more with these statements. Also, female respondents didn't see competition with friends as a very motivating feature.

Concerning data storage, most respondents didn't oppose to having their data stored in a server.

The online respondents identified several other factors (adding to the ones identified by the focus groups participants) that are deemed as important for long-term application usage (Figure 5). According to the online respondents, the quality of health information (validation, updated info, tailoring and detail), behavior tracking, healthy challenges promotion and reminders use are all important factors to be considered.

Again, online respondents didn't see the ability to connect with friends or other users as a very important factor for long-term application use. This was particularly true for female respondents.

*Table 2. Overview of the results from the focus groups*

| Theme | Key Points Identified | FG Sample Transcription |
|---|---|---|
| Desired features in a cancer prevention application | ***Health behavior tracking***<br>• Potentially motivating feature<br>• Allows the identification of behavior mistakes<br>• Tracking negative behaviors might trigger negative emotions | "A person is able to track and see how we are every day and I think that's an advantage because we can see if we exceeded something or not and that's going to influence our habits." (Participant B, FG#1) |
| | ***Health goal setting***<br>• Important motivation factor<br>• If associated with a reward system might boost motivation<br>• If goals aren't met, might have a negative effect on user's behavior | "People like to have things to accomplish, goals to achieve. And if the app doesn't have a goal people will… and it has to be interactive and simple." (Participant B, FG#2) |
| | ***Tailored information***<br>• Information tailoring is essential due to the nature of health information<br>• Excess of information might lead to confusion and hurt user's understanding, particularly concerning cancer | "Not a generic thing. Like, a person has bad eating habits, downloads some app that's going to suggest thousands of healthy things. Even if that person doesn't need them. Instead of just giving the same suggestions to all users, try to figure out how the person is, it's profile, and then use this information to create tailored suggestions." (Participant F, FG#1) |
| | ***Use of reminders***<br>• Use of reminders to go to medical appointments or to trigger healthy behaviors is very useful for behavior change<br>• This feature should be used with caution and only in relevant contexts to avoid becoming annoying and being deactivated by users. | "When I think about prevention and health the first thing that comes to mind is our eating habits. An app that, I don't know… for instance, uses reminders, that's also very important. Remind us to drink water or eat fruit." (Participant A, FG#1) |
| Personal health data storing and sharing | • The importance of keeping personal health data private and secure was consensual among participants<br>• Users may feel uncomfortable using an application that stores personal data online<br>• Participants revealed some willingness to share personal data with others, as long as they controlled what is shared<br>• Sharing personal information in specific contexts (to compete with friends or with users with the same health issue, for instance) could be potentially motivating | "One thing is to follow ourselves. Other thing is to have 'our friends from NSA' following us 24/7. And that links to the question of where the data is saved. One thing is keeping it on the phone and being able to delete it. A different thing is keeping it on the other side, in the cloud. Because there you can delete it, what you see, but you won't really delete it. It's like Facebook chat, you delete it but it isn't deleted." (Participant B, FG#1) |
| Important factors for long-term application usage | ***Easiness of use***, quality of the ***user interface***, ***peer influence*** (applications used by friends) and ***device optimization*** of the application (battery management, for instance) were identified as the most important factors for long-term usage | "I think that, the more information you have to input, less likely it will be to use the app for a long period of time. The first time we will like it and do it, the second also, the third one… right?" (Participant C, FG#2)<br>"The graphic output, the interface. It's… the app might be very good, if it has a horrible interface it can't be, I won't use it, it has to be attractive." (Participant A, FG#3) |

**Category: New Challenges and Issues**

N

*Figure 3. Online survey results of features to include on a cancer prevention application*

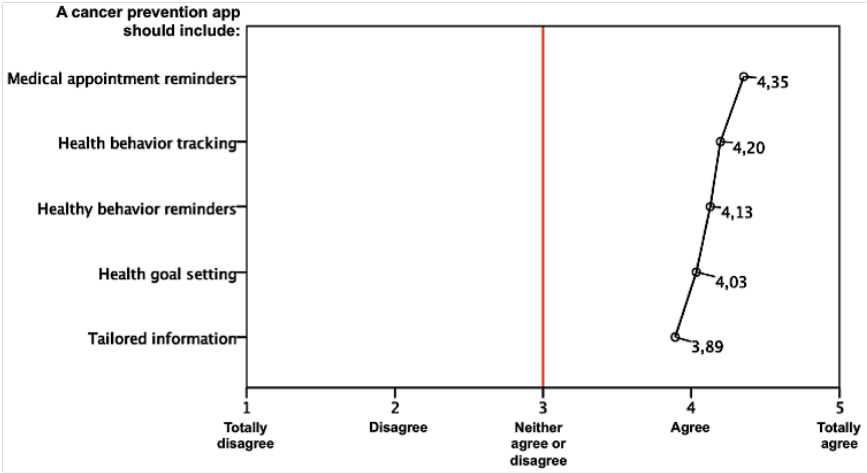



*Figure 4. Online survey results of personal health data storing and sharing by gender*

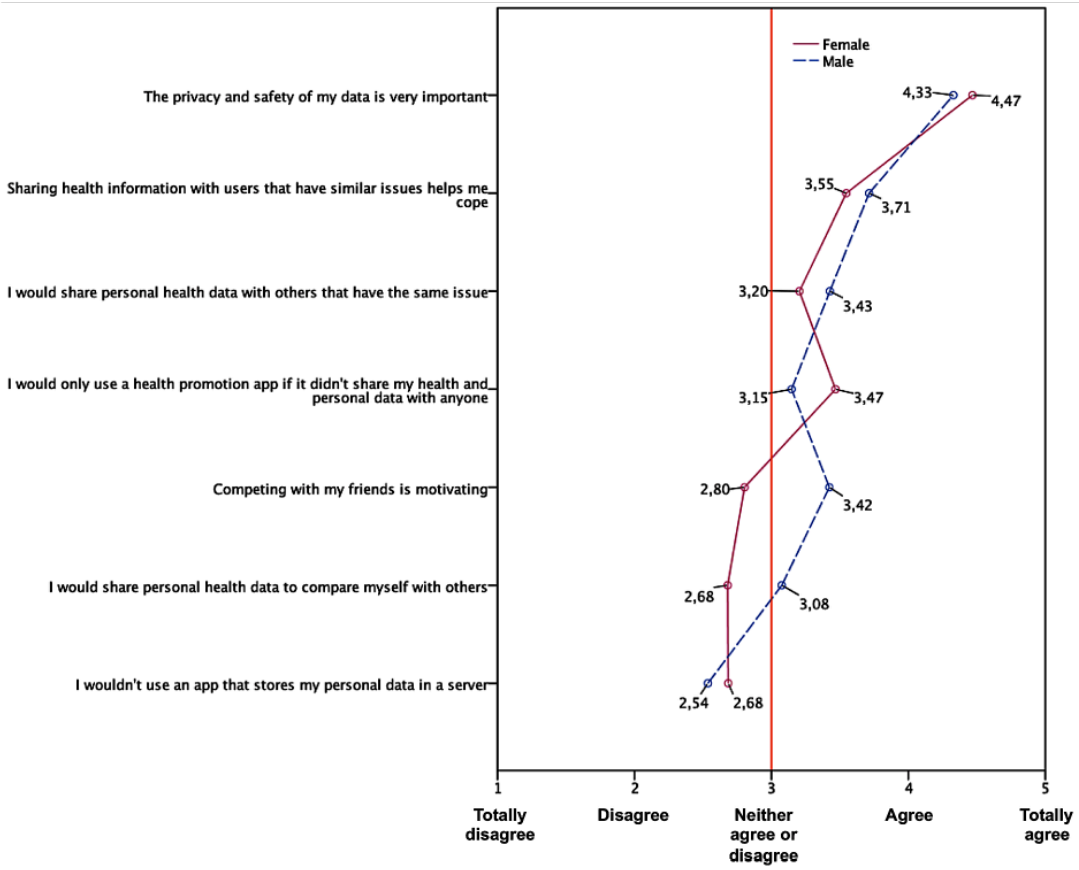
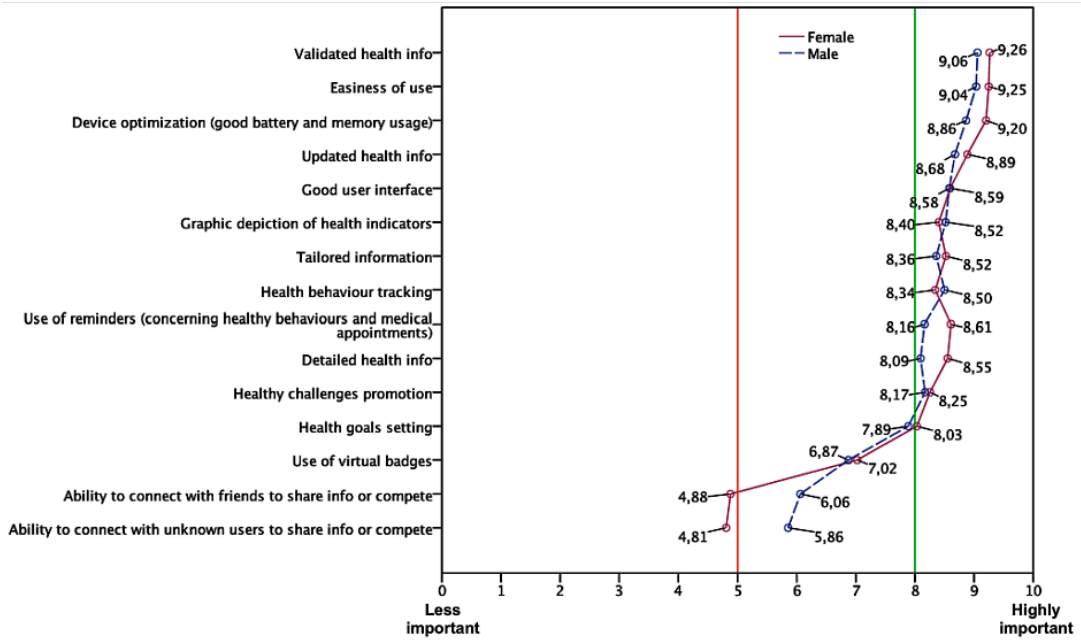


*Figure 5. Online survey results of the relative importance of factors for long-term application usage by gender (8 or more = very important)*




The study participants identified four main features that should be included in a cancer prevention application: health behavior tracking, health goal setting, reminders and tailored information. The first two were seen as more engaging and motivating and could be the core features to support behavior change. It was implied by several participants that seeing how we behave could be a call to action for most people and lead to the desired behavior change. Likewise, most participants considered that having goals to achieve was an important motivational factor and a feature that should be included. This has also been reported in previous studies (Ahtinen et al., 2009; Consolvo, Klasnja, McDonald, & Landay, 2012; Dennison, Morrison, Conway, & Yardley, 2013). The ability to set reminders was viewed as a very important feature, mainly to remind scheduled medical appointments but also to remind to comply with healthy guidelines (eat more fruit, for example). This feature was also highlighted in another study (Ramanathan, Swendeman, Comulada, Estrin, & Rotheram-Borus, 2013). Finally, study participants noted the importance of tailoring health information provided to the user. Several participants highlighted this feature as a way to help users understand what they have to do without being overwhelmed by too much information. This feature was stressed as essential when it concerns cancer, as there are many misconceptions and myths surrounding this disease (Burak & Boone, 2008).

Regarding information sharing, focus group participants showed some openness as long as this was user controlled and only in specific contexts, like between users with similar problems or with friends for competition purposes. However, online respondents seemed less keen on sharing information, despite recognizing its value - the majority agreed that sharing information with similar users would help them cope with a healthy lifestyle. This tendency was particularly apparent in female respondents and regarding information sharing for competition or comparison purposes. As for long-term use of health applications, the study participants identified several dimensions that could influence it. Easiness of use,

good user interface, good smartphone resource management, quality of health information (validation, updated information, tailoring and detail), behavior tracking, healthy challenges promotion and use of reminders were highlighted as the most important dimensions. Study results seem to show that, if a user perceives the application as useful, with a good user experience and having an increased value to them (mainly due to the type of information it contains), they will be more likely to use it for a long period of time. This is an important finding because, if we want them to change behavior in a consistent and sustained way, we have to find ways to engage users for a long period of time.

Features associated with gamification (use of virtual badges, competition with others), designed to increase motivation and to further engage users with applications, don't seem to be important dimensions for long-term use of health-related applications. This was more apparent in female respondents even though male respondents also didn't perceive it as so important as other dimensions.

The requirement analysis step allowed the definition of a guideline set for the development of a cancer prevention application (Table 3). The guidelines highlight the focus groups and online survey results and are linked to design and development dimensions. Each dimension provides a possible solution to address the corresponding guideline.

## Prototype Development

Happy aims to be a simple and easy-to-use cancer prevention application that attempts to persuade users to change their behavior, making healthier choices, and thus reducing their personal risk of developing several types of cancer. The application was designed bearing in mind the resulting guidelines of the requirement analysis step and uses Fogg Behavior Model (Fogg, 2009, 2011; Stanford Persuasive Tech Lab, 2010) as a theoretical framework.

Happy is based on the principle of tailoring, i.e., using information on a given individual/profile to determine what specific content he or she will receive (Hawkins, Kreuter, Resnicow, Fishbein, & Dijkstra, 2008). Thus, when users access Happy for the first time they need to answer a behavior assessment

*Table 3. Guidelines for the development of a cancer prevention application*

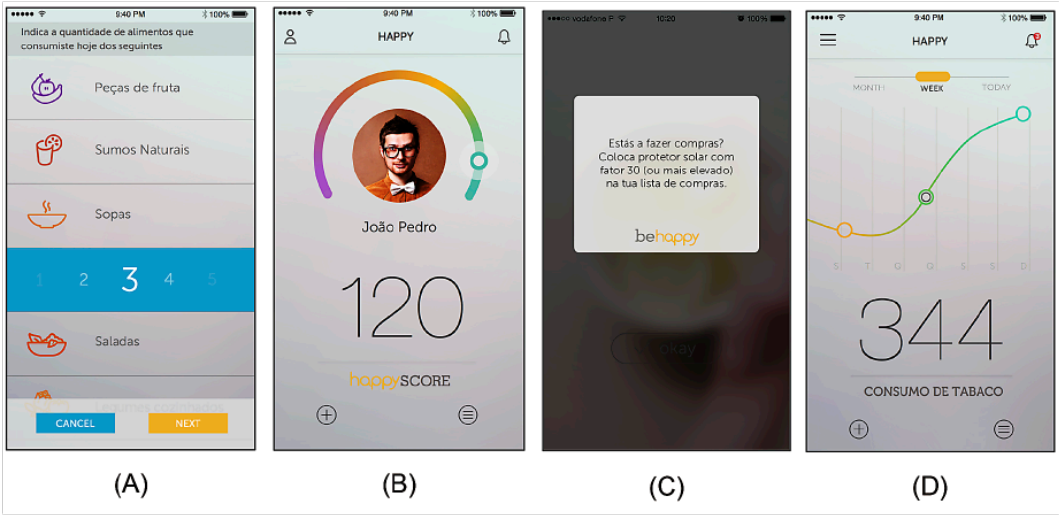
| | Guidelines | Dimensions |
|---|---|---|
| User experience | Application has to be light, simple to use, and behaviour tracking should be passive or based upon low burden inputs. | Easiness of use<br>User interface<br>Smartphone resource management<br>Data input |
| Motivation | Application has to be engaging and provide tools to enhance users' motivation. Gamification features aren't considered important. | Behaviour tracking<br>Healthy challenges promotion<br>Health goal setting |
| Usefulness | Application has to have useful tools that help users make healthier choices and gain insight on their behaviour. | Use of reminders<br>Behaviour tracking<br>Healthy challenges promotion |
| Application content | Application content must be validated and up to date.<br>Health information provided should be tailored to the users current health status. | Quality and pertinence of content |
| Social sharing | Application can have social features but they should be optional and user controlled. | Information sharing |
| Privacy and Safety | Application has to be safe to use and preserve users privacy using secure connections. | Safety<br>Security<br>Data storage |

questionnaire (Figure 6A). This assessment allows the definition of the users profile and determines the current level of cancer prevention, called HappyScore (Figure 6B). The HappyScore depicted on the landing page will allow the users to self-monitor their behavior changes. The highest the displayed number, the better the behavior in terms of cancer prevention. This strategy as proven effective in influencing health behaviors in other contexts (Helfer & Shultz, 2014). The score ranges from 0 to 150, having the commonly used 0 to 100 been deliberately avoided to prevent misunderstandings: if the score ranged from 0 to 100 it could be mistaken as a percentage of protection against cancer; thus 100 would mean 100% protection, a vision that is misleading as we can lower our personal risk of cancer but we can't eliminate it completely by having a healthier life.

The user profile is also used to tailor health messages to each individual. Tailored messages (Figure 6C) are the triggers of behavior change. The messages are tailored accordingly to the users profile, influenced by users previous behavior and take into account users context (location, time of day, week and month, weather conditions). There are messages designed to change specific behaviors and reminders to do self-examinations or to enroll in screenings. The goal is to deliver the right message to the right user in the right moment. The effort of tailoring messages to the users profile and context has been proven successful in other behavior change interventions (Campbell et al., 2009; Gerend, Shepherd, & Lustria, 2013) and is, therefore, a core feature of Happy. Messages target specific behaviors and follow the guidelines of the European Code Against Cancer (Boyle et al., 2003).

Happy also allows behavior tracking. Users can track their behavior by answering behavior questions that are sent to them periodically by the application or by deliberately entering behavior data. These behavior assessments are used to recalculate the users HappyScore and change the user profile over time, allowing the tailoring to occur concurrently to the changes in behavior. At any given time, users can explore the Statistics section (Figure 6D) of the application and assess their own behavior evolution. Statistics are the graphic feedback of behavior tracking. It is mainly a self-assessment and motivation tool. Graphic feedback can help people reflect on patterns of their activities and may help them change their behavior (Consolvo et al., 2012). Happy's behavior tracking relies upon low burden inputs. For

*Figure 6. Happy main features: behavior assessment questionnaire (A), HappyScore (application's landing page) (B), tailored message (C) and statistics (D)*



instance, from time to time, users will be prompted to input amounts of fruits and vegetables consumed that day. As users input this data, the correspondent graphic will start to take form, allowing users to track this behavior through time.

In order to further engage users with Happy there are two other sections: Challenges and Social.

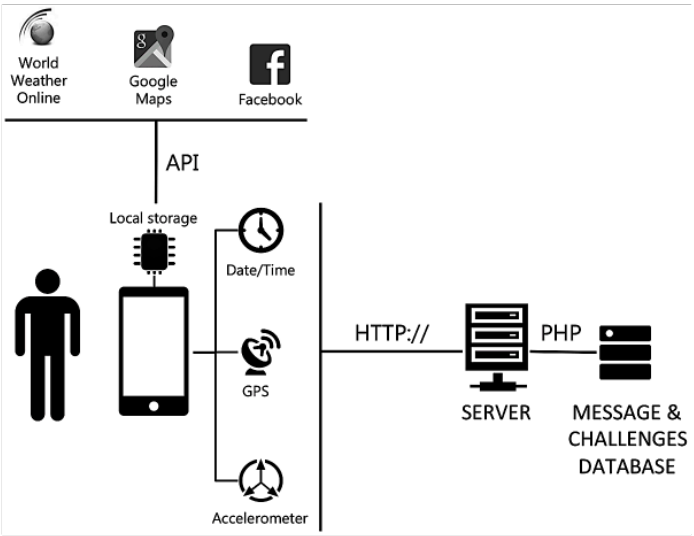
Challenges are healthy challenges meant to further engage users with the application. The challenges are optional and users can enroll them at their own will. They are designed to give small achievable goals to boost users motivation and help them reach desired behaviors. Each completed challenge has a score and can be used for comparison purposes with other users in the social section.

Social section displays all users that are added to the user's social network. It allows users to communicate with other users in an individual, group or application community level. This feature is designed to boost online support and competition between users. In order to leverage existing online social interactions, Happy was integrated with the most widely used social networking system: Facebook ("Facebook statistics," 2015). This was done using Facebook's open application-programing interface (API) that allows access to functions for online interaction to third party applications.

Happy's general architecture (Figure 7) consists of the sensors (date and time, GPS and accelerometer) embedded in the smartphone; the smartphone; a server (that acts simultaneously as a web server and a data repository); a message & challenges database; and World Weather Online, Google Maps and Facebook services. The smartphone's embedded sensors detect and feed data (GPS coordinates, device movement, date and time) to Happy. The application then processes this data using the World Weather Online and Google Maps API to generate significant contextual data (weather conditions and location). The smartphone transmits the data to the remote server where it is bundled with the user profile (previously stored in the server). This data set is then used to search the message database and select the message that is best suited to the user profile and current context. The selected message (tailored message) is then sent to the smartphone and presented to the user in the application.

Behavior data entered by users is sent to the server where it is registered and used to recalculate the HappyScore and statistics. These values are then sent to the smartphone and presented graphically to the

*Figure 7. Happy's general architecture*



user. All entered data is stored in the server and mapped into the user profile, influencing the subsequent messages sent to the user and the challenges that are suggested to the user by the application. The Facebook API is used to manage all social interactions between the user and his peers. Hypertext Transfer Protocol (HTTP) is used in all data transmission between the smartphone and the server, which means that the smartphone must have an Internet connection service such as General Packet Radio Service (GPRS), 3rd generation (3G), 4th generation (4G) or a wireless local area network. If the smartphone is temporarily disconnected from the Internet, all entered data will be stored locally and sent to the server when the connection is restored, updating all data values. Happy runs on Android OS and iOS, the two most commonly used smartphone platforms.

## FUTURE RESEARCH DIRECTIONS

Behavior change interventions using mobile technologies are a new research field. As technology evolves, new and more complex tools can be developed to help users change their behavior towards a healthier lifestyle. Recent developments have led to the commercialization of several electronic activity monitors, known as wearables, that can monitor health indicators (e.g. physical activity or sleep patterns) continuously throughout the day (Ledger & McCaffrey, 2014; Steinhubl, Muse, & Topol, 2015). These devices offer a great opportunity to enhance behavior change interventions. They can track all activity seamlessly, significantly lowering user input burden. Tracked data can be used to further tailor interventions to the users needs. Despite acknowledge potential, wearable devices also have disadvantages. They can't track all types of activities and often misinterpret performed activities (Consolvo et al., 2012). This inaccuracy can lead to user disappointment and might help explain why most users stop using wearables six months after purchase (Ledger & McCaffrey, 2014). There is still a long way to go until most people adopt some type of wearable that can help them improve their lifestyle.

The development of Happy, the cancer prevention application designed to change behavior, will continue as described. The prototype will be tested in a pilot study and refinements to the application will be included. Then, the application will be used in a large-scale intervention and its impact evaluation will allow an in-depth analysis of the real capabilities of Happy to induce behavior change in users and, thus, contribute to cancer prevention.

One major issue to be tackled in this project will be long-term use of the application. Studies have shown that continued active use of health related applications is very low (Consumer Health Information Corporation, n.d.). The value of healthy eating or physical activity arises from performing it in a sustainable way over time. Cancer prevention through behavior change relies upon performing healthy behaviors for the rest of people's lives. Health interventions usually do not approach behavior change from this long-term perspective (Consolvo et al., 2012). This is one of the most important challenges that future behavior change research will have to face.

## CONCLUSION

Cancer incidence could be reduced to half if populations adopted healthier behaviors. Behavior change, despite being a very difficult task, can be achieved with proper strategies. Smartphones provide a great opportunity for behavior change. They are personal, connected and always close-at-hand. They follow people around and can sense what they are doing, allowing interventions to occur at the most opportune

time. Smartphones have been used successfully in interventions ranging from smoking cessation, to weight loss and disease management. They can be very useful tools to empower people and help them make healthier choices.

Happy is an exploratory approach to cancer prevention using smartphones. The application's main goal is to persuade users to change their behavior, making healthier choices, thus reducing their personal risk of developing several types of cancer. The development process of Happy requires multiple steps and relies upon successive refinements of a prototype involving the target population. The work described shows that users are open to this type of intervention and identifies an opportunity to help people change behavior towards cancer prevention.

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## KEY TERMS AND DEFINITIONS

**Behavior Change:** Any transformation or modification of human behavior.

**Behavior Change Intervention:** Broad range of activities and approaches, focused on individual, community and environmental influences on behavior, designed to change behavior.

**Cancer Prevention:** All the active measures that can be taken to decrease the risk of cancer. Includes actions to lower exposure to known cancer risk factors (*primary prevention*) and diagnose pre-malignant forms of cancer (*secondary prevention*).

**Cancer:** Term used to describe more than 100 different diseases in which abnormal cells divide without control and are able to invade surrounding tissues.

**Healthy Behavior:** All behaviors that promote a healthy life. Includes being physically active, having a good diet, not smoking, among other behaviors.

**Mobile Phone:** Wireless handheld device that can make and receive calls among other features.

**Smartphone:** A mobile phone that has more advanced computing capability than basic feature phones. Smartphones typically have a relatively large screen and an operating system capable of running general-purpose applications.

**Smartphone Application:** Computer program designed to run on smartphones. Usually refers to simple programs that perform specific functions on the smartphone.

## Paper II

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# Guidelines for a cancer prevention smartphone application: A mixed-methods study

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ABSTRACT

*Objectives:* This study sought to explore the views and experiences of healthy young adults concerning the fundamental features of a cancer prevention smartphone app that seeks behaviour change.
*Methods:* Three focus groups were conducted with 16 healthy young adults that explored prior experiences, points of view and opinions about currently available health-related smartphone apps. Then, an online questionnaire was designed and applied to a larger sample of healthy young adults. Focus group and online questionnaire data were analysed and confronted.
*Results:* Study results identified behaviour tracking, goal setting, tailored information and use of reminders as the most desired features in a cancer prevention app. Participants highlighted the importance of privacy and were reluctant to share personal health information with other users. The results also point out important dimensions to be considered for long-term use of health promotion apps related with usability and perceived usefulness. Participants didn't consider gamification features as important dimensions for long-term use of apps.
*Conclusions:* This study allowed the definition of a guideline set for the development of a cancer prevention app.



## 1. Introduction

### 1.1. The importance of cancer prevention

It is estimated that, by the year 2030, cancer will affect more than 26 million people worldwide and over 17 million will die from this disease [1,2]. Tobacco and alcohol consumption, excessive exposure to the sun and lack of physical exercise are important risk factors for cancer [3–6]. In fact, more than half of cancer cases are due to wrong behavioural options [6]; if everyone adopted a healthier lifestyle, cancer incidence would fall dramatically [6,7].

Research has shown that there is a link between knowledge and the adoption of healthy behaviours [8–10]. Still, exceptions remain being smokers the most paradigmatic example: despite all the warnings and campaigns designed to promote smoking cessation, many people continue to smoke [11]. Information campaigns are needed to raise cancer awareness but they simply are not enough to promote behaviour change.

### 1.2. Smartphones and behaviour change

According to Fogg [12–14], behavioural changes occur when three elements converge in a given moment: Motivation, Ability and Trigger. If one of these three elements is missing, the change will not occur. This model clearly points out that motivation alone is not enough to induce a new behaviour; the target behaviour has to be simple enough to be performed by that person and a trigger has to be present to remind that person to perform that behaviour. Fogg defines trigger as "something that tells people to perform a behaviour now" [12]. An effective trigger will remind and instigate people to perform the target behaviour.

Mobile phones can be very useful in this sense: with mobile phones it is possible to persuade individuals to change their behaviour by delivering the right trigger in the right moment. The use of mobile phones to persuade individuals has many advantages

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[15]: 1) almost everyone has a mobile phone; 2) mobile phones are portable devices and people carry them everywhere; 3) people tend to create personal relationships with their phones; 4) the advanced features of smartphones enable context awareness of the phone user. Context awareness could be very important in behaviour change as it may provide the opportunity for situated learning, i.e., the opportunity to provide users with the knowledge needed to perform a new behaviour in a specific context that is meaningful to them [16].

There are many cancer smartphone applications (or "apps") available on the market today but they lack accountability and reliability and are mainly focused on general information about the disease [17]. In order to design a cancer prevention app focused on behaviour change, we have to carefully balance the persuasiveness of the app and its lightness of use because we want the user to use the app willingly for a long period of time. This implies the need to create a specific set of guidelines that will allow the conception of a cancer prevention smartphone app that can effectively lead users to change their behaviour, thus preventing cancer.

### 1.3. Similar studies

There are several studies that have explored the use of health-related smartphone apps and even personal experiences and points of view about them [18–22]. Although these studies are very useful, pointing out directions and guidelines for generic health-related smartphone apps, the specificity of cancer prevention requires a more in-depth analysis in order to identify opportunities and possible obstacles to the success of such a smartphone app.

### 1.4. Current study

This study sought to explore the views and experiences of healthy Portuguese young adults concerning the essential features a cancer prevention smartphone app that seeks behaviour change should have.

The study was conducted in two sequential steps: as a first step, we conducted three focus groups with healthy young adults that explored: 1) prior experiences with health-related apps, 2) points of view concerning currently available health-related apps, 3) points of view concerning desired features in a health promotion app and 4) opinions on what influences long term usage of health promotion apps. The second step was based on the focus groups analysis and led to the design and application of an online questionnaire to a larger sample of healthy Portuguese young adults. The results from the two steps were confronted and resulted on a guideline set that will be used to design a cancer prevention app.

## 2. Materials and methods

### 2.1. Participants

#### 2.1.1. Focus groups participants

Participants were recruited via e-mail. Two mailing lists were used: one from University of Aveiro and another from Ipatimup. Two hundred and twelve volunteers responded to the e-mail. The selection criteria included: a) being a smartphone user; b) age between 18 and 35 years old; and c) availability to participate on focus group time schedule. Sixteen participants met the above criteria. All participants provided informed consent to participate in the study.

#### 2.1.2. Online survey respondents

Respondents were recruited via e-mail and through the social network Facebook®. The same mailing lists were used, but the e-mails of the focus groups participants were excluded. The e-mail receivers were encouraged to forward the e-mail to all personal contacts and the Facebook® followers were encouraged to share the post to reach a larger number of people. The e-mail/Facebook® post had a direct link to the online survey. The questionnaire was open access and was available online during March 2014. A total of 1,693 questionnaires were collected and filtered using the same selection criteria as above (smartphone users with age between 18 and 35 years old), resulting in 798 valid questionnaires. All participants provided informed consent to participate in the study.

### 2.2. Procedure

#### 2.2.1. Focus groups

Three focus groups (with 6, 5 and 5 participants, respectively) were conducted between December 2013 and January 2014. The same interview schedule was used in all focus group (Supplementary file 1). The discussion began with a more general question to get participants talking about previous experiences (if any) with health-related apps. In order to encourage discussion and opinions, a series of slides illustrating different health-related apps was used. The apps were organized according to the following features: 1) tailored information, 2) behaviour tracking, 3) on-the-go information, 4) reminder use, 5) health goal setting, 6) graphic depiction of health indicators, 7) motivation, 8) social sharing, and 9) contextual information acquisition. The participants were encouraged to express their opinion highlighting which apps would they use and why, what problems did they envision and what features were lacking in these examples.

The focus groups were 70–90 min long. Two researchers were present in all groups. One assumed the moderator role, facilitating the discussion and presenting the materials, and the other the assistant role, taking field notes.

#### 2.2.2. Online survey

The online survey was made available during March 2014, in a dedicated website and all respondents reached the website by clicking in a link in the received e-mail or in Facebook® post. The online survey had a total of 24 questions distributed in four different pages (6 items per page) and took 10–15 min to complete.

### 2.3. Data analysis

#### 2.3.1. Focus groups

The focus groups were filmed and the content was transcribed. The transcripts were then analysed using inductive thematic analysis [23,24]. After initial coding, highlighting relevant discussion themes, all text segments were iteratively analysed. Themes were added or merged until they effectively represented all text segments and captured the essence of every focus group discussion. The transcript analysis and coding was done using the program WebQDA [25].

#### 2.3.2. Online survey

The data from the online survey was analysed using IBM SPSS Statistics, version 21. Data distribution was strongly asymmetrical (significantly different from a normal distribution), thus an *Independent Samples Mann-Whitney U Test* was used to test differences between genders. All p-values are presented with Holm-Bonferroni correction.

## 3. Results

### 3.1. Participants

Before entering this study, all participants answered a small survey concerning health and lifestyle and smartphone user experi-

**Table 1**
Survey comparative results between focus group and online survey participants.

| | Participants origin | |
|---|---|---|
| | Focus groups (n = 16) | Online survey (n = 798) |
| **Sociodemographic characteristics** | | |
| Gender, n (%) | | |
| Female | 10 (62.5) | 511 (64.0) |
| Male | 6 (37.5) | 272 (34.1) |
| No answer | 0 (0.0) | 15 (1.9) |
| Age, mean (SD) | 24.5 (2.9) | 23.8 (4.6) |
| Education level, n (%) | | |
| College degree | 16 (100) | 612 (76.7) |
| No college degree | 0 (0.0) | 180 (22.6) |
| No answer | 0 (0.0) | 6 (0.8) |
| **Health and lifestyle** | | |
| Physical exercise (weekly average), n (%) | | |
| ≥2 h[a] | 6 (37.5) | 234 (29.3) |
| 1–2 h | 3 (18.8) | 153 (19.2) |
| <1 h | 5 (31.3) | 273 (34.2) |
| None | 2 (12.5) | 137 (17.2) |
| No answer | 0 (0.0) | 1 (0.1) |
| Fruit and vegetable (daily average), n (%) | | |
| ≥5 portions[a] | 0 (0.0) | 34 (4.3) |
| 3–4 portions | 7 (43.7) | 211 (26.4) |
| 1–2 portions | 9 (56.3) | 506 (63.4) |
| None | 0 (0.0) | 45 (5.6) |
| No answer | 0 (0.0) | 2 (0.3) |
| Tobacco consumption, n (%) | | |
| Smoker | 2 (12.5) | 152 (19.0) |
| Former smoker | 2 (12.5) | 90 (11.3) |
| Non smoker[a] | 12 (75.0) | 552 (69.7) |
| No answer | 0 (0.0) | 4 (0.5) |
| Alcohol consumption (daily average), n (%) | | |
| >2 drinks | 0 (0.0) | 3 (0.4) |
| 1–2 drinks | 2 (12.5) | 169 (21.1) |
| None[a] | 14 (87.5) | 623 (78.1) |
| No answer | 0 (0.0) | 3 (0.4) |
| Body mass index (BMI), n (%) | | |
| High | 1 (6.3) | 203 (25.4) |
| Normal[a] | 15 (93.8) | 545 (68.3) |
| Low | 0 (0.0) | 50 (6.3) |
| Smartphone user experience | | |
| Smartphone type, n (%) | | |
| Android | 13 (81.3) | 592 (74.2) |
| iPhone | 3 (18.8) | 121 (15.2) |
| Other (windows phone, blackberry, . . .) | 0 (0.0) | 65 (8.1) |
| Don't know/No answer | 0 (0.0) | 20 (2.5) |
| Smartphone ownership time, n (%) | | |
| >1 year | 7 (43.8) | 516 (64.7) |
| 6–12 months | 6 (37.5) | 130 (16.3) |
| <6 months | 3 (18.8) | 152 (19) |
| No answer | 0 (0.0) | 0 (0.0) |
| Smartphone use (daily average), n (%) | | |
| >2 h | 7 (43.8) | 265 (33.2) |
| 1–2 h | 2 (12.5) | 195 (24.4) |
| <1 h | 7 (43.8) | 333 (41.8) |
| No answer | 0 (0.0) | 5 (0.6) |
| Used smartphone to monitor, n (%): | | |
| Tobacco consumption | 1 (6.3) | 14 (1.8) |
| Alcohol consumption | 0 (0.0) | 4 (0.5) |
| Body weight | 4 (25.0) | 125 (15.7) |
| Diet | 0 (0.0) | 100 (12.5) |
| Physical exercise | 7 (43.8) | 256 (32.1) |
| Other health issues (headaches, moods, . . .) | 4 (25.0) | 184 (23.1) |

[a] values compliant with cancer prevention guidelines [26].

ence (Table 1). Analysing the survey results, it is possible to analyse participant's health and lifestyle behaviour and user experience.

The difference between the two sample sizes is critical, decreasing the statistical power of the tests to values that clearly

compromises its' utility. For this reason, statistical tests comparing these groups were not performed.

Analysing the participant's reported behaviour (focus group and online survey), it is possible to perceive that the great majority doesn't comply with cancer prevention guidelines. This is true for physical exercise (only 240 participants, 29.4%, workout more than 2 h per week), fruit and vegetable consumption (merely 34 participants, 4.1%, are compliant with the guidelines), tobacco and alcohol consumption (174 participants, 21.3%, drink and 154 participants, 18.9%, smoke), and BMI (204 participants, 25.0%, reported being overweight or obese).

Concerning smartphone user experience, the majority of participants uses their smartphone more than 1 h per day (468 participants, 57.6%) and is a smartphone owner for more than a year (523 participants, 64.2%). Many participants (350 participants, 42.9%) have used their smartphone to monitor health-related behaviours such as tobacco consumption (15 participants, 1.8%), alcohol consumption (4 participants, 0.5%), body weight (129 participants, 15.8%), diet (100 participants, 12.2%), physical exercise (263 participants, 32.3%) and other health issues (188 participants, 23.1%).

### 3.2. Desired features in a cancer prevention app—focus groups

From all the app features discussed in the focus groups, four (health behaviour tracking, health goal setting, tailored information and use of reminders) were more prominent, emerging several times in all focus group discussions and viewed as the most promising features for a cancer prevention smartphone app.

#### 3.2.1. Health behaviour tracking

Behaviour tracking was viewed by a large majority of participants as one of the most interesting features.

> "A person is able to track and see how we are everyday and I think that's an advantage because we can see if we exceeded something or not and that's going to influence our habits."
> (Participant B, FG#1)

Participants emphasized the fact that being able to track our behaviour allows us to pinpoint our mistakes and seeing an improvement, might motivate us to continue what we are doing.

However, due to the nature of some health data, tracking might be problematic:

> "It's very hard because it needs a high amount of honesty from that person and I think that you know you're smoking, you're hurting yourself and I don't know if you want to... right? Be confronted with that on the screen."
> (Participant E, FG#3)

Related to this feature, was the graphic depiction of behaviour. Several participants emphasized the importance that graphs have on behaviour tracking.

> "I love graphs in apps. To see what we had, in the past, and what we will have in the future."
> (Participant D, FG#1)

> "One thing that's important is statistics. A person inputs data and then sees how it behaved during a month (...) this is important too, a person should have access to the inputted data"
> (Participant C, FG#2)

#### 3.2.2. Health goal setting

Goal setting was viewed as an important factor to keep interest in the application and as a way to stay motivated.

> "People like to have things to accomplish, goals to achieve. And if the app doesn't have a goal people will... and it has to be interactive and simple."
> (Participant B, FG#2)

Several participants stated that this feature, associated with a reward system might boost motivation.

> "Participant A: I quitted smoking about 3 months ago and the one thing that helped me in the apps I used were the rewards that are nothing... might not be regarded as special. Those things that... those milestones that show up in your phone and say 'congratulations'. That might seem stupid but it helped...
>
> Participant E: It's not stupid. It's positive reinforcement. It's setting a goal and human beings work like that: as long as we are focused and rewarded for what we do, we will do it with pleasure. That's why things seem easier."
> (FG#2)

However, it was also mentioned that, if goals aren't met, it might have a negative effect on user's behaviour.

#### 3.2.3. Tailored information

The idea of tailoring information according to the user's profile emerged several times in the focus group discussions. This necessity is tightly connected with the nature of health information. Excess of information was viewed as something that could impair user's understanding and lead to confusion, particularly concerning cancer.

> "Not a generic thing. Like, a person has bad eating habits, downloads some app that's going to suggest thousands of healthy things. Even if that person doesn't need them. Instead of just giving the same suggestions to all users, try to figure out how the person is, it's profile, and then use this information to create tailored suggestions."
> (Participant F, FG#1)

#### 3.2.4. Use of reminders

The use of reminders to go to medical appointments or to trigger healthy behaviours was viewed as very useful for behaviour change.

> "When I think about prevention and health the first thing that comes to mind is our eating habits. An app that, I don't know... for instance, uses reminders, that's also very important. Remind us to drink water or eat fruit."
> (Participant A, FG#1)

Some participants emphasized the necessity of triggering reminders at the right time and others considered that an excess of reminders could be counterproductive and could lead the user to deactivate this feature. Thus, according to the focus groups participants, this feature should be used with caution and only in relevant contexts.

### 3.3. Desired features in a health-related app—online survey

Concerning the desired features, the respondents of the online survey tended to agree with the focus group participants (Fig. 1).

### 3.4. Personal health data storing and sharing—focus groups

Many focus group participants stressed the importance of assuring the privacy and safety of the health data stored in a health-related app. There is sensitive data that could be misused by third parties.

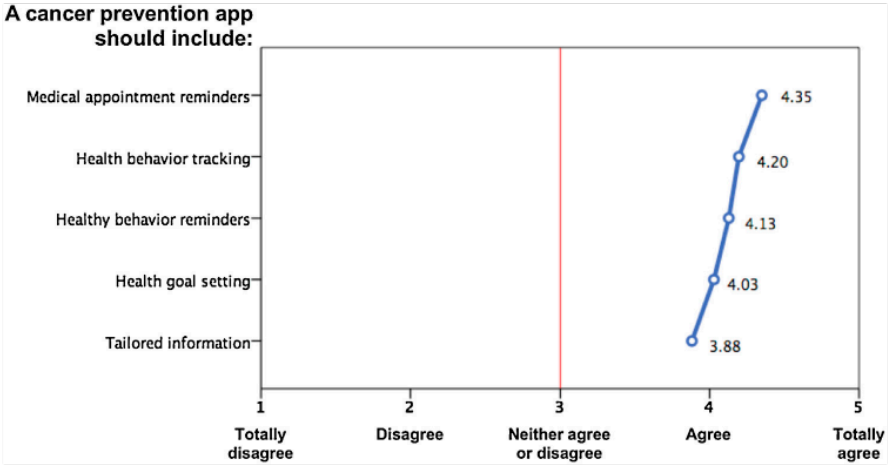


**Fig. 1.** Online survey results for features to include on a cancer prevention smartphone app (5 points likert scale).

"Everything that can be used against us regarding our health habits probably will be in the future. Anything they can grab, that can *screw* us, they will use it. 'Oh, you said in the app that you smoke 3 cigarettes a day, sorry but your insurance isn't 60€ but 75€ because you have a 2.75% higher probability to have lung cancer. That will cost us X more so your insurance will be heavier. It's like when you have an accident with your car, they raise your insurance.'
(Participant A, FG#3)

The physical storage of the collected data was also deemed as very important.

"One thing is to follow ourselves. Other thing is to have 'our friends from NSA' following us 24/7. And that links to the question of where the data is saved. One thing is keeping it on the phone and being able to delete it. A different thing is keeping it on the other side, in the cloud. Because there you can delete it, what you see, but you won't really delete it. It's like Facebook chat, you delete it but it isn't deleted."
(Participant B, FG#1)

Although these points were consensual, the majority of participants showed some tolerance to personal information sharing.

"Participant A: this monitors all your life, all your life. Since you get up till you go to bed.

Participant E: if you want to use your smartphone you have to... right? I think...

Participant B: Yes, it's almost like a privacy concession that people want or not.

Participant E: it's a concession because otherwise you won't do anything"
(FG#3)

They are willing to share some information as long as they control what is shared.

"Participant F: Yes, privacy is always important.

Participant B: That's what we were saying: what to share. We never want to share everything."
(FG#1)

The focus group participants also considered that sharing personal information could be beneficial in specific contexts.

"Why not share, smokers that is, the gradual reduction that they have achieved. Maybe sharing that in a 'just smokers' network motivated people, seeing that. 'That colleague was able to reduce several packs of cigarettes in a week', something like that."
(Participant C, FG#1)

And sharing information with friends for competition purposes was viewed as potentially motivating.

"Maybe with friends it will work pretty well, competition. See who gets more. See who does better."
(Participant E, FG#2)

### 3.5. Personal health data storing and sharing—online survey

The online respondents tended to agree with the focus groups participants regarding health data storing and sharing (Fig. 2).

Among online respondents there were significant statistical differences between genders regarding "Competing with my friends is motivating" ($p < 0.001$ and mean difference = 0.644), "I would share personal health data to compare myself with others" ($p < 0.001$ and mean difference = 0.407), "I would only use a health promotion app if it didn't share my health and personal data with anyone" ($p < 0.001$ and mean difference = 0.315), and "I would share personal health data with others that have the same issue" ($p = 0.044$ and mean difference = 0.216).

Both genders agreed that sharing health information with similar others could benefit them and would share information with them, although they stated that they would only use a health promotion app if it didn't share any personal information with others.

Contrary to what was stated on the focus groups the respondents were not sympathetic with information sharing for comparison purposes. This is more noticeable in the female gender as they tend to disagree more with these statements. Also, female respondents didn't see competition with friends as very motivating.

Regarding the storage of data, most respondents didn't oppose to having their data stored in a server.

### 3.6. Important dimensions for long-term app usage—focus groups

The focus groups participants stressed the importance of easiness of use and of the user interface for long-term app usage.

"I think that, the more information you have to input, less likely it will be to use the app for a long period of time. The first time we will like it and do it, the second also, the third one... right?"

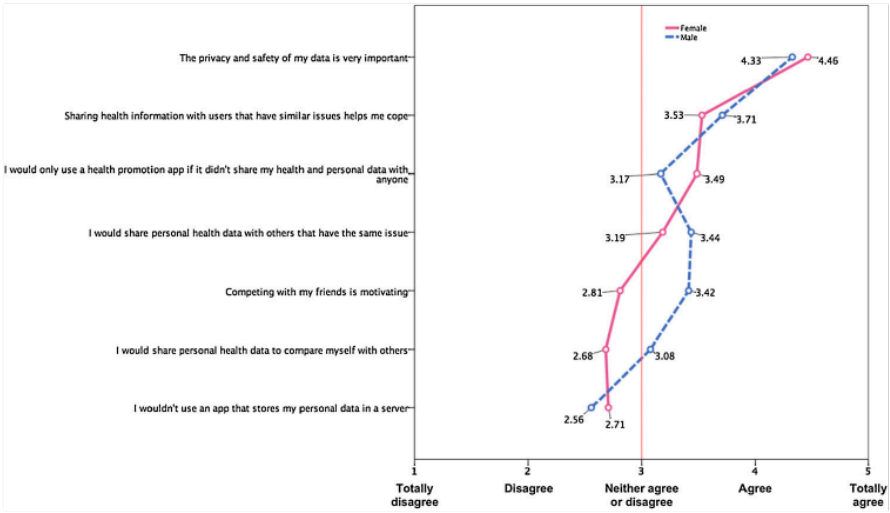


**Fig. 2.** Online survey results for personal health data storing and sharing by gender (5 points likert scale).

(Participant C, FG#2)

"Participant A: the graphic output, the interface. It's... the app might be very good, if it has a horrible interface it can't be, I won't use it, it has to be attractive.

Participant D: the easiness of... I don't know the word, it's not handling but, you know.

Moderator: the usability?

Participant D: that's it.

Participant E: I agree. A thing that you have to click and it's done, I think...

Participant A: it has to be pretty and functional"
(FG#3)

Peer influence was also highlighted as a very important factor, as was the need to efficient manage of phone resources (battery and memory).

"I think the group of friends is important. I think that, I might even delete the app the next day but if someone tells me that that is awesome I will download it."
(Participant E, FG#3)

"Is has to manage battery use well. There are awesome apps, like this one (Moves app), and a person at the end of the day has already low battery, nowadays no one has a phone with a battery that lasts more than two days, and with this (Moves app) not even a day."
(Participant B, FG#1)

### 3.7. *Important dimensions for long-term app usage—online survey*

The online respondents tended to agree with the focus groups participants but added other dimensions for long-term app usage (Fig. 3) concerning the quality of health information (validation, updated information, tailoring and detail), behaviour tracking, healthy challenges promotion and reminders use. Long-term app usage seems to involve a lot more dimensions than those highlighted on the focus groups.

There were significant statistical differences between genders regarding the following features: "Ability to connect with friends to share info or compete" ($p < 0.001$ and mean difference = 1.141), "Ability to connect with unknown users to share info or compete" ($p < 0.001$ and mean difference = 0.954), "Detailed health info" ($p < 0.001$ and mean difference = 0.486), "Use of reminders (concerning healthy behaviours and medical appointments)" ($p < 0.001$ and mean difference = 0.399), "Device optimization (good battery and memory usage)" ($p < 0.001$ and mean difference = 0.339), "Validated health info" ($p < 0.001$ and mean difference = 0.257), "Updated health info" ($p = 0.013$ and mean difference = 0.265) and "Easiness of use" ($p = 0.013$ and mean difference = 0.224). Although the difference between genders was significant regarding "Healthy challenges promotion" ($p = 0.044$), the mean difference was very small (0.138).

Again, respondents didn't see the ability to connect with friends or other users as a very important factor for long-term app use. This was particularly true for female respondents.

## 4. Discussion

Before entering this study, all participants completed a survey concerning health and lifestyle and smartphone user experience. This survey was designed to characterize participants' health and lifestyle behaviours and smartphone user experience. Despite not being a representative sample of the healthy Portuguese young adult population, due to sample size and participants profile (comprised mainly by graduate students), it does give some insight concerning this population behaviour. The results show that the great majority doesn't comply with cancer prevention guidelines. Healthy Portuguese young adults have to improve their behaviour if they want to stay healthy in the future. This scenario stresses the need to design interventions that could change these numbers and provides the best justification for the development of a cancer prevention smartphone app. The results also indicate that many individuals have used their smartphone to monitor health-related behaviours. This shows that this population is already using health-related apps and strengthens our belief that a cancer prevention app might have a widespread use. However, using smartphones to monitor diet, tobacco and alcohol consumption (three behaviours that raise the personal risk of cancer) is less common: only 119 participants in total, 14.6%, reported using apps for one or more of this purposes. This highlights the need to design apps that effectively

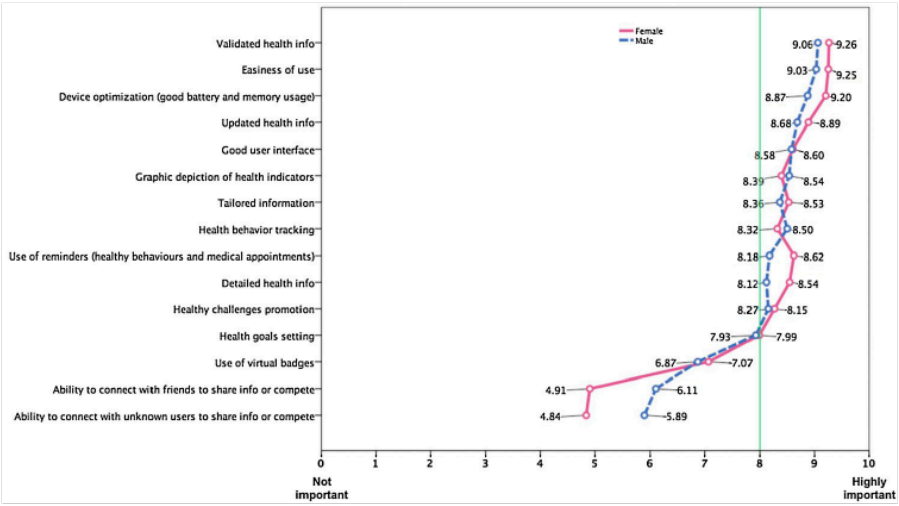


**Fig. 3.** Online survey results for the relative importance of dimensions for long-term app usage by gender (scale of 0–10, where 0 = Not important and 10 = Highly important; 8 or more = Very important).

engage users and promote long-term use. This is the only way that health-related apps in general and cancer prevention apps in particular could help users change these behaviours and lower their health risks.

This study explored the views and experiences of healthy Portuguese young adults concerning the essential features a cancer prevention smartphone app that seeks behaviour change should have. Overall, the results are concurrent with previous research [18–21] although there are some specificities that should be explored more thoroughly.

The study participants identified four main features that should be included in a cancer prevention smartphone app: health behaviour tracking, health goal setting, reminders and tailored information. The first two were seen as more engaging and motivating and could be the core features to support behaviour change. It was implied by several participants that seeing how we behave could be a call to action for most people and lead to the desired behaviour change. Likewise, most participants considered that having goals to achieve was an important motivational factor and a feature that should be included. This has also been reported in previous studies [18,20,21].

The ability to set reminders was viewed as a very important feature, mainly to remind scheduled medical appointments but also to remind to comply with healthy guidelines (eat more fruit, for example). This feature was also highlighted in another study [22].

Finally, study participants noted the importance of tailoring health information provided to the user. Several participants highlighted this feature as a way to help users understand what they have to do without being overwhelmed by too much information. This feature was stressed as essential when it concerns cancer, as there are many misconceptions and myths surrounding this disease [27].

Regarding information sharing, focus group participants showed some openness as long as this was user controlled and only in specific contexts, like between users with similar problems or with friends for competition purposes. However, online respondents seemed less keen on sharing information, despite recognising its value—the majority agreed that sharing information with similar users would help them cope. This tendency was particularly apparent in female respondents and regarding information sharing for competition or comparison purposes.

This attitude towards information sharing via social networks was also seen before [21]. This seems to indicate that, although social sharing can be present in a cancer prevention app, it should always be optional and user controlled and it shouldn't be the main focus of the app.

Some concerns were raised regarding privacy and safety of health information. This concern is a serious problem that every health-related app developer as to deal with and has been identified before [21]. Two different attitudes towards health information storage emerged in the focus groups. Some participants stated that they would only use a health promotion app that relied exclusively on local storage (information never leaving the smartphone), while others were prepared to take some risks, allowing information storage in a secure server (outside the smartphone). The second ones argued that if you want to take advantage of the ability of apps being connected to servers you would have to concede some privacy and take some risks. The online survey confirmed this data as the respondents tended to agree on using an app that stored personal data in a server.

As for long-term use of health apps, the study participants identified several dimensions that could influence it. Easiness of use, good user interface, good smartphone resource management, quality of health information (validation, updated information, tailoring and detail), behaviour tracking, healthy challenges promotion and use of reminders were highlighted as the most important dimensions. Study results seem to show that, if a user perceives the cancer prevention app as useful, with a good user experience, and having an increased value to them (mainly due to the type of information it contains), they will be more likely to use it for a long period of time. This is an important finding because, if we want them to change behaviour in a consistent and sustained way, we have to find ways to engage users for a long period of time. It is also in accordance with a study that analysed factors influencing the continued use of health apps [28].

Features associated with gamification (use of virtual badges, competition with others), designed to increase motivation and to further engage users with apps, don't seem to be important dimensions for long-term use of health-related apps. This was more apparent in female respondents even though male respondents also didn't perceive it as so important as other dimensions.

This study allowed the definition of a guideline set for the development of a cancer prevention smartphone app (Table 2).

**Table 2**
Guidelines for the development of a cancer prevention smartphone app.

| | Guidelines | Dimensions |
|---|---|---|
| User experience | App has to be light, simple to use and behaviour tracking should be passive or based upon low burden inputs. | Easiness of use<br>User interface<br>Smartphone resource management<br>Data input |
| Motivation | App has to be engaging and provide tools to enhance users' motivation. Gamification features aren't considered important. | Behaviour tracking<br>Healthy challenges promotion<br>Health goal setting |
| Usefulness | App has to have useful tools that help users make healthier choices and gain insight on their behaviour. | Use of reminders<br>Behaviour tracking<br>Healthy challenges promotion |
| App content | App content must be validated and up to date. Health information provided should be tailored to the users current health status. | Quality and pertinence of content |
| Social sharing | App can have social features but they should be optional and user controlled. | Information sharing |
| Privacy & Safety | App has to be safe to use and preserve users' privacy using secure connections. | Safety<br>Security<br>Data storage |

The guidelines highlight the focus groups and online survey results and are linked to design and development dimensions. Each dimension provides a possible solution to address the corresponding guideline.

## 5. Conclusions and future directions

This study provides important insights for the development of a cancer prevention smartphone app. It allowed the identification of several features that should be included in a cancer prevention app, and highlighted important dimensions to be considered for long-term use of health promotion apps, mainly related with usability and perceived usefulness. The proposed guideline set can be a very useful tool for the development of health-related apps focused on behaviour change and cancer prevention.

The guideline set will be used in the development of a cancer prevention smartphone app called Happy—Health Awareness and Prevention Personalized for You. Happy will use the Fogg Behaviour Model [13] as a theoretical framework, focusing on the persuasive power of triggers. Several strategies based in different psychology principles will be used to persuade users to change their behaviour, making healthier choices and thus reducing their personal risk of developing several types of cancer.

**Summary points**

What was already known on the topic

- Goal setting and behaviour tracking are important features in health promotion apps.
- Social sharing should be optional in health promotion apps.
- There are privacy and safety concerns when using health promotion apps.

What this study added to our knowledge

- Tailored information regarding cancer prevention is very important.
- Usefulness and easiness of use are important features for long-term use of health related apps.
- Gamification features aren't considered important for long-term use.
- A guideline set for the development of a cancer prevention app is proposed.

## Author contributions

Nuno Ribeiro—Conception and design of the study; Acquisition of data; Analysis and interpretation of data; Drafting of the article; Final approval of the version to be submitted.

Luís Moreira—Conception and design of the study; Analysis and interpretation of data; Critical revision of article; Final approval of the version to be submitted.

Ana Barros—Acquisition of data; Critical revision of article; Final approval of the version to be submitted.

Ana Margarida Almeida—Conception and design of the study; Analysis and interpretation of data; Critical revision of article; Final approval of the version to be submitted.

Filipe Santos-Silva—Conception and design of the study; Analysis and interpretation of data; Critical revision of article; Final approval of the version to be submitted.

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## Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijmedinf.2016.07.007.

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## Paper III

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# Happy: cancer prevention using smartphones

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**Abstract**

Tobacco and alcohol consumption, excessive sun exposure and lack of physical exercise are important risk factors for cancer. In fact, more than half of cancer cases are due to wrong behavioural options; if everyone adopted a healthier lifestyle, cancer incidence would fall dramatically. Information campaigns are critical to raise cancer awareness but they simply are not enough to promote behaviour change.
The main purpose of the work presented in this paper is to develop a smartphone app, capable of inducing behaviour changes on individuals. A cancer prevention app called Happy was designed and is currently being tested. Preliminary results from a feasibility study show that Happy might be an effective health promotion app, capable of persuading users to change their behaviour towards cancer prevention.



*Keywords:* Mobile devices; Smartphones; Cancer prevention; Behaviour change

## 1. Background

Estimates show that, by the year 2030, cancer will affect more than 26 million people worldwide and over 17 million will die from the disease [1,2]. Behaviours like smoking, drinking alcohol, physical inactivity, inadequate sun

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exposure and a poor diet can seriously increase the risk of cancer. In fact, it is estimated that more than half of all cancers are due to wrong lifestyle choices [3–6]. The European Code Against Cancer [7] states that many aspects of general health can be improved and many cancer deaths would be prevented if we adopted a healthier lifestyle. Individually, everyone should follow these cancer prevention guidelines to reduce their personal cancer risk. People have generally favorable attitudes towards healthy behaviours and might even consider following these guidelines; however, they often lack the skills needed to maintain it as part of their daily routine [8]. Behaviour change is a very challenging process.

Smartphones can be helpful tools to induce behaviour change. Like all mobile phones, they are personal, portable and always connected. Smartphones are also becoming ubiquitous, allowing extended interventions with relatively low implementation costs [9]. Using the various built-in sensors, they can "sense" time, location and even physical context in real time and tailor messages to the users' behaviour needs. Several studies have suggested that behaviour change is possible using smartphones. They have been used successfully in several interventions ranging from smoking cessation, to weight loss and disease management [9–12]. However, the large majority of these interventions rely on basic communication technology such as short message services (SMS). Smartphones have several embedded sensors that offer more complex and powerful capabilities. The potential of smartphones in behaviour change interventions hasn't yet been fully explored [11].

## 2. Happy: Health Awareness and Prevention Personalized for You

Happy is a cancer prevention smartphone app that aims to persuade users to change their behaviour, making healthier choices, thus reducing their personal risk of developing several types of cancer.

Happy uses the Fogg Behavior Model [13–15] as a theoretical framework, focusing on the persuasive power of triggers. It also uses several strategies based on different behaviour change techniques such as barrier identification, prompting, social support, social comparison, and behaviour modeling [16].

### *2.1. Target population*

The target population of this app is composed of healthy Portuguese young adults, with ages between 18 and 35 years old. The choice of a young population is due to two different reasons: (1) Cancer prevention should start at an early stage of life (due to the effect of long exposure to risk factors) [3]; (2) Almost all individuals included in this population own at least one mobile device [17].

### *2.2. App features*

Happy is based on the principle of tailoring, i.e., using information on a given individual/profile to determine what specific content he or she will receive [18]. Thus, when users access Happy for the first time they are required to answer a behaviour assessment questionnaire. The data collected allows the definition of the user profile and determines the current level of cancer prevention, called HappyScore (Fig. 1-A). HappyScore is represented on the landing page allowing the users to self-monitor their behaviour in a glanceable way. This strategy as proven to be effective in influencing health behaviours in other contexts [19]. HappyScore is calculated using weighted values for different cancer behavioural risk factors (Table 1). The resulting score ranges from 0 to 150: the highest the displayed number, the better the overall behaviour is in terms of cancer prevention. The user profile is also used to tailor health messages to each individual. Tailored messages (Fig. 1-B) are expected to be the triggers of behaviour change. The messages are tailored accordingly to the users profile, influenced by users previous behaviour and take into account users context (location, time of day, week and month, weather conditions). The effort of tailoring messages to the users profile and context has been proven successful in other behaviour change interventions [20,21] and is, therefore, a core feature of Happy. Messages target specific behaviours and follow the European Code Against Cancer guidelines [7].

Happy also allows behaviour tracking. Users can track their behaviour by answering behaviour questions that are sent to them periodically by the app or by deliberately entering behaviour data. These behaviour assessments are used to recalculate the users HappyScore and change the user profile over time, allowing the tailoring to occur

concurrently to the changes in behaviour. At any given time, users can explore the *Statistics* section (Fig. 1-C) of the app and assess their behaviour. *Statistics* are the graphic feedback of behaviour tracking. It is mainly a self-assessment and motivational tool. Graphic feedback will help people reflect about activities patterns and may help them change their behaviour [22].

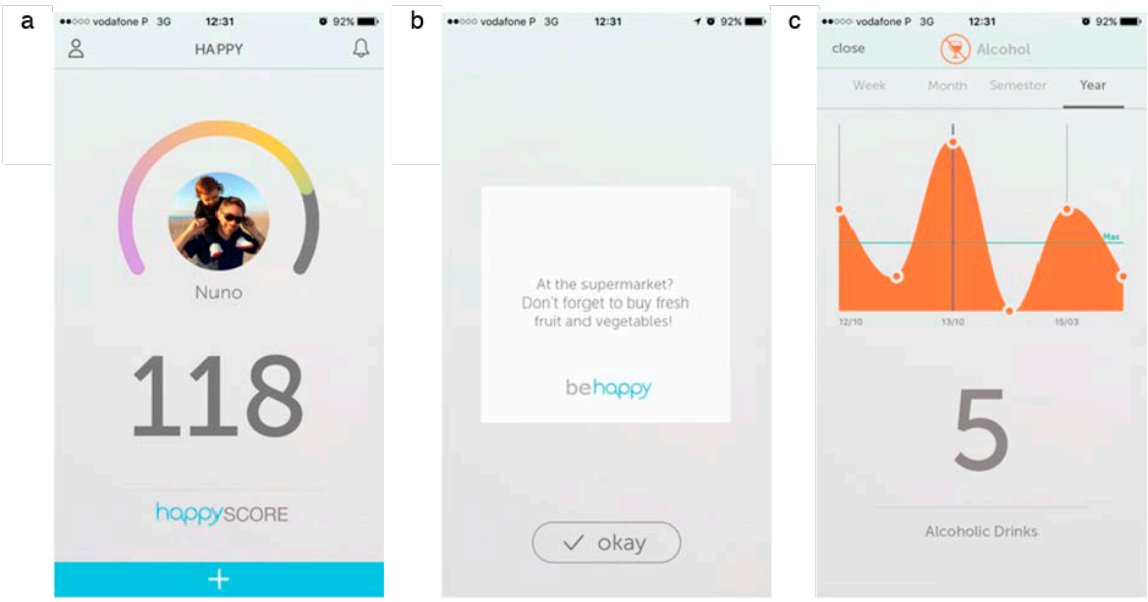


Fig. 1. (a) HappyScore (app landing page); (b) Tailored message; (c) Statistics.

Table 1. Contribution of behavioural factors and indexes to HappyScore.

| Behavioural factors and indexes | Description | Points |
|---|---|---|
| Smoking | Number of smoked cigarettes per day. From 0 to >25 cigarettes. | - 35 to 0 |
| Alcohol consumption | Number of alcoholic drinks consumed per day. From 0 to >1 drinks (Female); 0 to >2 drinks (Male). | -5 to 0 |
| Fruit and vegetables consumption | Number of portions of fruit and vegetables consumed per day. Range: 0 to ≥5 portions. | - 20 to 0 |
| Unhealthy foods consumption | Number of portions of unhealthy foods consumed per day (red meat, processed meat, and fatty foods). From 0 to >3 portions. | - 10 to 0 |
| Diet quotient | Ratio between portions of fruit and vegetables and portions of unhealthy foods (Cut point: 0.9). | - 8 to 0 |
| BMI | Body mass index calculated using height and current weight. From underweight to obesity. | - 15 to 0 |
| Physical activity level | Physical activity level as measured by the International Physical Activity Questionnaire, short form [23]. From low to high. | - 5 to 0 |
| UV radiation exposure | Number of sunburns last year. From 0 to >1. | - 2 to 0 |
| HPV and HBV vaccination | From "no vaccination" to "HBV and HPV vaccination" (Female) or "HBV vaccination" (Male) | 0 to 20 |
| Cervix cancer screening | Cervix cancer screening enrolment according to national guidelines [24]. Only applies to female. From "no screening performed" to "currently screened". | 0 to 10 |

| | | |
|---|---|---|
| Self-exams | Skin, breast (female) and testicular (male) self-exams performed. From "no self-exam performed" to "all self-exams performed". | 0 to 30 |

**HappyScore = 100 + (sum of all points)**

*2.3. General architecture*

Happy's general architecture is supported by the smartphone and its sensors (date and time, GPS and accelerometer) and a server (that acts simultaneously as a web server and a data repository) linked to the messages database, enabling the connection to a set of APIs (Application Program Interfaces), namely World Weather Online, and Google Maps services. The smartphone's embedded sensors detect and feed data (GPS coordinates, device movement, date and time) to Happy. The app then processes this data using the World Weather Online and Google Maps API to generate significant contextual data (weather conditions and location). The smartphone transmits the data to the remote server where it is bundled with the user profile (previously stored in the server). This data set is then used to search the message database and select the message that is best suited to the user profile and current context. The selected message (tailored message) is then sent to the smartphone and presented to the user in the app.

Behaviour data entered by users is also sent to the server where it is registered and used to recalculate the HappyScore and statistics. These values are then sent to the smartphone and presented graphically to the user. All entered data is stored in the server and mapped into the user profile, dynamically adjusting the subsequent messages sent to the user. Hypertext Transfer Protocol (HTTP) is used in all data transmission between the smartphone and the server, which means that the smartphone must have an Internet connection service such as General Packet Radio Service (GPRS), 3rd generation (3G), 4th generation (4G) or a wireless local area network. If the smartphone is temporarily disconnected from the Internet, all entered data will be stored locally and sent to the server when the connection is restored, updating all data values. Happy runs on Android OS and iOS, the two most commonly used smartphone platforms.

*2.4. App development*

Happy was developed iteratively through a series of steps, described below.

*Requirement analysis*: three focus groups with healthy Portuguese young adults (n=16) were conducted to explore: 1) prior experiences with health-related apps, 2) points of view concerning currently available health-related apps, 3) points of view concerning desired features in a health promotion app and 4) opinions on what features mostly influence long term usage of health promotion apps. Based on the focus groups analysis, a questionnaire was designed and applied online to a larger sample (n=798) of healthy Portuguese young adults. The results were analysed and a set of specific guidelines was produced for the design and development of the cancer prevention app.

*Prototype development*: based on the resulting guidelines of the requirement analysis step, as well as on the scientific literature, a functional prototype of Happy was developed.

*Usability test*: a usability test was performed to test Happy's ability to be used by real users in real contexts. Ten volunteers performed seven tasks in the app and then answered a usability questionnaire. The *Think Aloud Method* [25] was used to further extract information from the users performance. Three usability problems were identified during the test. Solutions to overcome these problems were embedded on the prototype. Overall, Happy's usability test results were very good deeming this app as simple and easy to use.

*Feasibility study*: Happy was field tested during a 28-day trial period by 32 volunteers. The results of this study are presented in the next section of the paper.

## 3. Feasibility study

### 3.1. Methods

Individuals were recruited via e-mail and a Facebook announcement. Interested participants were required to answer an online survey. Potential participants were included if they were: (1) 18 to 35 years of age, (2) Android or iOS smartphone users. Selected participants were instructed to download and install the app on their personal phones, and register in the system by answering the initial behaviour assessment.

Participants were informed that the app would send one message per day and would prompt them to answer a behaviour question at the end of each day. Participants were instructed to use the app for 28 consecutive days (4 weeks) and were required to answer an online questionnaire at the end of this period. The questionnaire was designed to assess feasibility and perceived impact of the app.

### 3.2. Results

#### 3.2.1. Feasibility

Thirty-two participants used the app during a 28-day trial. On average, during the 28-day trial period, there were 13 (40.6%) active users per day (Fig. 2). Each session, i.e., each user interaction with the app, took on average 31 seconds.

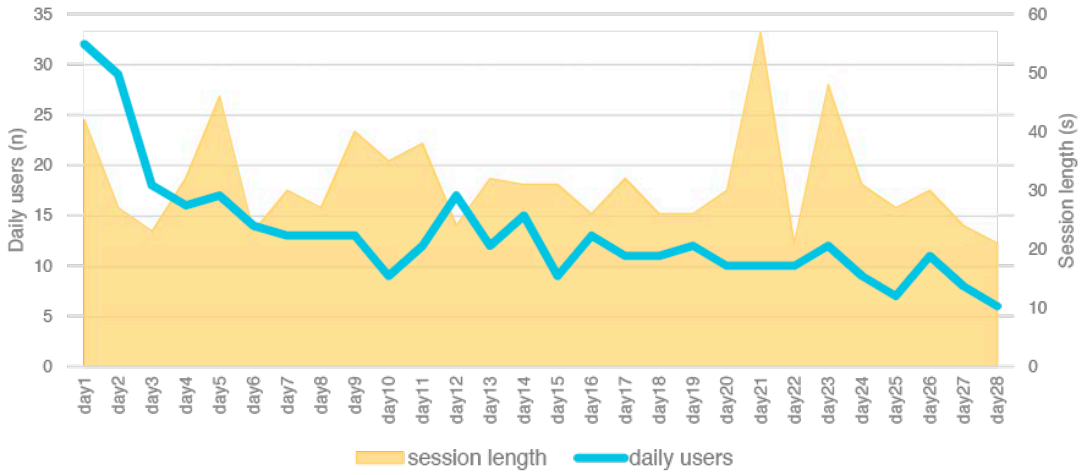


Fig. 2. Daily users and session length during Happy's 28-day trial period.

Participants were prompted by the app to answer a behaviour question at the end of each day. On average, each user entered behaviour data in 12 occasions (41.0% of the app prompts). However, 56.0% of the occasions, they answered more than one question.

#### 3.2.2. Perceived impact of the app

The majority of participants agreed that the app could have a real impact in cancer prevention (Fig. 3).

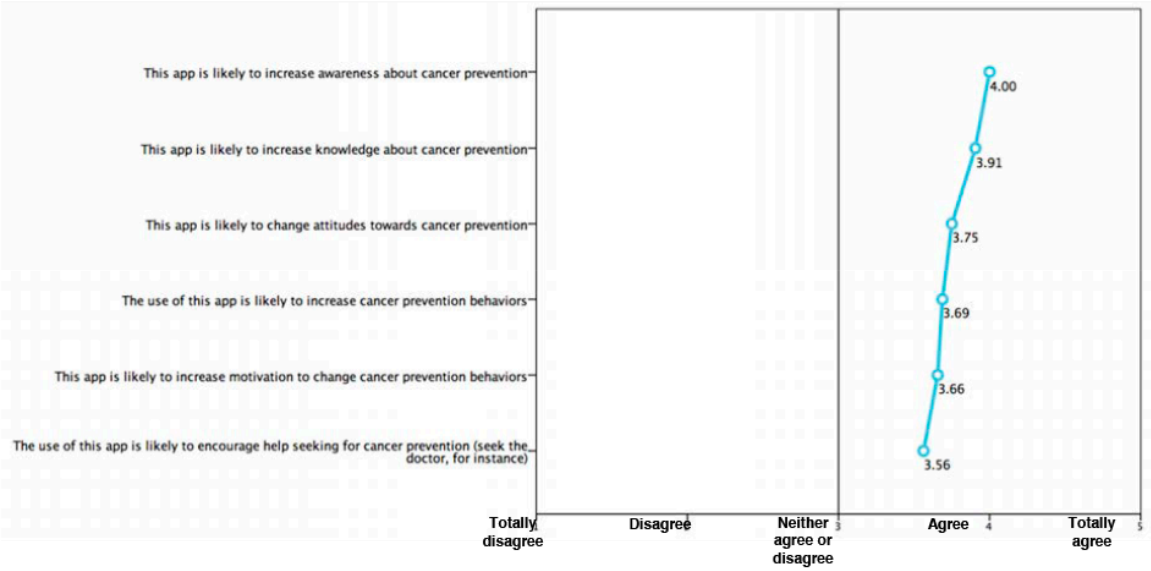


Fig. 3. Perceived impact of Happy (average score).

In fact, self-reported behaviour data showed a slight improvement in some cancer prevention behaviours which, in terms of overall cancer prevention, contributed to a 7 points rise in the average HappyScore during the 28-trial (Fig. 4).

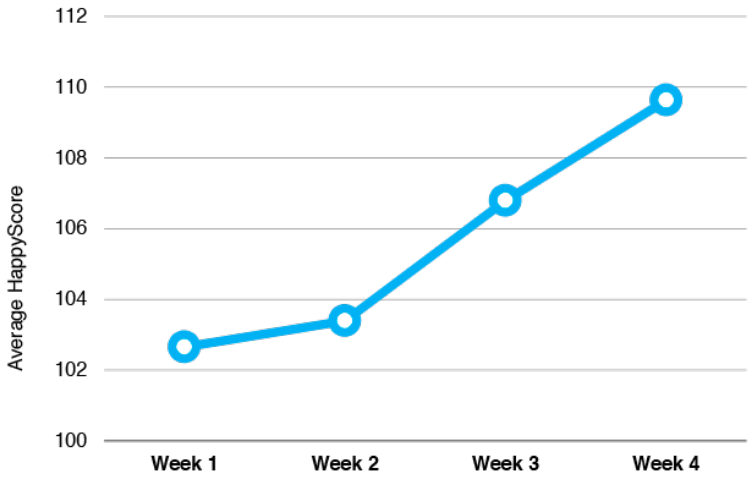


Fig. 4. Average HappyScore during the 28-day trial (week averages).

A repeated measures ANOVA analysis showed that the change in HappyScore was statistical significant ($P$=0.031).

### *3.3. Discussion*

This study showed the feasibility of a behaviour intervention delivered by smartphone designed to persuade users to change their behaviour towards cancer prevention. Results revealed that, on average, participants interacted with the app in 12 different occasions during the 28-day trial. This suggests that user engagement was low. Given that Happy was used in real life settings, this is not surprising albeit disappointing. In fact, previous research on mobile health apps has also shown that about 75% of app users open it fewer than 10 times [26]. On the other hand, users inputted more behavioural data than that requested by the app in half of the occasions. Similarly, tailored messages were sent to participants everyday as push notifications. There was no need for the user to open the app to read them. As such, user-system interaction might be underrepresented in the results.

Our findings also indicate that Happy might be an effective way to promote cancer prevention. The majority of participants agreed that the app might increase cancer awareness and knowledge, and even motivate users to change behaviours. This seems to be corroborated by the data collected during the 28-day trial as there was an increase in the average HappyScore by 7 points. These preliminary results seem to indicate that an intervention delivered by smartphone can effectively promote behaviour change towards cancer prevention.

## 4. Conclusion

Cancer incidence could be reduced to half if populations adopted healthier behaviours. Behaviour change, despite being a very difficult task, can be achieved with proper strategies. Smartphones can be very useful tools to empower people and help them make healthier choices providing the support needed to behaviour change.

Happy is a smartphone app that aims to promote cancer prevention behaviours. It has been shown that Happy is simple and easy to use. Preliminary results from the feasibility study show that it might be an effective tool to persuade users to change their behaviour towards cancer prevention.

### *4.1. Future research directions*

Cancer prevention through behaviour change relies upon performing healthy behaviours for the rest of people's lives. Thus, long-term use of Happy is essential for the success of the underlying intervention. The feasibility study results showed that user engagement was low. Consequently, refinements will have to be made to the app to further engage users with Happy. This will include adding two new functionalities: challenges and social. Challenges are healthy challenges meant to further engage users with the app. The challenges will be optional and users can enrol them voluntarily. They will be designed to give small achievable goals to boost users' motivation and help them reach desired behaviours. Each completed challenge will have a score and can be used for comparison purposes with other users. Social will display all users that are added to the user's social network. It will allow users to communicate with other users in an individual, group or app community level. This feature will be designed to boost online support and competition between users. In order to leverage existing online social interactions, Happy will be integrated with the most widely used social networking system: Facebook [27]. This will be done using Facebook's open application-programing interface (API) that allows access to functions for online interaction to third party apps.

Happy will then be used in a large-scale intervention to evaluate its effectiveness. This will allow an in-depth analysis of the real capabilities of Happy to induce behaviour change in users and, thus, contribute to cancer prevention.

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## Paper IV

Ribeiro, N., Moreira, L., Almeida, A. M. P., & Santos-Silva, F. (2017). Mobile Seamless Learning Tool for Cancer Education. In Ó. Mealha, M. Divitini, & M. Rehm (Eds.), *Citizen, Territory and Technologies: Smart Learning Contexts and Practices* (pp. 3–10). http://doi.org/10.1007/978-3-319-61322-2_1

# Mobile Seamless Learning Tool for Cancer Education

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**Abstract.** Mobile seamless learning provides the foundation for new digital solutions capable of adapting the contents to the learner needs and contexts. Studies have shown that cancer prevention knowledge remains reduced in modern societies. Given the worldwide burden of cancer, there is a need to increase cancer literacy in the populations, namely through the development of innovative strategies. This paper describes a 3 months two-arm quasi-experimental effectiveness study of a new mobile seamless learning tool for cancer education. Results showed that this application significantly increased cancer prevention knowledge of the users when compared to a control population ($p < 0.001$). This study provides evidence that a mobile seamless education tool can merge into the users' daily routine increasing users' knowledge by providing relevant cancer prevention information through messages delivered over an extended period of time. These innovative health education solutions will further expand the context of a smart learning ecosystem.

**Keywords:** Mobile learning · Seamless learning · Cancer prevention · Cancer literacy · Smartphone app

## 1 Introduction

A smart learning ecosystem can be described as a means to enable learning processes by removing or lowering barriers (Giovannella 2014). In this sense, mobile learning plays a very important role since it breaks down barriers and allows learning to take place in different contexts, enriching the learning processes (Park 2011). Mobile devices can be seen as "learning hubs", giving ubiquitous access to knowledge and connecting individual learners to communities of learners and physical or digital places. This is the underlying concept of mobile seamless learning, where a learner can learn in a variety of scenarios and contexts that can be easily switched given that it is mediated by a personal mobile device (Wong 2012). Mobile devices can make the educational process "just in time, just enough and just for me" (Peters 2007).

Smart cities are, in part, characterized by the emphasis on sustainable use of resources aimed at improving the well being of societies and the quality of life of its citizens


Ó. Mealha et al. (eds.), *Citizen, Territory and Technologies: Smart Learning Contexts and Practices*, Smart Innovation, Systems and Technologies 80, DOI 10.1007/978-3-319-61322-2_1

(Giovannella et al. 2012). On the other hand, cancer is set to become a major cause of morbidity and mortality in the coming decades in the world, thus representing an increasingly bigger burden on society (Bray et al. 2012). There is a need to develop smarter learning ecosystems regarding effective primary prevention strategies that might increase cancer awareness with corresponding healthier behaviours and early disease detection. Recent studies have shown some concerning results: general knowledge of certain cancer risk factors (such as alcohol, red and processed meats, low amounts of fruit and vegetables) and prevention behaviours remains alarmingly low (American Institute for Cancer Research 2017; Costa et al. 2016; Peacey et al. 2006; Sherman and Lane 2014). This calls for the need to better promote cancer literacy (Diviani and Schulz 2011) among the general public.

Smartphone applications can have a relevant role in these processes and have been pointed out as important tools to promote cancer prevention. A quick search in a major smartphone app distribution store such as Apple App Store or Google Play Store reveals several thousand health-related apps designed to promote smoking cessation, healthy eating, and other behaviours related with reduced risk of cancer. However, most of them lack scientifically validated data and haven't yet been tested in research studies to determine their effectiveness (Coughlin et al. 2016; Pandey et al. 2013).

The aim of this study was to assess the effectiveness of Happy, a cancer prevention smartphone app, as a mobile seamless learning tool for cancer education, which is based, among other features, on tailored messages adjusted to the users' context (location, time of day, week and month, weather conditions).

## 2 Methods

### 2.1 Happy, a Mobile Seamless Learning Tool for Cancer Education

Happy (Health Awareness and Prevention Personalized for You) is a cancer prevention smartphone app that aims to help users learn about cancer prevention in order to persuade them to make healthier choices, thus reducing their personal risk of developing several types of cancer.

Happy is based on the principle of tailoring, i.e., using information on a given individual/profile to determine what specific content he or she will receive (Hawkins et al. 2008). When users access Happy for the first time, they are required to answer a behaviour assessment questionnaire (Fig. 1a). The data collected allows the definition of the user profile and determines the current level of cancer prevention, called HappyScore (Fig. 1b). The HappyScore is represented on the landing page allowing the users to self-monitor their behaviour in a glanceable way.

Happy sends one tailored cancer prevention message a day to each user (Fig. 1c). This allows learning to occur through time in a non-intensive way, lowering the user burden and avoiding user rejection.

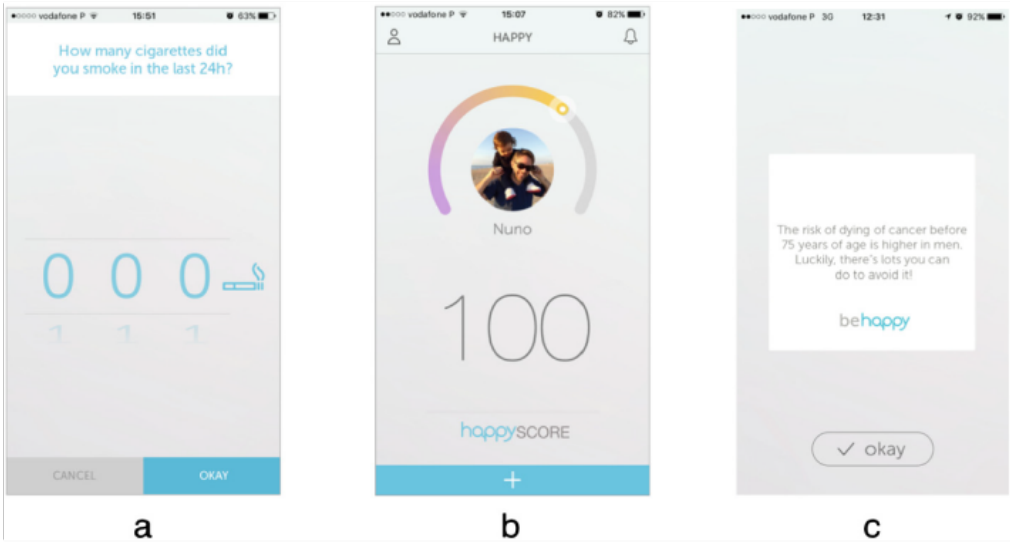


**Fig. 1.** Screenshots of the smartphone app Happy: (a) Sample question from the behaviour assessment questionnaire; (b) Landing page (HappyScore = 100); (c) Tailored cancer prevention message

The user profile is also used to tailor the cancer education messages sent to each user. Additionally, messages are tailored accordingly to the users' context (location, time of day, week and month, weather conditions). When a user is located in a target place, the message sent to her will take this in consideration, increasing the relevance and adequacy of the message content to the user (Table 1). The effort of tailoring messages to the users' profile and context is important because it allows the delivery of cancer prevention messages with less redundant information, that are more likely to be remembered and processed by the receiver (Hawkins et al. 2008). Also, it provides the needed adaptive flexibility to the app that allows mobile seamless education to occur. A total of 1,120 messages were developed. Messages follow the European Code Against Cancer guidelines (Schüz et al. 2015) and target specific risk factors of cancer, providing educational information.

Happy also allows behaviour monitoring. Users can track their behaviour by answering behaviour questions that are sent to them periodically by the app (1 each day) or by deliberately entering behaviour data. These behaviour assessments allow two different things in the context of the app. They are used to:

- update the user profile over time. This allows message tailoring to occur concurrently to the changes in behaviour emphasizing the risk factors that matter most to that user;
- recalculate the users' HappyScore. This shows the user the cause and effect link of a particular behaviour to the level of cancer prevention, an intense and very personal learning experience.

Happy also has a section that allows users to connect to each other, facilitating communication between them and a section with healthy challenges meant to engage the users with the app.

**Table 1.** Examples of tailored cancer education messages used in the app

| Tailored message | Trigger context |
|---|---|
| *Enjoying the beach? Beware: clouds don't protect from UV rays! Wear sunscreen and look for a shade. Be happy* | Time of day: 12 h to 16 h<br>UV index: >6<br>Temperature: >18°C<br>Weather: Cloudy<br>Location: Beach |
| *Cervix cancer is the second deadliest form of cancer among young women. Don't risk your life. Book an appointment with your gynaecologist. Be happy* | Profile: female, more than one year since last pap smear<br>Time of week: Monday to Friday<br>Time of day: 10 h to 20 h |
| *At the supermarket? Did you know that by reducing the amount of salt you're reducing your stomach cancer risk? Avoid foods that come in a package like chips. Be happy* | Profile: high salt consumption<br>Time of day: 10 h to 20 h<br>Location: Supermarket |
| *Going out? Did you now that drinking alcohol raises your risk of cancer? Don't drink. If you do, stick to one drink a night. Be happy* | Profile: alcohol drinker, female<br>Time of day: 21 h to 23 h<br>Time of week: Thursday, Friday or Saturday<br>Location: Bar/Disco |

## 2.2 Study Design

A two-arm quasi-experimental design was used with baseline (at study enrolment) and post-test (3 months later) assessments. All elements in the intervention group used the smartphone app Happy whereas the elements of the control group didn't. All app users (n = 3,252) received an email with a link to an online questionnaire in the beginning of the study. Users that answered the questionnaire and had more than 18 years were included in the intervention group. The same email was sent to a mailing list from University of Aveiro (n = 2,558). Every individual that answered the questionnaire, had a smartphone and had more than 18 years was included in the control group. Three months later, all study participants received a new email requiring them to answer the same online questionnaire a second time.

The online questionnaire consisted in two groups of questions:

- Sociodemographic characterization: age, gender, education, and email address;
- Knowledge assessment: 15 multiple choice questions concerning several dimensions of cancer prevention (risk factors, epidemiology and behaviour guidelines).

The primary outcome of the study was knowledge, measured as the difference between baseline and post-test knowledge assessments. The differences between baseline and post-test knowledge assessments were tested using independent and paired samples *t* tests (inter and intra groups, respectively).

# 3 Results

## 3.1 Participants

As shown in Fig. 2, a total of 3,252 and 2,558 participants were eligible for the intervention and control groups, respectively. Of these, 523 (16.1%) and 103 (4.0%) answered the baseline questionnaire. In the post-test assessment, 401 (76.7%) and 22 (21.3%) didn't answer the questionnaire and, thus, were lost to follow-up in the intervention and control groups respectively. One participant was excluded from the control group because she downloaded and used the intervention app.

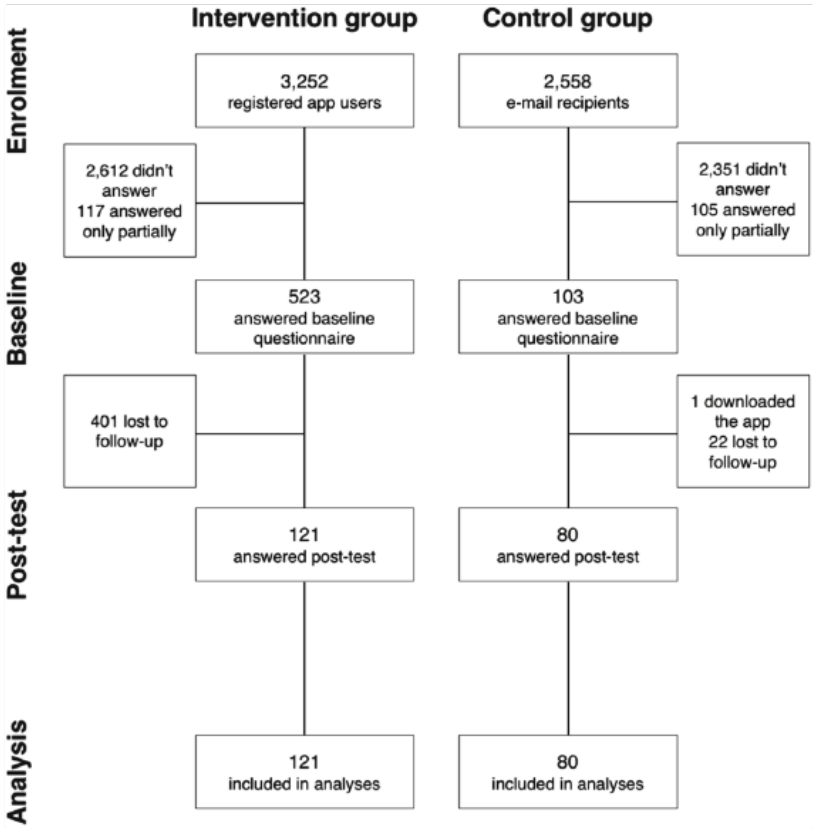


**Fig. 2.** Enrolment overview

Participant characteristics are presented in Table 2. Participants were predominantly 31 to 40 years old (39.3%), female (77.6%), and had a college degree (86.1%).

**Table 2.** Demographic characteristics of study participants, n (%)

| | | All (n = 201) | Intervention group (n = 121) | Control group (n = 80) |
|---|---|---|---|---|
| Gender | Female | 156 (77.6) | 93 (76.9) | 63 (78.8) |
| | Male | 45 (22.4) | 28 (23.1) | 17 (21.3) |
| Age | 18–25 years | 73 (36.3) | 33 (27.3) | 40 (50.0) |
| | 26–30 years | 49 (24.4) | 26 (21.5) | 23 (28.8) |
| | 31–40 years | 79 (39.3) | 62 (51.2) | 17 (21.3) |
| Education | Undergraduate | 28 (13.9) | 16 (13.2) | 12 (15.0) |
| | Graduate | 173 (86.1) | 105 (86.8) | 68 (85.0) |

### 3.2 Knowledge Assessment

Figure 3 shows the baseline and post-test knowledge assessment results. A significant increase in knowledge was observed on the intervention group, with a mean increase of 0.08 points ($p < 0.001$), from 0.66 (baseline) to 0.74 (post-test). Knowledge remained almost equal on the control group, from 0.70 (baseline) to 0.71 (post-test), a mean difference of only 0.01 points. The differences between groups in the post-test were also significant ($p < 0.001$).

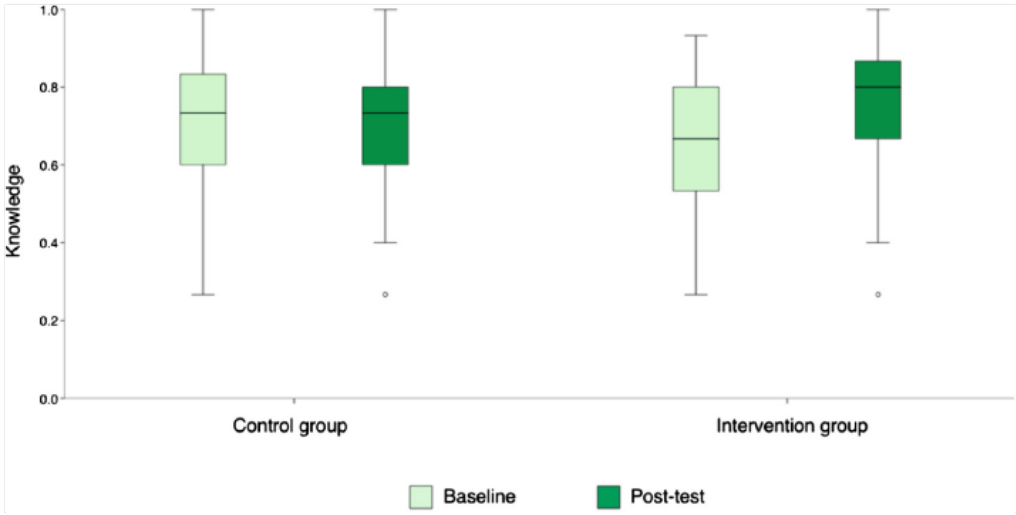


**Fig. 3.** Baseline and post-test knowledge assessment results

## 4 Discussion and Conclusion

Smart learning ecosystems have the potential to revolutionize the way we look at education. Mobile devices, as "learning hubs", are at the core of this revolution. They provide the means to implement seamless learning systems, allowing learning to occur through numerous contexts and moments in time. This study aimed at assessing the effectiveness

of Happy, a cancer prevention smartphone app, as a mobile seamless education tool for cancer education. Happy uses tailored cancer prevention messages as the main way to seamlessly educate users about cancer prevention. Users receive one message per day, tailored to the profile and physical context of the user. This allows the delivery of relevant cancer prevention messages that are more likely to be remembered and processed by the receiver. The app is designed to adapt to behaviour changes that might occur in users, guaranteeing that the content delivered is always relevant for the user.

The study was conducted with 201 participants distributed in two groups (intervention and control). Participants were mainly 31 to 40 years old, female and had a college degree. At baseline, knowledge assessment showed that both groups had a similar level of cancer prevention knowledge: 0.66 and 0.70 in the intervention and control group, respectively. The intervention group used the app for 3 months, whereas the control group didn't receive any intervention. The results of the post-test revealed that the level of cancer prevention knowledge remained the same in the control group and significantly increased in the intervention group ($p < 0.001$). This suggests that the app effectively contributed to changes in terms of cancer prevention knowledge. It's worth noting that this was a low burden intervention (users only received one message per day) and that the app was used in the context of everyday lives. Thus, this study provides evidence that a mobile seamless learning tool can be merged into the users' daily routine and still influence users' knowledge by providing relevant cancer prevention information through messages sent over an extended period of time (3 months). Happy was developed as a "just in time, just enough and just for me" cancer education tool. In this sense, it proved to be a good strategy to provide relevant cancer education content and, thus, increase cancer literacy in the studied population.

The proposed approach described in this article was based on a model that can be applied to different contexts, opening new possibilities in other educational themes or by integrating a larger smart learning ecosystem. More than an end solution to a problem, this approach should be seen as a means to provide continuity from formal to informal educational contexts, eliminating barriers in the learning process and contributing to create new modalities that enhance learning experiences in different domains and scenarios.

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## Paper V

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Research Paper

# Pilot study of a smartphone-based intervention to promote cancer prevention behaviours

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ABSTRACT

*Background:* Estimates predict that more than half of all cancers are due to inadequate lifestyle choices. Smartphones can be successfully used to support the behaviour change needed to prevent cancer.
*Objective:* The purpose of this study was to field-test Happy, a smartphone app designed to promote cancer prevention behaviours, based on tailored-messages.
*Methods:* Thirty-two participants downloaded and used the app for 28 consecutive days (4 weeks). At the end of this period, they all answered an online questionnaire and ten of them were interviewed. Usability, feasibility, message receptivity, and perceived impact of the app were assessed.
*Results:* Compliance with cancer prevention guidelines was lower than expected. Happy was considered simple, intuitive and easy to use. Messages sent by the app were considered easy to understand, providing good advice and meaningful information that catch reader's attention. Participants also considered that Happy might be an effective way to promote cancer prevention. Collected data showed an increased frequency in several cancer prevention related behaviours and an increase in the overall putative cancer prevention level.
*Conclusions:* This study showed the viability of designing and implementing smartphone-based interventions to promote cancer prevention behaviours. The results suggest that Happy is usable and might help users change their behaviour towards healthier choices and thus reduce their personal cancer risk.

## 1. Introduction

It is predicted that by the year 2030 cancer will affect more than 22 million people worldwide with over 17 million dying from the disease [1,2]. Factors like tobacco, sedentarism, alcohol, UV rays and a poor diet can seriously raise the risk of cancer. In fact, it is estimated that more than half of all cancers are due to inadequate lifestyle choices [3–10]. The European Code Against Cancer [11] states that many aspects of general health can be improved and many cancer deaths can be prevented if healthier lifestyles are adopted. These prevention behaviours can be achieved by following these guidelines: (1) Do not smoke; (2) Maintain a healthy body mass index (BMI); (3) Implement some brisk physical activity every day; (4) Increase daily intake of vegetables and fruits (at least five servings per day); (5) Limit alcohol consumption to one or two drinks per day (women and men, respectively); (6) Avoid excessive sun exposure; (7) Enrol in cancer screening tests (cervical, breast and colorectal); (8) Participate in vaccination programs against hepatitis B virus (HBV), and human papillomavirus (HPV); (9) Avoid exposure to known cancer-causing substances. Although people have favourable attitudes towards healthy behaviours, they often lack the skills needed to maintain them as part of their daily routine [12].

Several studies have suggested that smartphone apps can support successful behaviour changes ranging from smoking cessation, to weight loss and disease management [13–19]. However, most of these studies describe limited interventions designed to target a specific behaviour. Targeting multiple behaviours at once, we can promote a health awareness that, in turn, might trigger other healthier behaviours with great benefits for the global health status [20]. This is particularly important in the area of cancer prevention, as the overall risk of cancer is a result of concurrent risk factors.

This paper reports the results from a pilot study of a smartphone-based intervention designed to promote cancer prevention behaviours called Happy (Health Awareness and Prevention Personalized for You).

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**Table 1**
Contribution of behavioural factors and indexes to Happy Score.

| Behavioural factors and indexes | Description and range | Points |
|---|---|---|
| Smoking | Number of smoked cigarettes per day. From > 25 to 0 cigarettes. | 0–35 |
| Alcohol consumption | Number of alcoholic drinks consumed per day. From > 1–0 drinks (Female); > 2–0 drinks (Male). | 0–5 |
| Fruit and vegetables consumption | Number of portions of fruit and vegetables consumed per day. Range: 0–≥5 portions. | 0–20 |
| Unhealthy foods consumption | Number of portions of unhealthy foods consumed per day (red meat, processed meat, and fatty foods). From > 3 to 0 portions. | 0–10 |
| Physical activity level | Physical activity level as measured by the International Physical Activity Questionnaire, short form [30]. From low to high. | 0–5 |
| UV radiation exposure | Number of sunburns last week. From > 1 to 0. | 0–2 |
| HPV and HBV vaccination | From "no vaccination" to "HBV and HPV vaccination" (Female) or "HBV vaccination" (Male) | 0–20 |
| Cervix cancer screening | Cervix cancer screening enrolment according to national guidelines [31]. Only applies to female. From "no screening performed" to "currently screened". | 0–10 |
| Self-exams | Skin, breast (female) and testicular (male) self-exams performed. From "no self-exam performed" to "all self-exams performed". | 0–30 |
| Diet quotient | Ratio between portions of fruit and vegetables and portions of unhealthy foods (Cut point: 0.9). | 0–8 |
| BMI | Body mass index calculated using height and current weight. From obesity to normal weight. | 0–15 |

## 2. Materials and methods

### 2.1. Happy smartphone app

The development of the smartphone app Happy has been described in detail elsewhere [21]. In brief, Happy uses Fogg Behaviour Model [22,23] as a theoretical framework, and is based on the principle of tailoring [24]. When users access the app for the first time, they are required to answer a questionnaire. The questionnaire has 13 and 14 questions for men and women, respectively, and assesses diet, physical activity, weight, alcohol and tobacco consumption, ultraviolet (UV) radiation exposure, vaccination, screenings and self-exams. This questionnaire allows user profiling and determines the current putative level of cancer prevention, called Happy Score (HSc) in the context of the app. This score was created for the purposes of this app and isn't a clinically validated measure of cancer prevention. HSc summarizes the information about user's behaviours associated with cancer risk/prevention. It is calculated by adding up the points obtained for every self-reported behaviour (Table 1). The points attributed to each behaviour were weighted according to available scientific evidence [25–28]. The resulting score ranges from 0 to 150: the highest the displayed number, the better the overall behaviour in terms of cancer prevention. HSc is represented on the landing page, allowing users to self-monitor their behaviour in a glanceable way (Fig. 1a). This strategy has proven to be effective in influencing health behaviours in other contexts [29].

Behaviour assessment during app use was done through Ecological Momentary Assessment [32,33]. Each day, 30 min before self-reported bedtime, users were prompted to answer one behaviour question, randomly assigned from the whole behaviour assessment questionnaire (Fig. 1b). They could also report behaviours by taping the button " + " on the app's landing page (Fig. 1a).

These behaviour assessments were used to recalculate the users' HSc and change the user profile over time, allowing message tailoring to occur concurrently to behaviour changes. At any given moment, users could assess their behaviour by exploring the statistics section of the app (Fig. 1c).

Happy also sent one tailored message per day within the self-reported waking hours of the user via push notification (Table 2). A total of 1120 messages were developed. Messages followed the European Code Against Cancer guidelines [11] and targeted specific behaviours, providing educational information, reminders, motivators and facilitators. The messages were tailored to the users' profile, and took into account users' context (location, time of day, week and month, weather conditions). All reported behaviours that didn't comply with cancer prevention guidelines, were targeted by the app.

### 2.2. Recruitment

Individuals were recruited via e-mail and Facebook. The recruitment e-mail was sent to a mailing list from University of Aveiro

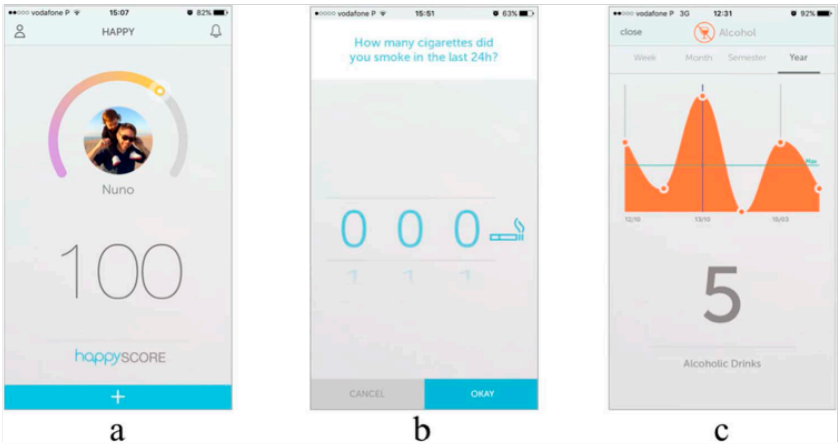


Fig. 1. Screenshots of the smartphone app Happy: landing page (HSc = 100) (a); Sample question from the behaviour assessment questionnaire (b); Statistics section (c).

**Table 2**
Examples of tailored messages used in the app.

| Target behaviour | Trigger context | Tailored message |
|---|---|---|
| Limit alcohol consumption | Profile: alcohol drinker<br>Time of day: 21 h–23 h<br>Time of week: Thursday, Friday or Saturday<br>Location: Bar/Disco | *Going out? Have fun and dance like crazy. When its time to drink listen to your body and drink water. Be happy* |
| Avoid excessive sun exposure | Time of day: 12 h–16 h<br>UV index: > 6<br>Location: Beach<br>Temperature: > 18 °C<br>Weather: Sunny | *Enjoying the beach? Beware: at this hour the sun exposure is unsafe. Look for a shade. Be happy* |
| Increase daily intake of vegetables and fruits | Profile: low fruit and vegetable consumption<br>Time of day: 10 h–20 h<br>Location: Supermarket | *At the supermarket? Don't forget to buy fresh fruit and vegetables! Be happy* |
| Enrol in cancer screening tests | Profile: female<br>Delay: one year since last pap smear<br>Time of week: weekdays<br>Time of day: 10 h–20h | *It's time to look at your inner beauty. Book an appointment with your gynaecologist and do the pap smear. Be happy* |

(n = 2558) and the study announcement was posted on the official Ipatimup Facebook page. Voluntary participants were required to answer an online survey. The survey was available online for two weeks. Respondents with age between 18 and 35 years old, and with Android or iOS smartphones were eligible to participate in the study. The option for this population was based in three different reasons: (1) Cancer prevention should start at an early stage of life (reducing exposure time to risk factors); (2) Individuals in this age range typically take control of their own behaviour (as opposed to younger individuals); (3) Nearly all individuals in this age range own at least one mobile device and are very tech-savvy. All participants provided informed consent to participate in the study. The study was approved by the University of Aveiro's Ethics Committee.

### 2.3. Procedure

Participants were informed that the app would send one message per day and would prompt them to answer a behaviour question at the end of each day. A small visual guide was provided via e-mail to illustrate the app functionalities along with a contact they could use for technical assistance. Participants were instructed to use the app for 28 consecutive days (4 weeks) and were required to answer an online questionnaire at the end of this period. The questionnaire was designed to assess usability, feasibility, message receptivity, and perceived impact of the app. At the end of this process, participants were asked to take part in in-depth semi-structured interviews to further explore these topics.

### 2.4. Outcome measures

#### 2.4.1. Usability

Usability was evaluated from data provided on the online questionnaire. Several usability factors were assessed: learnability, efficiency, memorability, error recovery, navigation, and subjective satisfaction. The assessment tool used in the questionnaire was adapted from a usability and feasibility study of a social mHealth application for physical activity [34].

#### 2.4.2. Feasibility

Feasibility was evaluated from data collected at the interviews and directly from Happy. Participants' motivation and user experience with Happy, and user-system interactions were assessed regarding feasibility.

#### 2.4.3. Message receptivity

Message receptivity was evaluated from data provided on the online questionnaire and at the interviews. The assessment tool used in the questionnaire was adapted from a study on the usage of SMS to address HIV knowledge, risk reduction, social support, and patient involvement [35].

#### 2.4.4. Perceived impact of happy

Perceived impact was evaluated from the data provided on the online questionnaire and at the interviews. The questionnaire was adapted from the Mobile Application Rating Scale [36]. Behavioural data collected in the app was also used to assess perceived impact. Since HSc is an overall measure of putative cancer prevention behaviour, it was used as an indicator of change along with data from individual behaviours. Users were required to answer one single question per day (regarding one single behaviour), randomly assigned from the whole behaviour assessment questionnaire, and could also deliberately report behaviours on demand. Thus, it was not possible to ensure the assessment of all behaviours everyday. This could create over or under-representation of individual behaviours influencing HSc overall measure. To minimize this bias, all collected data was computed and week averages were calculated.

### 2.5. Data analysis

#### 2.5.1. Qualitative data

Interviews were audio recorded and the content was transcribed. The transcripts were then analysed using inductive thematic analysis [37]. After initial coding, highlighting relevant themes, all text segments were iteratively analysed. Themes were added or merged until they effectively represented all text segments and captured the essence of every interview. The transcript analysis and coding was done using the software NVIVO, version 11.

#### 2.5.2. Quantitative data

Descriptive statistics and exploratory data analysis was performed. Week comparisons of all behaviour data collected in the app were done using repeated measures ANOVA test. All statistical analysis was done using IBM SPSS Statistics, version 22.

## 3. Results

### 3.1. Participants

A total of 53 individuals answered the initial recruitment survey but only 50 qualified to participate (relevant age and smartphone type) in this study. Selected participants were instructed to download and install the app on their personal phones, and register in the system by answering the initial behaviour assessment. Eighteen participants (36.0%) didn't install the app, resulting in a final sample size of 32 users. At the end of the 28-day trial period, 10 participants agreed to take part in-depth semi-structured interviews.

Table 3 summarizes the demographic data of the participants, along with the self-reported baseline behaviour.

### 3.2. Usability

In general, participants gave positive evaluations to almost all usability factors, except error recovery and app expectations (Table 4).

Overall, the majority of participants stated that they were satisfied with the quality of the app (62.5%). Participants liked the interface of the app (93.8%) and agreed it is pleasant (87.5%) and easy to use (81.3%). However, the majority didn't consider the error recovery system effective (56.2%) and expected more features (65.6%). During the interviews, participants mentioned features that they would like to see added to the app. The most mentioned (9 out of 10 interviewees)

**Table 3**
Demographic characteristics and self-reported baseline behaviour of study participants.

| | | Participants (n = 32) |
|---|---|---|
| Demographic characteristics | | |
| Gender, n (%) | Female | 17 (53.1) |
| | Male | 15 (46.9) |
| Age, mean (SD) | | 25.6 (4.8) |
| Smartphone type, n (%) | Android | 18 (56.3) |
| | iPhone | 14 (43.8) |
| Self-reported behaviour (baseline) | | |
| Level of Physical Activity, n (%) | High | 7 (21.9) |
| | Moderate | 4 (12.5) |
| | Low | 21 (65.6) |
| Fruit and vegetables (daily average), n (%) | ≥5 servings | 11 (34.4) |
| | 3–4 servings | 9 (28.1) |
| | 1–2 servings | 10 (31.2) |
| | None | 2 (6.3) |
| Tobacco consumption (daily average), n (%) | > 10 cigarettes | 1 (3.1) |
| | 1–10 cigarettes | 14 (43.8) |
| | Non smoker | 17 (53.1) |
| Alcohol consumption (daily average), n (%) | > 2 drinks | 0 (0.0) |
| | 1–2 drinks | 15 (46.9) |
| | None | 17 (53.1) |
| Body mass index (BMI), n (%) | Obese | 4 (12.5) |
| | Overweight | 6 (18.8) |
| | Normal weight | 22 (68.8) |
| Sunburn in the previous year, n (%) | Yes | 4 (12.5) |
| | No | 28 (87.5) |
| Performed skin self-exam, n (%) | Yes | 6 (18.8) |
| | No | 26 (81.2) |
| Compliance with cervix cancer screening guidelines (n = 17), n (%) | Yes | 11 (64.7) |
| | No | 6 (35.3) |
| Performed breast self-exam (n = 17), n (%) | Yes | 14 (82.4) |
| | No | 3 (17.6) |
| Performed testicular self-exam (n = 15), n (%) | Yes | 3 (20.0) |
| | No | 12 (80.0) |
| HPV vaccination (n = 17), n (%) | Yes | 9 (52.9) |
| | No | 6 (35.3) |
| | Don't know | 2 (11.8) |
| HBV vaccination, n (%) | Yes | 23 (71.9) |
| | No | 5 (15.6) |
| | Don't know | 4 (12.5) |

were challenges and social features:

I think it's a way of creating groups of people that have the same goal and don't know how to get there. It's easier in a group, like an exercise group, or a diet group, it's always easier to do it like that than alone. So I like it. (Interviewee #05)

I think that having challenges and this type of interaction between users is the right way for the success of the app. (Interviewee #02)

However, some interviewees (3 out of 10), when asked, declined to share sensitive information in a social network:

Imagine that my value [Happyscore] is not good, I'm not going to share it! I know this is prevention but still… (Interviewee #09)

One interviewee also suggested that the app should be connected to other apps on the smartphone:

[App] should connect to other apps such as the calendar because people are lazy, when I read a message suggesting to setup an alarm to remind me [of the next breast self-exam], I didn't do it, but if it had a button "add this to your calendar?", I would go for it. (Interviewee #09)

Most participants (81.2%) affirmed they would use the app for a longer period of time (Table 5) and almost all (90.6%) would recommend it to others (Table 6).

**Table 5**
Reported willingness to continue using Happy (n = 32).

| How much longer would you use this app? | n | % |
|---|---|---|
| None | 6 | 18.8 |
| Up to 6 months | 16 | 50.0 |
| 6–12 months | 6 | 18.8 |
| 1–2 years | 1 | 3.1 |
| 2 or more years | 3 | 9.4 |

### 3.3. Feasibility

#### 3.3.1. User-system interaction

On average, during the 28-day trial period, there were 13 (40.6%) active users per day. Participants were prompted by the app to answer a behaviour question at the end of each day (30 min before self-reported bedtime). On average, each user entered behaviour data in 12 different days (41.0% of the app prompts). The least active user only entered data on 2 occasions and the most active user entered data on 26 different occasions. However, in 56.0% of the occasions, participants answered more than one question per day. The dropout rate was high, with only 6 users (19.0%) completing the 28-day trial period of the app (Fig. 2).

#### 3.3.2. User experience and motivation

During the interviews, all participants (10 out of 10) expressed willingness to receive this type of intervention through their personal phones.

**Table 4**
Overall usability evaluation (n = 32).

| Usability factors | Agree/Strongly agree | | Illustrative participant quotations |
|---|---|---|---|
| | n | % | |
| I like the interface of this app | 30 | 93.8 | *Pretty interesting and useful. (P01)* |
| The app's interface is pleasant | 28 | 87.5 | |
| It was easy to learn how to use the app | 26 | 81.3 | *A simple and intuitive app, despite having some flaws when synchronizing information.* (P05) |
| It was easy and simple to use the app | 26 | 81.3 | |
| The organization of information was clear | 24 | 75.0 | |
| It was easy to navigate to find what I need | 23 | 71.9 | *Overall, I felt it was easy to interact with the menus and to input data in the app.* (P08) |
| It was easy to obtain what I need | 17 | 53.1 | |
| Whenever I made a mistake using the app, I could recover easily and quickly | 14 | 43.8 | |
| This app has all the features I expected it to have | 11 | 34.4 | *I think the concept is pretty interesting, and a good project to develop. While the app reminded me everyday to answer the questionnaire, I sometimes ended up forgetting, because I didn't have internet or for other reasons.* (P22) |
| The app gave error messages that clearly told me how to fix problems | 9 | 28.1 | |
| Overall, I am satisfied with the quality of the app | 20 | 62.5 | |

**Table 6**
Reported willingness to recommend app to others (n = 32).

| Would you recommend this app to other people? | n | % |
|---|---|---|
| No, I would not recommend this app to anyone | 3 | 9.4 |
| Yes, I would recommend this app to several people | 21 | 65.6 |
| Yes, I would recommend this app to everyone | 8 | 25.0 |

A smartphone is something that is always with us and is easily accessible. So, if there is something that reminds us… and maybe in decision making: "am I going to exercise today?" maybe that's what's missing. I think so, I think so. Smartphone is a good method. (Interviewee #03)

As for the user experience with Happy, one interviewee expressed it as a very positive one, stating that it was not immediately associated with cancer.

For me, this app, I rarely associate it with cancer. In the app when we… the app is called Happy, when we enter it has a Happyscore, it has my name on it, it… and it's got nothing visually that associates it with cancer, so I'm going to use it because it induces healthy lifestyles, period. (Interviewee #05)

Several interviewees (8 out of 10) felt motivated to use the app, especially because it raises awareness.

It's interesting to have there an app where we can register [our behaviour] daily (Interviewee #04)

I think it's a good way to be constantly aware of this question of cancer prevention (Interviewee #06)

However, some interviewees (4 out of 10) stated that the app has to be more interactive to be effective.

In terms of concept I think it is interesting but there was something missing… (Interviewee #02)

If it always stays the same I think I will not use it for long and will consequently delete it. (Interviewee #09)

### 3.3.3. *Message receptivity*

Overall, participants were very receptive to the messages (Table 7).

The majority of participants agreed that the messages were easy to understand (84.4%), gave good advices (75.0%), provided new and meaningful information (65.6% and 62.5%, respectively), and grabbed reader's attention (59.4%). This was also suggested in the interviews (8 out of 10 interviewees):

[Messages] are simple and I think that in this type of thing, the simpler, the better. In other words, something that isn't coded with many technical terms, something relaxed and that can be easily read because sometimes we are with our phone but our head is in another place and I think that, I don't know, in terms of style I think that, yeah, they are good. (Interviewee #06)

Overall I think that all of them make sense and are interesting. And the way they are written also has… they are easy to read. (Interviewee #07)

On the other hand, only a small portion of participants felt that the messages were designed for them (18.8%) and were motivated by the messages to change their behaviour (25.0%).

**Table 7**
Evaluation of message receptivity items (n = 32).

| Item | Agree/Strongly agree | |
|---|---|---|
| | n | % |
| The messages were easy to understand | 27 | 84.4 |
| I trusted the information in the messages | 26 | 81.3 |
| The messages gave me good advice | 24 | 75.0 |
| I learned something new from the messages | 21 | 65.6 |
| The messages said something important to me | 20 | 62.5 |
| The messages made me question my current behaviour | 19 | 59.4 |
| The messages grabbed my attention | 19 | 59.4 |
| The messages told me something I didn't already know about cancer prevention | 18 | 56.3 |
| I learned about services or resources available to me from the messages | 18 | 56.3 |
| The messages motivated me to be involved in my health care | 15 | 46.9 |
| The messages motivated me to change my behaviour | 8 | 25.0 |
| I felt like the messages were designed for me | 6 | 18.8 |
| The messages promoted behaviours that are difficult for me to do | 4 | 12.5 |
| The messages contradicted what I know about cancer prevention | 1 | 3.1 |
| The messages were confusing | 0 | 0.0 |
| Overall, I liked the messages | 22 | 68.8 |

## 3.4. *Impact of happy*

### 3.4.1. *Perceived impact in cancer prevention*

The majority of participants agreed that the app could have a real impact in cancer prevention (Table 8).

Several interviewees (8 out of 10) highlighted the app features that might increase behaviour awareness and could lead to behaviour change. The identified functionalities include:

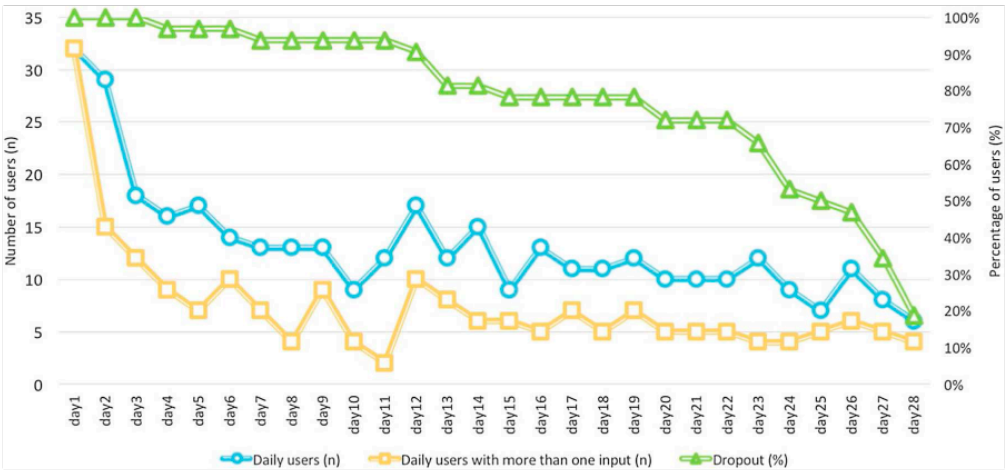


**Fig. 2.** Daily users, daily users with more than one input and dropout curve during Happy's 28-day trial period.

**Table 8**
Perceived impact of Happy (n = 32).

| Perceived impact | Agree/Strongly agree | |
|---|---|---|
| | n | % |
| This app is likely to increase awareness about cancer prevention | 28 | 87.5 |
| This app is likely to increase knowledge about cancer prevention | 27 | 84.4 |
| This app is likely to change attitudes towards cancer prevention | 25 | 78.1 |
| This app is likely to increase motivation to change cancer prevention behaviours | 22 | 68.8 |
| The use of this app is likely to encourage help seeking for cancer prevention (seek the doctor, for instance) | 20 | 62.5 |
| The use of this app is likely to increase cancer prevention behaviours | 23 | 71.9 |

– the presence of the HSc represented on the landing page;

We saw when we said we ate "bad" foods (fried food and such), and we lowered our score, it was… we thought "right, I shouldn't have eaten that" or "I should have eaten a healthier food". The fact that we have a score and we see the effect of that score in our behaviour ends up motivating us to have a better score. (Interviewee #01)

– the behaviour assessment questionnaire;

When I started using the app, at least when I started inserting the values of what I ate, pastries, etc., etc., I started thinking "I eat lots of junk food" and that I think is something that helps a lot, people become aware of what they eat during the day, or smoke, or drink and maybe that type of sensi… of, it's not sensitizing it's… rethinking our routines, maybe it will lead to positive results, and so I think it could fulfil its goal. (Interviewee #02)

– and the messages.

I think it has lots of potential… I did many of the things that the app, the messages that the app sent, because they were so simple it was easy. (Interviewee #05)

However, some interviewees (3 out of 10) consider that the impact that the app might wear off with time and is dependent of the user profile.

Maybe in an initial point because afterwards people end up looking at it like a routine app and it loses impact. I felt it, it had more impact the first time I answered the questionnaire and then, as I answered it over time, it didn't have the same impact. (Interviewee #03)

Well, it always depends how we take it. It's like all apps, be it physical exercise or whatever. We have to feel motivated to take it, to take the suggestions seriously and do it, but yes, the suggestions would come up and, ok, it can, for someone that is focused and wants to take it seriously, I think its good. (Interviewee #04)

### 3.4.2. Behaviour impact

Self-reported behaviour data showed an improvement trend in some cancer prevention behaviours (Table 9).

Overall, tobacco and alcohol consumption decreased while fruit and vegetable consumption and the level of physical activity increased. Some participants performed the suggested skin and testicular self-exams (7 and 2, respectively) and 2 female participants declared being vaccinated against HPV. There was an increase in the BMI. None of these changes were statistically significant.

In terms of overall cancer prevention, average HSc improved during the 28-trial by 7 points (Fig. 3).

A repeated measures ANOVA analysis showed that the change in HSc was not statistical significant ($p$-value = 0.068), although the trend shows a consistent increase after week 1.

## 4. Discussion

### 4.1. Main results

The goal of this study was to field-test Happy, a smartphone app designed to promote cancer prevention behaviours. Thirty-two participants downloaded and used the app during a 28-day trial. The self-reported behaviour (baseline assessment) showed that the majority of participants didn't comply with cancer prevention guidelines. Two thirds of the participants had a low level of physical activity, and daily consumed less than 5 portions of fruit and vegetables. Nearly half of the participants presented themselves as smokers and declared alcohol consumption and about one third has a BMI above normal weight. One third of the female participants didn't comply with cervix cancer screening guidelines, despite being a common form of cancer in women [2]. Likewise, the majority of male participants had never performed a testicular self-exam, a simple and quick way to detect the most frequent cancer in young men in Western populations [38]. Also, less than a fifth of all participants performed a skin self-exam, an important tool to prevent skin cancer, the most common form of cancer [39]. The gathered data stresses the need to design interventions that could change these behaviours and provide the best justification for the development of a cancer prevention smartphone app.

The pilot study showed that Happy is usable and can be easily accepted by users. There are some refinements needed, though, mainly in error recovery features. Also, the majority of participants expected more features in the app indicating that the current version requires more development to add new functionalities. Participants suggested adding challenges and social features to the app and integrating the app with other apps on the smartphone (calendar app, for instance). This corroborates the findings made by Johnson and colleagues [40] that gamification can have a positive impact in health behaviours. However, previous research with this population has shown that features associated with gamification and information sharing via social networks

**Table 9**
Average change by behaviour (baseline values and weekly averages) (n = 32).

| Self-reported behaviour | Baseline | Week1 | Week2 | Week3 | Week4 | Change |
|---|---|---|---|---|---|---|
| BMI, Mean (SD) | 23.8 (1.8) | 23.8 (1.8) | 23.8 (1.8) | 23.9 (1.8) | 24.2 (2.1) | +0.4 |
| Fruit and vegetables (daily average), Mean (SD) | 4.0 (3.1) | 3.6 (2.4) | 3.6 (2.7) | 3.8 (3.1) | 4.8 (4.7) | +0.8 |
| Level of Physical Activity, Median | Low | Moderate | High | High | Moderate | +1.0 |
| Enrolled cervix cancer screening (n = 17), n (%) | 11 (64.7) | 11 (64.7) | 11 (64.7) | 11 (64.7) | 11 (64.7) | 0.0 |
| Performed breast self-exam (n = 17), n (%) | 15 (88.2) | 15 (88.2) | 15 (88.2) | 15 (88.2) | 15 (88.2) | 0.0 |
| Performed skin self-exam (n = 32), n (%) | 6 (18.8) | 9 (28.1) | 9 (28.1) | 11 (34.4) | 13 (40.6) | +7.0 |
| Performed testicular self-exam (n = 15), n (%) | 3 (20.0) | 4 (26.7) | 5 (33.3) | 5 (33.3) | 5 (33.3) | +2.0 |
| HPV vaccination (n = 17), n (%) | 9 (52.9) | 11 (64.7) | 11 (64.7) | 12 (70.6) | 12 (70.6) | +3.0 |
| HBV vaccination (n = 32), n (%) | 23 (71.8) | 26 (81.2) | 26 (81.2) | 26 (81.2) | 26 (81.2) | +3.0 |
| Tobacco (daily average), Mean (SD) | 5.5 (3.5) | 5.8 (4.0) | 9.0 (8.5) | 5.0 (4.2) | 2.5 (0.7) | −3.0 |
| Alcohol (daily average), Mean (SD) | 0.7 (0.5) | 0.3 (0.5) | 0.3 (0.4) | 0.5 (0.5) | 0.3 (0.4) | −0.4 |

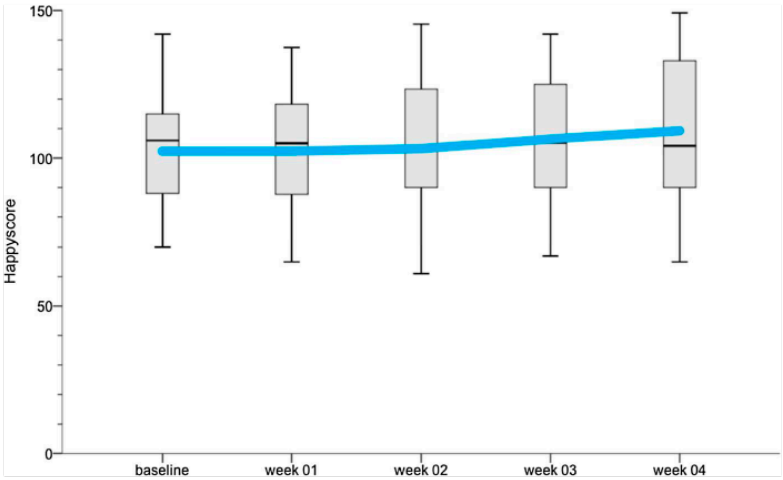


Fig. 3. Average HSc during the 28-day trial.

aren't considered important dimensions for long-term use of health-related apps [41]. Some participants in this study also confirmed this view in the interviews.

Happy was designed for daily use with tailored messages sent to participants everyday as push notifications. Nonetheless, results show that user-system interactions occurred, on average, in only 12 different occasions during the 28-day trial and dropout rate was high, with only 6 users (19.0%) completing the 28-day trial period. Since there was no need for the users to open the app to read the messages we might consider that the user-system interaction might be underrepresented in the results.

The low user engagement with mobile health apps has been described in previous research, with about 75% of users opening the app fewer than 10 times [42]. Such trend was also consistent in interview recruitment with only 10 participants opting-in on the interviews. This has been called the "Law of attrition" regarding ehealth interventions and might be explained in this case by factors related to the ease of dropout (participants could stop using the app at any time) and the lack of personal contact between researchers and study participants (recruitment was done online and all contacts occurred through e-mail) [43]. This effect could be reduced by offering some type of reward at the end of the trial or by arranging a first meeting, during the enrolment phase, to provide a more personal contact between researchers and participants.

Results also showed the viability of designing and implementing this type of intervention. Participants indicated willingness to have a cancer prevention app installed in their own smartphones and to receive messages that promote prevention behaviours. As for message receptivity, participants considered that the messages were easy to understand, gave good advices, provided new and meaningful information, and grabbed reader's attention. However, only 18.8% of the participants felt like the messages were designed for them. This seems to indicate that the tailoring process wasn't effective. Since Happy is based on the principle of tailoring this is a very important result that requires further investigation. The research team identified some technical issues regarding the tailoring algorithm that might explain this result. In fact, most of the messages sent by the app missed the context of the user due to problems associated with the integration of the smartphone's GPS data. Thus, participants received general messages mostly about cancer prevention and cancer risk factors that are relevant to them but didn't consider it as sufficiently tailored messages. Further development is required to tackle these technical issues and to improve the algorithm to ensure that message tailoring effectively occurs since this has been proven to be successful in other interventions [44,45].

Finally, impact results indicate that Happy is perceived as an effective way to promote cancer prevention. The interviewed participants highlighted the HSc represented on the landing page, the behaviour assessment questionnaire, and the messages as the functionalities that might contribute to this goal. The mentioned features are embedded with several behaviour change techniques [46]: prompt information related with behaviour-health link and consequences; prompt barrier identification; prompt self-monitoring of behaviour; provide feedback on performance. Thus, results seem to indicate that these features can be successfully used in the promotion of cancer prevention behaviours. In fact, the majority of participants agreed that the app might increase cancer awareness and knowledge, and even motivate users to change behaviours. This seems to be corroborated by the data collected during the 28-day trial that showed the real impact with an increase both in several cancer prevention behaviours and in the average HSc. These preliminary results provide evidence that an intervention delivered by smartphone might promote behaviour change towards cancer prevention.

### 4.2. Limitations

Given the very nature of the study, there are some limitations. First, the study is based on a small convenience sample (n = 32). The recruitment method and the number of participants of the study condition the generalization of results. Second, the study time span (28 days): this is a short period to effectively assess consistent behaviour changes towards healthy choices. Furthermore, this is not a controlled study. Thus, the registered increase on several cancer prevention behaviours cannot unequivocally be attributed exclusively to app use. It is also worth noting that all behaviours were assessed using self-reports. This could raise potential problems of reliability. However, it has been shown that the continuous assessment of health data by self-reporting can be as reliable as clinical assessments [47]. Another point to consider is the use of HSc as an overall putative cancer prevention measure. Given that this score was created for the purpose of this app and hasn't been validated, we cannot attribute any clinical significance to the observed changes. For these reasons, results need to be interpreted with caution.

### 4.3. Future work

This study provided preliminary results needed to further develop Happy. Improved usability and new functionalities might help increase

user engagement and user-system interactions. These features, combined with measures to increase participation (such as offering rewards at the end of the trial or arranging a first face-to-face meeting), might help prevent the high dropout rate registered in this study. This is pivotal since all behaviour change interventions delivered through smartphones rely upon a continuous use of the app.

App development will continue with the integration of new features and debugging of the identified technical issues. Refinements will include two new features: challenges and social features. Challenges will be designed to give small achievable goals to boost users' motivation and help them reach desired behaviours. Social features will allow users to communicate with other users and to share HSc and completed challenges. The goal is to enhance online support and competition. In order to leverage existing online social interactions, Happy will be integrated with the most widely used social networking system: Facebook [48]. These features will be optional and users will have full control over what they share with others.

To further investigate the potential benefits of Happy in terms of behaviour change towards cancer prevention, there is a need to design a long term and large sample size study. A one year long two-arm, parallel, randomized controlled trial will be designed. Each arm of the trial should have a minimum of 100 participants in order to detect significant differences between groups. Participants will be offered a small financial reward and there will be an enrolment meeting to increase participant retention. This will allow an in-depth analysis of the real capabilities of Happy to support behaviour change in users and, thus, contribute to cancer prevention. The use of a larger sample will also show if the impact findings reported here are replicable in a wider and more heterogeneous young adult population.

### 4.4. Conclusions

Happy is an exploratory approach to cancer prevention using smartphones. This study showed that participants are willing to have a cancer prevention app installed in their personal smartphones and to receive messages that promote prevention behaviours. However, study results also showed that dropout rate was high. This stresses the need to increase user engagement, mainly by adding gamification and social sharing features to the app.

Happy was considered simple, intuitive and easy to use. Also, users perceived it as a tool capable of supporting behaviour change towards healthier choices and thus reducing personal cancer risk.

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## Summary points

What was already known on the topic

- Several studies have suggested that smartphone apps can support behaviour changes.
- Most interventions target one single behaviour.

What this study added to our knowledge

- Majority of participants doesn't comply with cancer prevention guidelines.
- Participants are willing to use a cancer prevention app in their every-day life.
- A multiple-behaviour intervention delivered by smartphone can promote cancer prevention.

## Conflict of interest

None.

## Authors Contributions

Nuno Ribeiro: Conception and design of the study, Acquisition of data, Analysis and interpretation of data, Drafting of the article, Final approval of the version to be submitted. Luís Moreira: Conception and design of the study, Analysis and interpretation of data, Critical revision of article, Final approval of the version to be submitted. Ana Margarida Almeida: Conception and design of the study, Analysis and interpretation of data, Critical revision of article, Final approval of the version to be submitted. Filipe Santos-Silva: Conception and design of the study, Analysis and interpretation of data, Critical revision of article, Final approval of the version to be submitted.

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## Supplementary file 1

Interview schedule from the focus groups performed in Study I

# FOCUS GROUPS
**(GUIÃO DE PERGUNTAS)**

INTRODUÇÃO

"*Obrigado por estarem presentes e por terem demonstrado interesse em colaborar nesta investigação*."

Apresentação do moderador

**Objetivo**: Determinar que caraterísticas e funcionalidades são pretendidas numa aplicação de promoção de saúde/prevenção de cancro.

**Regras de funcionamento do FG**:
1. Queremos que sejam vocês a falar (e queremos a opinião de todos)
2. Não há respostas certas ou erradas (todas as opiniões são importantes)
3. O que é dito nesta sala fica aqui (o anonimato será garantido)
4. A discussão será filmada (evitar falar ao mesmo tempo)

**ICEBREAKER**: *Para começar pedia-vos que dissessem o vosso nome e que respondessem à seguinte questão*:
Se tivessem fundos ilimitados, onde gostariam de passar férias?

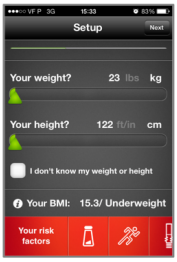
| | | |
|---|---|---|
| **Participantes do FG:** | | **Data:** ____/_____/_____ |

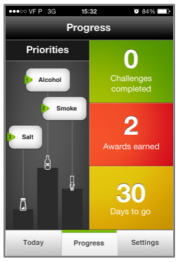
| **Questões** | **Temas discutidos** |
|---|---|
| 1. Na vossa opinião, de que modo é que o smartphone pode ser útil na promoção da saúde e de hábitos saudáveis? | |
| *Vamos agora mostrar-vos alguns slides com várias aplicações de saúde disponíveis atualmente no mercado. Sabemos que algumas das suas caraterísticas já foram discutidas até ao momento. Vamos também distribuir a mesma informação impressa para que possam ver com mais pormenor* **> MATERIAL DE APOIO <** | |
| 2. O que acham destas aplicações?<br>2.1. Do vosso ponto de vista, quais é que consideram úteis?<br>2.2. Podem dizer-me em que situação as utilizariam? | |
| 3. Que mais opções gostariam que estas aplicações tivessem? | |
| 4. Na vossa opinião, que fatores contribuem para que se use ou deixe de usar estas aplicações?<br>4.1. De que modo o facto dos amigos usarem/não usarem estas aplicações influencia a vossa decisão? | |
| 5. Que tipo de problemas ou preocupações podem ser suscitados por estas aplicações? | |
| 6. Há mais alguma coisa sobre este assunto que não tenha sido discutido e que queiram partilhar? | |

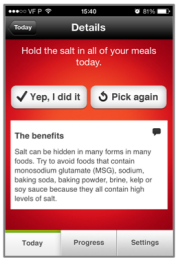
# MATERIAL DE APOIO

## PERSONALIZAÇÃO

Algumas aplicações recolhem informação pessoal e utilizam-na para personalizar os conteúdos que são apresentados



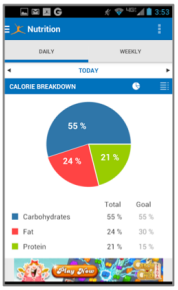



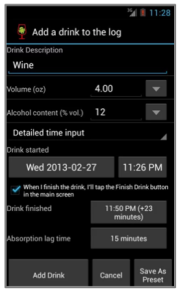




App ilustrada: <30 Days

**MONITORIZAÇÃO DE COMPORTAMENTOS**

Várias aplicações permitem a monitorização de comportamentos como a quantidade de calorias diárias ou de álcool ingerido. O input de dados destas aplicações é feito manualmente pelo utilizador. Outras aplicações fazem a monitorização de modo automático, utilizando o acelerómetro do dispositivo para obter dados como o número de passos dados ao longo do dia.



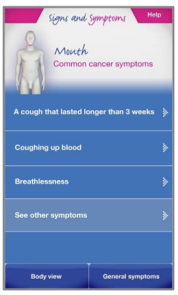



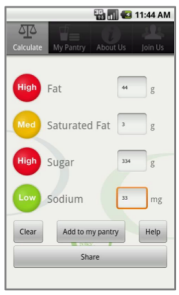


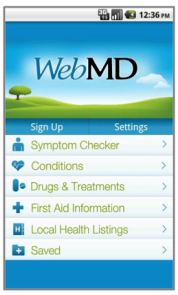
Apps ilustradas: Calorie Counter – MyFitnessPal; AlcoDroid Alcohol Tracker; Moves

**FONTES DE INFORMAÇÃO ÚTIL**

Existem muitas aplicações que fornecem informação sobre saúde. A informação apresentada pode ser sobre sintomas de doenças, conteúdo em termos nutricionais, etc.



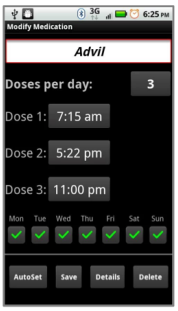



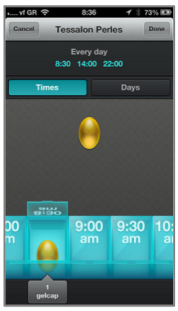



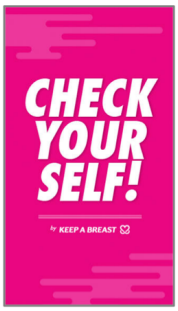

Apps ilustradas: Cancer Signs and Symptoms; Traffic Light Food Tracker; WebMD

## ENVIO DE LEMBRETES

Os smartphones podem emitir sons ou vibrar quando há uma nova notificação ou um lembrete. Existem aplicações que usam estas funcionalidades para lembrar a toma de medicação ou a realização de um auto-exame mamário, por exemplo.



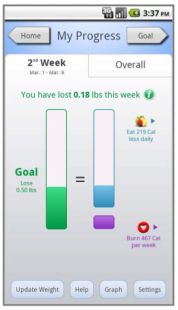



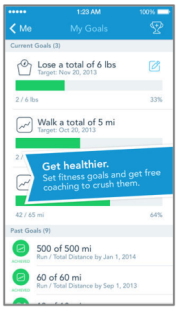

Apps ilustradas: Med Reminder; Pillboxie; Keep a breast

## DETERMINAÇÃO DE OBJETIVOS PESSOAIS

Algumas aplicações permitem ao utilizador determinar os seus objetivos e planos de ação.



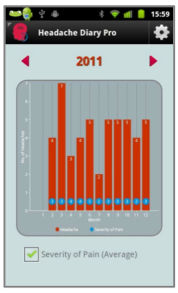





Apps ilustradas: CardioTrainer; Way of Life – The Ultimate Habit Maker & Breaker; RunKeeper

**OUTPUT GRÁFICO DA EVOLUÇÃO DA SAÚDE**

Muitas aplicações permitem visualizar graficamente os dados introduzidos ou recolhidos automaticamente pelo dispositivo.

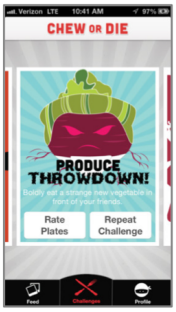





Apps ilustradas: TactioSaúde; HeadacheDiary Pro; ARGUS – Motion and Fitness Tracker

**MOTIVAÇÃO**

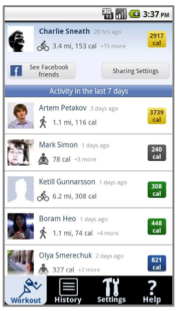
Existem aplicações destinadas a aumentar a motivação dos utilizadores para realizar comportamentos saudáveis como correr ou comer de forma mais equilibrada, por exemplo.

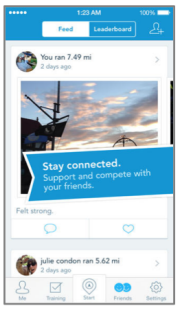



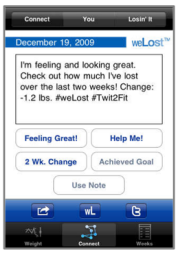

Apps ilustradas: Zombies, Run!; Chew or Die

## PARTILHA NAS REDES SOCIAIS

Algumas aplicações permitem ao utilizador partilhar os seus resultados com amigos através das redes sociais ou de uma rede privada.



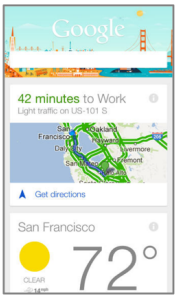



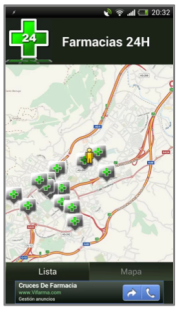



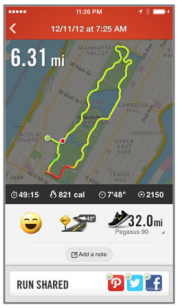

Apps ilustradas: CardioTrainer; RunKeeper; weLost™ Social Weight Loss Network

## AQUISIÇÃO DE INFORMAÇÃO CONTEXTUAL

Várias aplicações utilizam os sensores dos smartphones para adquirir informação contextual (localização, hora, etc) e sugerir ações ao utilizador ou mostrar graficamente os resultados.




Apps ilustradas: Google Now; Farmacias 24H; Nike+ Running

## Supplementary file 2

Online survey from Study I

## Inquérito Sobre Utilização de Aplicações de Promoção de Saúde

Este inquérito destina-se a recolher informações sobre as caraterísticas e funcionalidades que são pretendidas em aplicações de promoção de saúde.
Esta investigação está a ser desenvolvida no âmbito do Programa Doutoral em Multimédia em Educação da Universidade de Aveiro em colaboração com o IPATIMUP (Instituto de Patologia e Imunologia Molecular da Universidade do Porto).

As respostas devem ter por base a sua opinião sincera. Tenha em mente que não há respostas certas nem erradas.
O questionário é anónimo e os dados serão utilizados exclusivamente no âmbito deste trabalho de investigação.
A qualquer momento pode interromper o preenchimento do questionário, caso não se sinta à vontade para prosseguir.
Desde já agradecemos a sua colaboração.

O investigador,

Nuno Ribeiro
(nribeiro@ipatimup.pt)

## I. Tecnologia

**1. Indique todos os tipos de dispositivos móveis que possui:**

Smartphone (*telemóvel com funcionalidades avançadas capaz de executar programas para além dos previamente instalados no sistema operativo*)
Telemóvel
Tablet
Nenhum

**2. Há quanto tempo possui um smartphone?**

Menos de 1 mês
Entre 1 e 6 meses
Entre 6 e 12 meses
Entre 1 e 2 anos
Mais de 2 anos

**3. Caso tenha mais que um smartphone, responda às seguintes questões tendo em mente apenas o que mais utiliza.**

**3.1. Qual a marca do seu smartphone?**

Apple
LG
Motorola
Nokia
Samsung
Outra marca
Não sei

**3.2. Indique qual o sistema operativo do seu smartphone:**

iOS
Symbian
Windows Phone
Android
Blackberry
Outro Sistema Operativo
Não sei

**3.3. Por dia, em média, quanto tempo passa a interagir com o seu smartphone?**

Menos de 15 minutos
Entre 16 e 30 minutos
Entre 31 minutos e 1 hora
Entre 1 e 2 horas
Mais do que 2 horas

**3.4. Qual a atividade que realiza mais frequentemente no seu smartphone?**

Fazer chamadas
Enviar SMS ou MMS
Fotografar
Ouvir música
Ver vídeos
Navegar na Internet
Outra

**3.5. Indique, em média, com que frequência realiza as seguintes tarefas no seu smartphone:**

| | nunca | 1 a 6 vezes por semana | 1 vez por dia | 2 ou mais vezes ao dia |
|---|---|---|---|---|
| Fotografar. | | | | |
| Ouvir música. | | | | |
| Ver vídeos. | | | | |
| Navegar na Internet. | | | | |
| Jogar. | | | | |
| Editar documentos (texto, imagens, etc...). | | | | |

**4. Indique com que frequência realiza as seguintes tarefas:**

| | nunca | raramente | frequentemente | sempre |
|---|---|---|---|---|
| Ler revistas especializadas da área das novas tecnologias da informação (ex.: Exame Informática) | | | | |
| Procurar informação em blogues e sites de informática. | | | | |
| Consultar informação técnica sobre novos dispositivos, mesmo quando não tenciona comprá-los a curto prazo. | | | | |
| Utilizar a internet como fonte de informação sobre saúde | | | | |

**5. Numa escala de 0 a 10 (0 = "nada importante"; 10 = "muito importante"), indique a importância que atribui às seguintes fontes de informação sobre saúde:**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Profissionais de saúde (médicos, enfermeiros,...) | | | | | | | | | | | |
| Familiares | | | | | | | | | | | |
| Amigos | | | | | | | | | | | |
| Internet | | | | | | | | | | | |
| Livros e revistas | | | | | | | | | | | |
| Outra: _____ | | | | | | | | | | | |

**6. Indique quais das seguintes tarefas já realizou, utilizando um dispositivo móvel (selecione todas as opções que se apliquem):**

Registo do nº de cigarros consumidos (visando, por ex, a redução do consumo de tabaco)

Registo do nº e tipo de bebidas consumidas (visando, por ex, a redução do consumo de bebidas alcoólicas)

Monitorização do peso corporal (ex.: registo das alterações de peso ao longo de um mês)

Monitorização da dieta (ex.: controle da quantidade de calorias ingeridas por dia)

Monitorização do exercício físico realizado (ex.: registo do n.º de km percorridos e tempo decorrido num treino)

Monitorização de outros aspetos relacionados com a saúde (ex.: nível de humor; ciclo menstrual; dores de cabeça...)

## II. Saúde e estilo de vida

**1. No que se refere ao seu estilo de vida, considera-se uma pessoa:**

Nada ativa
Pouco ativa
Nem muito nem pouco ativa
Bastante ativa
Muito ativa

**2. Em média, quanto exercício físico pratica por semana?**

Não pratico exercício físico
Menos de 30 minutos
Entre 30 minutos e 60 minutos
Entre 1 e 2 horas
Mais de 2 horas

**3. De uma forma geral, como classifica a sua alimentação?**

Nada saudável
Pouco saudável
Nem muito nem pouco saudável
Bastante saudável
Muito saudável

**4. Em média, quantas porções de frutas e vegetais consome por dia?**

Nenhuma
Uma
Duas
Três
Quatro
Cinco ou mais porções

**5. Tendo em conta a sua estatura, como classifica o seu peso corporal atual?**

Muito abaixo do ideal
Ligeiramente abaixo do ideal
Ideal
Ligeiramente acima do ideal
Muito acima do ideal

**6. Qual a sua altura?** ___,__ m

**7. Qual o seu peso?** __,__ kg

**8. Relativamente ao consumo de tabaco, indique a opção que mais se adequa a si:**

Atualmente sou fumador(a)
Atualmente não sou fumador(a), mas já fui no passado
Nunca fui fumador(a)

**9. Em média, quantas bebidas alcoólicas consome por dia?**

Nenhuma
Uma
Duas

Três
Quatro ou mais

## III. Caraterísticas e funcionalidades pretendidas em aplicações mobile de promoção de saúde

### 1. Indique o seu grau de concordância com as seguintes afirmações:

| | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| Uma aplicação mobile de promoção de saúde deve permitir monitorizar indicadores de saúde (exemplo: peso ou consumo de tabaco). | | | | | |
| Uma aplicação mobile de promoção de saúde deve permitir definir objetivos (exemplo: perder 5 kg num mês). | | | | | |
| Uma aplicação mobile de promoção de saúde deve enviar mensagens sobre saúde específicas para o utilizador. | | | | | |
| Uma aplicação mobile de promoção de saúde deve permitir ativar lembretes de consultas médicas. | | | | | |
| Uma aplicação mobile de promoção de saúde deve permitir definir lembretes que motivem comportamentos saudáveis. | | | | | |
| Uma aplicação mobile de promoção de saúde deve permitir fazer o diagnóstico automatizado de problemas de saúde | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Ver um gráfico que mostre a evolução positiva da quantidade de exercício físico realizado é motivador para mim | | | | | |
| Ver um gráfico que mostre a evolução negativa do meu peso deixa-me desmotivado e sem vontade de fazer alguma coisa. | | | | | |
| Seria capaz de partilhar dados pessoais e de saúde com outros utilizadores para poder comparar a evolução ao longo do tempo. | | | | | |
| Seria capaz de partilhar dados pessoais e de saúde com outros utilizadores a passar pelo mesmo problema. | | | | | |
| A partilha de informação com um grupo de utilizadores que têm o mesmo problema de saúde que eu pode ajudar-me a ultrapassar esse problema. | | | | | |
| Competir com os meus amigos para ver quem faz mais desporto é motivador para mim. | | | | | |
| É importante conseguir aceder aos dados que introduzo na aplicação através do computador (consultando um website, por exemplo). | | | | | |
| A privacidade dos meus dados de saúde é muito importante. | | | | | |
| Seria incapaz de utilizar uma aplicação mobile que guardasse os meus dados pessoais e de saúde num servidor, por muito seguro que seja. | | | | | |
| Só seria capaz de utilizar uma aplicação mobile de promoção de saúde se esta não partilhasse os meus dados pessoais e de saúde com ninguém. | | | | | |
| A validação científica da informação presente numa aplicação mobile de promoção de saúde é muito importante. | | | | | |

**2. Numa escala de 0 a 10 (0 = "nada importante"; 10 = "muito importante"), indique a importância que atribui às seguintes caraterísticas e funcionalidades de uma aplicação mobile de promoção de saúde para estimular uma utilização sustentada no tempo (utilização da aplicação mobile por mais de 100 dias consecutivos).**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | NS/ NR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Capacidade de monitorizar comportamentos ao longo do tempo | | | | | | | | | | | | |
| Capacidade de representar graficamente a evolução dos indicadores de saúde | | | | | | | | | | | | |
| Capacidade de determinar objetivos (por exemplo, perder 10 kg em 30 dias) | | | | | | | | | | | | |
| Capacidade de personalização da aplicação para que disponibilize apenas informação de saúde considerada relevante para o utilizador | | | | | | | | | | | | |
| Possibilidade de definir lembretes para realizar comportamentos saudáveis ou ir ao médico no timing correto | | | | | | | | | | | | |
| Possibilidade de se ligar a uma rede de amigos com os quais possa partilhar informações ou competir | | | | | | | | | | | | |
| Possibilidade de se ligar a uma rede de utilizadores desconhecidos com o mesmo problema de saúde/objetivo com os quais possa partilhar informações ou competir | | | | | | | | | | | | |
| Facilidade de utilização da aplicação | | | | | | | | | | | | |
| Aspeto gráfico apelativo | | | | | | | | | | | | |
| Capacidade de promover desafios saudáveis junto dos utilizadores | | | | | | | | | | | | |
| Capacidade de recompensar os sucessos do utilizador com pontos virtuais | | | | | | | | | | | | |
| Conter informação pormenorizada sobre saúde | | | | | | | | | | | | |
| Conter informação atualizada sobre saúde | | | | | | | | | | | | |
| Conter informação sobre saúde validada cientificamente | | | | | | | | | | | | |
| Otimização da aplicação para o dispositivo (não usar demasiada memória ou gastar muita bateria) | | | | | | | | | | | | |

## IV. Dados sociodemográficos

**1. Idade**

**2. Género**

Masculino
Feminino

**3. Habilitações literárias**

Ensino básico (9.º Ano)
Ensino secundário (12.º Ano)
Ensino superior: Licenciatura
Mestrado
Doutoramento

**Muito obrigado pela sua participação.**

## Supplementary file 3

Usability questionnaire from Study II

## TESTE DE USABILIDADE DO HAPPY

____/_____/2015

**1. Género**: ☐ F ☐ M

**2. Idade**: ____

**3. Habilitações literárias**

☐ Ensino básico (9.º Ano)
☐ Ensino secundário (12.º Ano)
Ensino superior:
☐ Licenciatura
☐ Mestrado
☐ Doutoramento

**4. Há quanto tempo possui um smartphone?**

☐ Menos de 1 mês.
☐ Entre 1 e 6 meses.
☐ Entre 6 e 12 meses.
☐ Entre 1 e 2 anos.
☐ Mais de 2 anos.

**5. Por dia, em média, quanto tempo passa a interagir com o seu smartphone?**

☐ Menos de 15 minutos.
☐ Entre 16 e 30 minutos.
☐ Entre 31 minutos e 1 hora.
☐ Entre 1 e 2 horas.
☐ Mais do que 2 horas.

**6. Indique o seu grau de concordância com as seguintes afirmações:**

| Afirmações | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. Foi fácil aprender a utilizar a aplicação | | | | | |
| 2. A aplicação é fácil e simples de usar | | | | | |
| 3. É fácil obter o que se quer da aplicação | | | | | |
| 4. O interface da aplicação é agradável | | | | | |
| 5. Gosto do aspeto da aplicação | | | | | |
| 6. A informação está claramente organizada | | | | | |
| 7. É fácil navegar nesta aplicação | | | | | |
| 8. Sempre que ocorreu um erro ao utilizar a aplicação consegui recuperar de forma fácil e rápida | | | | | |
| 9. A aplicação mostra mensagens de erro que me dizem claramente como resolver problemas | | | | | |
| 10. A aplicação tem todas as funções e funcionalidades que esperava que tivesse | | | | | |
| 11. De um modo geral, fiquei muito satisfeito(a) com a qualidade do serviço/informação prestada por esta aplicação | | | | | |

## Supplementary file 4

Online questionnaire from Study III

## Questionário De Avaliação
## Da Aplicação Happy

Este inquérito destina-se a recolher a sua opinião sobre a aplicação Happy.
Tenha em mente que as suas respostas devem ter por base uma opinião sincera. O questionário não é anónimo, mas os seus dados pessoais serão tratados de forma confidencial e exclusivamente no âmbito desta investigação.
A qualquer momento pode interromper o preenchimento do questionário caso não se sinta à vontade para prosseguir.

Desde já agradecemos a sua colaboração.

Nuno Ribeiro
(nribeiro@ipatimup.pt)

## I. Dados demográficos

1. **Nome**
2. **E-mail**
3. **Idade**
4. **Género**
   Masculino
   Feminino
5. **Habilitações literárias**
   Ensino básico
   Ensino secundário
   Ensino superior (licenciatura)
   Ensino superior (mestrado ou doutoramento)

## II. Avaliação da aplicação

6. **De um modo geral, o que achou da aplicação Happy?**

7. **Indique em que medida concorda ou discorda com cada uma das seguintes afirmações:**

| Afirmações | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. Foi fácil aprender a utilizar a aplicação | | | | | |
| 2. A aplicação é fácil e simples de usar | | | | | |
| 3. É fácil obter o que se quer da aplicação | | | | | |
| 4. O interface da aplicação é agradável | | | | | |
| 5. Gosto do aspeto da aplicação | | | | | |
| 6. A informação está claramente organizada | | | | | |
| 7. É fácil navegar nesta aplicação | | | | | |
| 8. Sempre que ocorreu um erro ao utilizar a aplicação consegui recuperar de forma fácil e rápida | | | | | |
| 9. A aplicação mostra mensagens de erro que me dizem claramente como resolver problemas | | | | | |
| 10. A aplicação tem todas as funções e funcionalidades que esperava que tivesse | | | | | |
| 11. De um modo geral, fiquei muito satisfeito(a) com a qualidade do serviço e da informação prestada por esta aplicação | | | | | |

## III. Avaliação das mensagens recebidas através da aplicação

**8. Indique em que medida concorda ou discorda com cada uma das seguintes afirmações:**

| Afirmações | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. No geral, gostei das mensagens | | | | | |
| 2. Aprendi algo novo com as mensagens | | | | | |
| 3. As mensagens eram fáceis de perceber | | | | | |
| 4. Confiei na informação contida nas mensagens | | | | | |
| 5. As mensagens apresentaram coisas importantes para mim | | | | | |
| 6. As mensagens captaram a minha atenção | | | | | |
| 7. As mensagens apresentaram coisas que eu não sabia sobre prevenção de cancro | | | | | |
| 8. As mensagens eram confusas | | | | | |
| 9. Senti que as mensagens foram escritas para mim | | | | | |
| 10. As mensagens promoviam comportamentos que eram difíceis de fazer | | | | | |
| 11. As mensagens motivaram-me a mudar o meu comportamento | | | | | |
| 12. As mensagens contradisseram o que eu já sabia sobre prevenção de cancro | | | | | |
| 13. As mensagens motivaram-me a preocupar-me mais com o meu estado de saúde | | | | | |
| 14. As mensagens deram-me bons conselhos | | | | | |
| 15. As mensagens levaram-me a refletir sobre o meu comportamento atual | | | | | |
| 16. As mensagens informaram-me sobre serviços e exames de rastreio de cancro disponíveis para mim | | | | | |

## IV. Avaliação subjetiva do interesse da aplicação

**9. Recomendaria esta aplicação a outras pessoas (amigos/ familiares/ conhecidos)?**

Não, não recomendaria esta aplicação a ninguém
Recomendaria esta aplicação a algumas pessoas
Recomendaria esta aplicação a todas as pessoas que conheço

**10. Durante quanto mais tempo acha que utilizaria esta aplicação?**

Nenhum
Mais 1 a 6 meses
Mais 6 a 12 meses
Mais 1 a 2 anos
2 ou mais anos

**11. Pagaria para utilizar esta aplicação?**

Não
Talvez
Sim

## V. Avaliação do potencial da aplicação na mudança comportamental

**12. Indique em que medida concorda ou discorda com cada uma das seguintes afirmações:**

| Afirmações | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. Esta aplicação sensibiliza as pessoas para a importância da prevenção de cancro. | | | | | |
| 2. Esta aplicação aumenta os conhecimentos sobre prevenção de cancro. | | | | | |
| 3. Esta aplicação induz uma mudança de atitude sobre a prevenção de cancro. | | | | | |
| 4. Esta aplicação motiva as pessoas a mudarem comportamentos e a prevenirem o cancro. | | | | | |
| 5. Esta aplicação incentiva as pessoas a procurar ajuda na prevenção do cancro (procurar o médico, por exemplo). | | | | | |
| 6. Esta aplicação incentiva as pessoas a mudarem o seu comportamento de modo a prevenir o cancro. | | | | | |

## VI. Entrevistas a utilizadores da aplicação Happy

Esta investigação implica ainda a realização de entrevistas com alguns dos utilizadores da aplicação Happy. As entrevistas serão realizadas via Skype de acordo com a disponibilidade indicada. As entrevistas decorrerão em dois períodos: de 21 a 23 de dezembro e de 28 a 30 de dezembro.

**12. Está disponível para ser entrevistado no âmbito desta investigação?**

Sim.

Não.

**13. Indique a sua disponibilidade (assinale os períodos em que tem disponibilidade):**

| | 21/12 (2ªF) | 22/12 (3ªF) | 23/12 (4ªF) | 28/12 (2ªF) | 29/12 (3ªF) | 30/12 (4ªF) |
|---|---|---|---|---|---|---|
| Manhã | | | | | | |
| Tarde | | | | | | |

**14. Utilize o seguinte espaço de comentário para incluir qualquer indicação que considere relevante para a marcação da entrevista.**

**Muito obrigado pela sua participação.**

## Supplementary file 5

Interview schedule from Study III

# ENTREVISTAS

**(GUIÃO DE PERGUNTAS)**

1. **No geral, qual é a sua opinião sobre a aplicação?**
   1.1. O que é que gostou mais?
   1.2. O que é que não gostou?
   1.3. O que é que mudava?

2. **Esta aplicação tem como objetivo induzir comportamentos de prevenção de cancro nos utilizadores.**
   2.1. Acha que o smartphone é um meio adequado para este tipo de intervenção?
      2.1.1. Porquê?
   2.2. Acha que esta aplicação cumpre o seu objetivo (ou seja, é capaz de induzir comportamentos de prevenção de cancro nos utilizadores)?
      2.2.1. Quais são as potencialidades da aplicação para cumprir esse objetivo?

3. **Houve alguma situação em que tenha utilizado a aplicação por sua vontade, ou seja, sem ser em resposta a uma notificação?**
   3.1. Pode descrever a situação?

4. **Quando se inscreveu na aplicação preencheu um questionário sobre os seus comportamentos e foi-lhe atribuído um valor correspondente ao seu nível de prevenção de cancro (no contexto da aplicação chama-se Happyscore).**
   4.1. O que pensou quando viu o seu Happyscore?
   4.2. Esse valor levou-o(a) de algum modo a reconsiderar o seu comportamento?
   4.3. Durante o período de tempo em que utilizou a aplicação alguma vez pensou no que estava a fazer e em como isso iria influenciar o seu Happyscore?
   4.4. Alterou alguma coisa no seu comportamento com o objetivo de fazer o seu Happyscore subir?

5. **Durante o período de utilização da aplicação recebeu várias mensagens.**
   5.1. O que pensou quando leu a primeira mensagem?
   5.2. Sentiu que as mensagens que recebeu se adequavam ao seu perfil e ao seu contexto?
      5.2.1. Porquê?
   5.3. Houve alguma mensagem que o(a) tenha feito refletir sobre a sua saúde?
      5.3.1. O que dizia a mensagem?
      5.3.2. Por que é que essa mensagem o(a) fez pensar?

5.4. Em algum momento deixou de fazer alguma coisa ou fez algo diferente influenciado(a) por uma mensagem recebida?

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*Vou agora mostrar algumas mensagens. Pode ou não ter recebido estas mensagens durante as 4 semanas que utilizou a aplicação.*

MATERIAL DE APOIO #1

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5.5. Qual a sua opinião sobre estas mensagens?

5.5.1. Quer discutir alguma mensagem em particular que tenha recebido e que não esteja aqui representada?

**6. Durante o período de utilização da aplicação alguma vez consultou a secção de estatísticas?**

6.1. O que é que procurou saber nas estatísticas?

6.2. As estatísticas ajudaram-no(a) a avaliar e a tentar alterar o seu comportamento?

6.2.1. De que modo?

**7. A utilização desta aplicação suscitou-lhe algum problema ou preocupação em particular?**

**8. Utilizaria a aplicação durante mais tempo?**

[Se resposta for "**SIM**"] 8.1. Porquê? O que é que o(a) motiva a utilizar a aplicação?

[Se resposta for "**NÃO**"] 8.1. Porquê? O que é que seria necessário para o(a) motivar a utilizar a aplicação?

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*Vou agora mostrar três funcionalidades que estamos a pensar acrescentar a esta aplicação.*

MATERIAL DE APOIO #2

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**9. Qual a sua opinião sobre estas funcionalidades?**

9.1. Acha que vão contribuir para uma maior e melhor utilização da aplicação?

**10. Que outras funcionalidades acrescentava a esta aplicação?**

10.1. O que é que lhe falta para ser a "aplicação ideal"?

**11. Há mais alguma coisa que não tenha sido falada e que queira partilhar?**

**MATERIAL DE APOIO #1**

**EXEMPLOS DE MENSAGENS**

**Mensagem #1**

*Mantém sempre a tua roupa de desporto pronta. Nunca se sabe quando vais ter uma vontade irresistível de fazer exercício!*

**Mensagem #2**

*A roupa escura protege melhor contra os UV. Pensa nisto na hora de escolher a tua roupa.*

Meteorologia: Sol, UV >8

**Mensagem #3**

*Cria um lembrete no teu telemóvel para te lembrares de realizar o autoexame da mama. As melhores horas para o fazer são ao início do dia e ao deitar.*

**Mensagem #4a**

*Está na hora de espreitar a tua beleza interior! Marca uma consulta no teu ginecologista ou no centro de saúde e faz o Papanicolaou.*

Género: feminino

**Mensagem #4b**

*Está na hora de ver como estão as "jóias da família". Examinar os teus testículos pode salvar-te a vida...*

Género: masculino

**Mensagem #5**

*A esta hora os UV estão muito elevados. Não te exponhas diretamente ao Sol.*

UV>8

**Mensagem #6**

*Vais almoçar? Acompanhar a refeição com água permite-te saborear melhor o que comes...*

12h-14h

**Mensagem #7**

*O exercício físico reduz o teu risco de cancro do cólon e do reto em 30%. Mexe-te!*

**Mensagem #8**

*A infeção crónica pelo vírus da hepatite B é o principal fator de risco do cancro do fígado. Informa-te junto do teu médico.*

**Mensagem #9**

*Sabias que ao reduzires o consumo de álcool estás a reduzir o teu risco de cancro? Não bebas. Se beberes, limita o teu consumo a uma bebida por dia.*

**Mensagem #10**

*Sabias que esta é uma das horas favoritas das pessoas da tua idade para fazer exercício?*

19h-21h
Seg-Sex

**Mensagem #11**

*90% dos casos de cancro da pele são causados por uma exposição inadequada ao sol. Evita a exposição das 11h às 17h.*

9h-11h
UV>7

**Mensagem #12**

*Mais de 80% dos ex-fumadores portugueses deixaram de fumar porque tomaram consciência dos riscos do tabaco. E tu quando é que ganhas juízo?*

**MATERIAL DE APOIO #2**
**FUNCIONALIDADES NOVAS**

**MATERIAL DE APOIO #2**
**FUNCIONALIDADES NOVAS**

**Botão de emergência**

Botão na aplicação que envia mensagens ao utilizador no momento em que este precisa. O utilizador carrega no botão e seleciona dos comportamentos possíveis qual o que quer receber. Surgem botões com chamadas de ação do tipo:

"tenho fome"
"tenho sede"
"apetece-me mexer o corpo"
"apetece-me fumar"

Ao carregar num desses botões o sistema envia uma mensagem com dicas para estas situações.

**MATERIAL DE APOIO #2**
**FUNCIONALIDADES NOVAS**

**Desafios**

Dar a possibilidade ao utilizador de aceitar desafios saudáveis e monitorizar o seu cumprimento dentro da aplicação.

Exemplos de desafios:
"Não fumar durante 1 semana"
"Não utilizar elevadores durante um mês"

Cada desafio tem um nº de pontos que o utilizador ganhará se o cumprir. Os pontos são cumulativos e servem para comparação com outros utilizadores

**MATERIAL DE APOIO #2**

**FUNCIONALIDADES NOVAS**

**Rede Social**

Dar a possibilidade ao utilizador de se conectar a amigos que utilizem o Happy.

Possibilidade de comparar HappyScores e pontuação, formar grupos de amigos por interesses específicos (grupo da dieta ou do exercício físico, por exemplo) e desafiar os amigos para desafios saudáveis específicos (competição pelos pontos)

## Supplementary file 6

University of Aveiro Ethics Committee's approval of Study IV and Study V

**Parecer nº: 11/2015.**
**Requerentes:** Doutora Ana Margarida de Almeida.
**Título do Projeto:** "HAPPY: Prevenção de cancro mediada por dispositivos móveis".
**Orientadora:** Doutora Ana Margarida de Almeida.
**Equipa de Investigação:**
Doutora Ana Margarida de Almeida (DECA);
Dr. Nuno Ribeiro - Bolseiro de investigação e
Dr. Luís Moreira - elemento responsável pelo acompanhamento e tratamento dos dados estatísticos recolhidos (Informação de 7/ABR16).
**Enquadramento institucional**: estudo inserido em projeto de doutoramento) - referência SFRH/BD/92996/2013, financiado pela Fundação Calouste Gulbenkian através do Projeto HYPE –Healthy Youth through Prevention Education.
**Relator:** Professor Jorge Carvalho Arroteia.
**Relatores Adjuntos**: Professor António J. A. Nogueira, Professor António Rocha Andrade, Professor Armando J. Formoso de Pinho e Professora Paula Cristina M. S. Pereira.

**Relatório**

O processo encontra-se instruído contendo elementos essenciais relativos a:
- caracterização do projeto,
- equipa de investigação,
- bibliografia de referência,
- apresentação do estudo,
- apoio do Centro de Investigação: CIC.Digital / Departamento de Comunicação e Arte.
- anexos:
  – Estudo de aplicação Happy,
  – Informação sobre o projeto Happy,
  – Respostas solicitadas pelo Conselho de Ética e Deontologia (25NOV2015), enviadas em 28NOV2016,
  – Esclarecimento adicional de 7ABR2016.

**Parecer**

**A. Fundamentação**

1. A proposta relativa ao projeto apresenta-se fundamentada no que respeita aos objetivos, metodologia de recolha e tratamento de dados e bibliografia.
2. O trabalho de investigação compreende dois estudos em simultâneo:
– Estudo A – estudo randomizado controlado;
- Estudo B – estudo comparativo
3. A informação aos participantes (Anexo 1) esclarece que *"não há qualquer risco inerente à participação neste estudo"*;

universidade de aveiro

# CONSELHO DE ÉTICA

4. Os riscos associados ao desenvolvimento do Projeto estão contemplados, uma vez que, de acordo com o pedido de parecer, pretende-se apenas a *"recolha de dados*

*pessoais dos participantes no estudo, incluindo dados de saúde e de hábitos comportamentais"*.

1. Segue o estabelecido na Lei nº 12/2005, de 26 de Janeiro – *"Informação genética pessoal e informação de saúde"*, bem como a Lei n.º 46/2007, de 24 de Agosto que *"Regula o acesso aos documentos administrativos e a sua reutilização, revoga a Lei n.º 65/93, de 26 de Agosto, com a redacção introduzida pelas Lei nºs 8/95, de 29 de Março, e 94/99, de 16 de Julho, e transpõe para a ordem jurídica nacional a Directiva n.º 2003/98/CE, do Parlamento e do Conselho, de 17 de Novembro, relativa à reutilização de informações do sector público"*

Face ao exposto entende-se que a proposta em análise respeita os princípios de ética neste tipo de investigação na medida em que o estudo:

1. regista os consentimentos informados quer os prestados por escrito quer os prestados eletronicamente;
2. salvaguarda a participação voluntaria dos intervenientes;
3. indica o acompanhamento da investigação por parte da Orientadora;
4. esclarece que *"A aplicação não efetua diretamente qualquer medição referente ao comportamento do utilizador"*.
5. Os dados recolhidos no projeto são analisados pela equipa de investigação, mantendo-se confidenciais e anónimos, sob a responsabilidade do doutorando e orientadora por um período a definir pelos responsáveis do estudo;
6. A documentação resultante da recolha de informação sobre os participantes faz parte de uma *"base de dados segura com recurso a encriptamento de dados"* (Resposta ao despacho de 25 de Novembro de 2015 – CED - enviado via email no dia 28 de Janeiro de 2016

**B. Sugestões**

1. Deve ser definido um período de tempo em concreto para a destruição da base de dados;
2. Depois de concluído o estudo em causa deverá o mesmo ser divulgado, pelo menos, aos que nele intervieram.

**C. Conclusão**

**De acordo com o anteriormente assinalado e os princípios seguidos pelo CED é emitido o seguinte parecer:**

A Comissão Permanente do Conselho de Ética, constituída pelos ora Relatores, após a apreciação conjunta da documentação recebida e atendendo a que os procedimentos descritos no estudo de investigação asseguram a não utilização de qualquer método invasivo e que os participantes serão oportunamente informados e esclarecidos das condições em que vão decorrer as observações e recolha de dados e

que os dados recolhidos serão tratados de maneira a permanecerem confidenciais e anónimos,

entende, por unanimidade, que ficam salvaguardadas as exigências éticas, os princípios da justiça e da autonomia e bem-estar dos participantes e, por isso, dá parecer favorável, na condição de que a obtenção dos consentimentos informados seja feita por termo, recolhida em folha separada, no qual devem constar as assinaturas do responsável pelo projeto e do participante, esta aposta num período não inferior a 24h relativamente à informação que lhe tenha sido prestada, à realização do projeto intitulado "HAPPY. Prevenção de cancro mediada por dispositivos móveis",

Os Relatores:

_____

_____

_____

**D. Decisão**

Submetido ao CED o parecer da sua Comissão Permanente, este Conselho em sua reunião plenária de 13 de Abril de 2016, por entender que ficam salvaguardadas as exigências éticas e os princípios da justiça e da autonomia e bem-estar dos participantes, concorda por unanimidade com o mesmo, em razão do que, uma vez cumprida a condição nele referida o ratifica e dá parecer favorável à realização do projeto "HAPPY: Prevenção de cancro mediada por dispositivos móveis".

Aveiro, 13 de Abril de 2016.

Conselho de ética e Deontologia da Universidade de Aveiro.

Presidente: _____

Vice - Presidente: _____

Secretário: _____

## Supplementary file 7

Dropout questionnaire from Study IV

## Estudo sobre as razões para deixar de utilizar a aplicação Happy

Recebeu o convite para responder a este questionário porque deixou de utilizar a aplicação para smartphone Happy (pode saber mais sobre a aplicação aqui: http://happy-app.eu).
Gostaríamos de saber as razões que o(a) levaram a deixar de utilizar esta aplicação. As suas respostas serão muito importantes para percebermos o que leva as pessoas a deixar de utilizar este tipo de aplicações. Por esses motivos, as suas respostas devem ter por base uma opinião sincera.
Esta investigação está a ser desenvolvida no âmbito do Programa Doutoral em Multimédia em Educação da Universidade de Aveiro em colaboração com o Ipatimup (Instituto de Patologia e Imunologia Molecular da Universidade do Porto). O inquérito por questionário não é anónimo, mas os seus dados pessoais serão tratados de forma confidencial e exclusivamente no âmbito desta investigação.
A qualquer momento pode interromper o preenchimento do questionário caso não se sinta à vontade para prosseguir.
Desde já agradecemos a sua colaboração.

O investigador,

Nuno Ribeiro
(nribeiro@ipatimup.pt)

## I. Razões para deixar de utilizar a aplicação Happy

1. **Indique as razões que o(a) levaram a deixar de utilizar a aplicação Happy.**

2. **Indique 3 ou mais pontos que considera positivos na aplicação Happy.**

3. **Indique 3 ou mais pontos que considera negativos na aplicação Happy.**

## II. Avaliação da aplicação

**1. Indique em que medida concorda ou discorda com cada uma das seguintes afirmações:**

| Utilidade da aplicação | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. A aplicação sensibilizou-me para a importância da prevenção de cancro. | | | | | |
| 2. A aplicação aumentou os meus conhecimentos sobre prevenção de cancro. | | | | | |
| 3. A aplicação induziu em mim uma mudança de atitude sobre a prevenção de cancro. | | | | | |
| 4. A aplicação motivou-me a mudar comportamentos e a prevenir o cancro. | | | | | |
| 5. A aplicação incentivou-me a procurar ajuda na prevenção do cancro (procurar o médico, por exemplo). | | | | | |
| 6. A aplicação incentivou-me a mudar o meu comportamento de modo a prevenir o cancro. | | | | | |

| Facilidade de uso da aplicação | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. Foi fácil para mim perceber como a aplicação funciona. | | | | | |
| 2. As interações com a aplicação são fáceis de realizar. | | | | | |
| 3. Considero a aplicação fácil de utilizar. | | | | | |
| 4. Foi fácil para mim dominar o funcionamento da aplicação. | | | | | |

| Experiência de utilização da aplicação | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. A minha experiência com a aplicação foi sempre agradável. | | | | | |
| 2. Gostei de utilizar a aplicação. | | | | | |
| 3. Foi divertido utilizar a aplicação. | | | | | |
| 4. Foi interessante utilizar a aplicação. | | | | | |

| Confirmação das expectativas | Discordo Totalmente | Discordo | Nem concordo nem discordo | Concordo | Concordo Totalmente |
|---|---|---|---|---|---|
| 1. A minha experiência com a aplicação foi melhor do que esperava. | | | | | |
| 2. O serviço prestado por esta aplicação revelou-se melhor do que esperava. | | | | | |
| 3. De um modo geral, as minhas expectativas em relação a esta aplicação confirmaram-se | | | | | |

**2. Globalmente, como classifica a sua experiência de utilização da aplicação Happy?**

| Muito negativa | Negativa | Mais ou menos | Positiva | Muito positiva |
|---|---|---|---|---|
| | | | | |

**3. De um modo geral, como classificaria a aplicação Happy? (nota de 0 a 10)**

0 1 2 3 4 5 6 7 8 9 10

## III. Dados demográficos

**1. Habilitações literárias**

Ensino básico
Ensino secundário
Ensino superior: licenciatura
Ensino superior: mestrado
Ensino superior: doutoramento

**Muito obrigado pela sua participação.**

## Supplementary file 8

Online questionnaire from Study V

## Estudo sobre comportamento e conhecimento de prevenção de cancro

Este inquérito por questionário destina-se a recolher informações sobre o seu comportamento e conhecimento sobre prevenção de cancro. Esta investigação está a ser desenvolvida no âmbito do Programa Doutoral em Multimédia em Educação da Universidade de Aveiro em colaboração com o Ipatimup (Instituto de Patologia e Imunologia Molecular da Universidade do Porto).

As suas respostas devem ter por base uma opinião sincera. O inquérito por questionário não é anónimo, mas os seus dados pessoais serão tratados de forma confidencial e exclusivamente no âmbito desta investigação.
A qualquer momento pode interromper o preenchimento do questionário caso não se sinta à vontade para prosseguir.
Desde já agradecemos a sua colaboração.

O investigador,

Nuno Ribeiro
(nribeiro@ipatimup.pt)

## I. Saúde e estilo de vida

1. **Género**
   Masculino
   Feminino

2. **Qual o seu peso?** __,__ kg

3. **Indique a quantidade total (aproximada) que consumiu dos seguintes alimentos nos últimos 3 dias:**
   Peças de fruta ___ (nº)
   Sumos naturais ___ (nº)
   Sopas ___ (nº)
   Saladas ___ (nº)
   Legumes cozinhados ___ (nº)
   Carnes vermelhas ___ (nº)
   Alimentos tipo fast-food ___ (nº)
   Alimentos fritos ___ (nº)
   Folhados, quiches e tartes ___ (nº)
   Doces e sobremesas ___ (nº)
   Queijos
   Enchidos ___ (nº)

4. **Nos últimos 7 dias, em quantos dias andou pelo menos 10 minutos seguidos?** __ dias

| |
|---|
| [Se dias > 0]<br><br>4.1. Em média, nesses dias, quanto tempo andou por dia? ___ minutos |

5. **Nos últimos 7 dias, em quantos dias realizou atividades físicas moderadas?** __ dias

| |
|---|
| [Se dias > 0]<br><br>5.2. Em média, nesses dias, quanto tempo por dia dedicou<br>a atividades físicas moderadas? ___ minutos |

6. **Nos últimos 7 dias, em quantos dias realizou atividades físicas intensas?** __ dias

| |
|---|
| [Se dias > 0]<br><br>6.3. Em média, nesses dias, quanto tempo por dia dedicou<br>a atividades físicas intensas? ___ minutos |

7. **Consome bebidas alcoólicas?**
   Sim
   Não

| |
|---|
| [Se "Sim"]<br><br>7.1. Quantas bebidas alcoólicas consumiu nos últimos 7 dias? ___ (nº de bebidas) |

8. **Fuma?**
   Sim
   Não

| |
|---|
| [Se "Sim"]<br><br>8.1. Quantos cigarros fuma em média por dia? ___ (nº de cigarros) |

9. **Nos últimos 3 meses apanhou algum escaldão solar?**
   Sim
   Não

10. **Nos últimos 3 meses frequentou alguma vez um solário?**
    Sim
    Não

11. **Costuma aplicar protetor solar quando se expõe ao Sol?**
    Sempre
    Quase sempre
    Algumas vezes
    Nunca

**Perguntas apenas para as respondentes do GÉNERO FEMININO**

**12. Dos seguintes exames, indique os que já realizou**

A. Exame de Papanicolaou
B. Autoexame mamário
C. Autoexame da pele

[Se Indicar exame A, por exemplo]

A.1. Indique a data da última realização do exame: mm/aaaa

**13. Está vacinada contra o vírus da hepatite B (HBV)?**

Sim, estou vacinada
Não, mas estou em fase de vacinação
Não
Não sei

**14. Está vacinada contra o vírus do papiloma humano (HPV)?**

Sim, estou vacinada
Não, mas estou em fase de vacinação
Não
Não sei

**Perguntas apenas para os respondentes do GÉNERO MASCULINO**

**12. Dos seguintes exames, indique os que já realizou**

A. Autoexame testicular
B. Autoexame da pele

[Se Indicar exame A, por exemplo]

A.1. Indique a data da última realização do exame: mm/aaaa

**13. Está vacinado contra o vírus da hepatite B (HBV)?**

Sim, estou vacinado
Não, mas estou em fase de vacinação
Não
Não sei

## II. Avaliação de conhecimentos sobre prevenção de cancro

As seguintes questões de escolha múltipla pretendem avaliar o seu grau de conhecimento sobre prevenção de cancro. Caso não saiba a resposta a alguma pergunta por favor selecione a opção "Não sei".

1. **Qual o agente que pode originar o cancro do fígado?**
   *Helicobacter pylori*
   *Pseudomonas sp*
   Vírus do Papiloma Humano (HPV)
   Vírus da Hepatite B (HBV)
   Não sei

2. **Qual dos seguintes cancros pode ser prevenido com a toma de uma vacina?**
   Cancro da mama
   Cancro do colo do útero
   Cancro colo-retal
   Cancro da pele
   Não sei

3. **Qual das seguintes medidas diminui o risco de cancro?**
   Consumir fruta e vegetais todos os dias
   Consumir carnes vermelhas 5 vezes por semana
   Consumir álcool 2 vezes por semana
   Fumar apenas 1 dia por semana
   Não sei

4. **Qual das seguintes medidas aumenta o risco de cancro?**
   Praticar exercício físico regularmente
   Aumentar o consumo de calorias na alimentação
   Erradicar a bactéria *Helicobacter pylori*
   Diminuir o consumo de sal
   Não sei

5. **O risco de uma mulher vir a ter cancro da mama diminui…**
   Se não consumir álcool
   Se tiver poucos parceiros sexuais
   Se aumentar o consumo de calorias na alimentação
   Se não utilizar anti-transpirantes
   Não sei

6. **Qual o agente que origina o cancro do colo do útero?**
   *Helicobacter pylori*
   *Pseudomonas sp*
   Vírus do Papiloma Humano (HPV)
   Vírus da Hepatite B (HBV)
   Não sei

7. **O risco de ter um cancro colo-retal aumenta…**
   Se tiver uma dieta rica em carne vermelha

Se não existirem outros casos na família
Se estiver infetado com *Helicobacter pylori*
Se for do sexo feminino
Não sei

**8. Qual a causa da grande maioria dos casos de cancro de pele?**
Mutações hereditárias
Exposição exagerada e/ou inadequada ao sol
Produção de vitamina D em excesso
Exposição prolongada à radioatividade
Não sei

**9. O cancro da mama é uma doença que afeta…**
Apenas homens
Apenas mulheres
Maioritariamente homens
Maioritariamente mulheres
Não sei

**10. Qual o exame de rastreio utilizado no cancro do colo do útero?**
Biopsia
Mamografia
Endoscopia
Exame de Papanicolaou
Não sei

**11. Qual o período do dia em que é mais perigosa a exposição solar?**
7h-10h
16h-18h
9h-11h
11h-17h
Não sei

**12. Qual o tipo de cancro de pele mais mortal?**
Carcinoma basocelular
Melanoma
Carcinoma espinocelular
Sarcoma
Não sei

**13. O consumo de tabaco aumenta o risco de…**
Cancro colo-retal
Cancro do pulmão
Cancro do esófago
Todos os cancros anteriores
Não sei

**14. Qual o cancro mais comum entre os jovens do sexo masculino com idades entre os 15 e os 35 anos?**
Linfoma
Leucemia
Cancro do pulmão
Cancro testicular
Não sei

**15. Qual o comportamento que mais contribui para o aumento do risco de cancro?**
Consumir carnes vermelhas e processadas
Não estar vacinado contra o HPV
Beber álcool
Fumar
Não sei

## III. Aplicações instaladas

**Perguntas apenas para os respondentes do GRUPO CONTROLO**

**1. Instalou alguma aplicação de prevenção de cancro nos últimos 3 meses?**
Sim
Não

[Se "Sim"]
1.1. Indique o nome da aplicação (ou aplicações) que instalou.

**Perguntas apenas para os respondentes do GRUPO EXPERIMENTAL**

**1. Instalou alguma aplicação de prevenção de cancro nos últimos 3 meses para além da Happy?**
Sim
Não

[Se "Sim"]
1.1. Indique o nome da aplicação (ou aplicações) que instalou.

**Muito obrigado pela sua participação.**
No âmbito deste estudo voltará a ser contactado daqui a 3 meses

Nuno Ribeiro

Departamento de Comunicação e Arte
Departamento de Educação e Psicologia
**Universidade de Aveiro**

2018