Designing a Digital Personal Coach to Promote a Healthy Diet and Physical Activity Among Patients After Cardiothoracic Surgery

Ana Martins[1,3][a], Isabel Nunes[3][b], Luís Velez Lapão[2,3][c] and Ana Londral[1,2][d]
[1]*Value for Health CoLAB, Lisboa, Portugal*
[2]*Comprehensive Health Research Center, Nova Medical School, Nova University of Lisbon, Lisboa, Portugal*
[3]*Department of Mechanical and Industrial Engineering, NOVA School of Science and Technology, Nova University of Lisbon, Lisboa, Portugal*

Keywords: Digital Coach, Text-Message Intervention, Conversational Agents, Behavior Change Theory, Cardiothoracic Surgery.

Abstract: This position paper describes the design of a text-message intervention that uses behavior change theory to help design the intervention to improve patients' diet and physical activity. The text-message intervention aims to guide patients to improve their self-efficacy in managing their disease to reduce complications and hospital readmissions and improve health-related outcomes, well-being, and quality of life. Design Science Research methodology is used to support problem definition, design, development, and evaluation of a sustainable, useful, and valuable artifact.

1 INTRODUCTION

A healthy lifestyle can reduce the burden associated with chronic diseases by preventing their appearance, and promoting health maintenance. Protective behaviors should be taught to chronic patients to improve their quality of life and long-term well-being. This can reduce the workload of healthcare professionals by making patients active agents in their health (Bauer et al., 2014; Kontis et al., 2014). Behavior change interventions can guide the process of change and help maintain a healthy behavior (Grimmett et al., 2019). The use of conversational agents can be an affordable and efficient way to personalize care by delivering personalized content based on what is reported and needed by the patient (Chaix et al., 2019; Fitzpatrick et al., 2017; Stephens et al., 2019; Ghandeharioun et al., 2019).

Cardiovascular disease (CVD) is the biggest cause of mortality and morbidity worldwide (WHO, 2021). A prospective cohort study found that cardiovascular disease events are caused by modifiable risk factors. The predominant factors were hypertension, high low-density lipoprotein (LDL) cholesterol, household pollution, and tobacco use (Yusuf et al., 2020).

Cardiothoracic surgery has decreased mortality and morbidity of cardiovascular patients, allowing patient's to live longer. However, because surgery is a stressful event (Gardner et al., 2005; Pinto et al., 2016; Tadas et al., 2021), it may result in a failure to fully understand the medical information provided and compromise health outcomes. These facts have led researchers to focus on ways to increase patients' awareness of their disease to improve their well-being and quality of life and prevent further events from occurring (Tully, 2013). Pervasive technology might be used to improve modifying risk factors and quality of life.

Behavior change interventions (BCIs) systematically organize actions that target specific behaviors with the intent to improve a target behavior in a target population (Michie et al., 2011). Interventions to change behavior are complex due to the interacting components they are composed of. In the design phase, specifications must be understandable to ensure proper evaluation of effectiveness.

The Behavior Change Wheel (BCW) summarizes 19 behavior change frameworks and was developed using expert consensus and validation (Michie et al., 2011) to guide researchers in the design and evaluation phases. The framework divides intervention de-

[a] https://orcid.org/0000-0002-4890-3941
[b] https://orcid.org/0000-0002-0428-0930
[c] https://orcid.org/0000-0003-0506-1294
[d] https://orcid.org/0000-0002-8002-6790

Martins, A., Nunes, I., Lapão, L. and Londral, A.
Designing a Digital Personal Coach to Promote a Healthy Diet and Physical Activity Among Patients After Cardiothoracic Surgery.
DOI: 10.5220/0011776800003414
In *Proceedings of the 16th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2023) - Volume 5: HEALTHINF*, pages 595-602
ISBN: 978-989-758-631-6; ISSN: 2184-4305
Copyright © 2023 by SCITEPRESS – Science and Technology Publications, Lda. Under CC license (CC BY-NC-ND 4.0)

sign into three phases: (1) understanding the behavior, (2) identifying intervention options, and (3) identifying content and implementation options. In the first phase, the definition of the problem in behavioral terms is specified, the target behavior is selected and specified, and a needs assessment is performed. The behavioral analysis is performed using the model of capacity, opportunity, and motivation (COM-B). Capability stands for the psychological and physical ability to perform a certain activity. Opportunity is characterized as the external factors that could trigger/enable a particular behavior, and motivation is the conscious and unconscious cognitive processes that lead the agent to perform a particular behavior intuitively or rationally. Phase 2 establishes the intervention functions and policy categories are identified. Education, persuasion, incentivization, coercion, training, restriction, environmental structuring, modeling, and enablement are intervention functions that can be used to achieve a specific target behavior (Michie et al., 2011). In the last phase, the content and implementation options are clarified. Behavior change techniques (BCTs) should be defined in this phase.

BCTs are observable, replicable, and irreducible components that aim to redirect causal processes that regulate target behavior. They can give us cues about how the content delivered by the conversational agent influences the receiver (Michie et al., 2013). Mechanisms of action (MoAs) give us a better understanding of how BCTs act on individuals to produce the expected effects. Based on the studies published to date, the Human Behavior Change Project has developed a tool that maps BCTs to MoAs. This allows the MoA underlying the change to be identified (Carey et al., 2018; Johnston et al., 2021).

In this position paper, we describe the methodology we used to develop a pilot study aimed at integrating behavior change theory into a digital solution to promote healthy eating and regular physical activity. Future work is also explained.

2 METHODS

Design Science Research Methodology (DSRM) is used to ensure that a successful artifact created to address a problem that meets the interests of all stakeholders is produced (Hevner et al., 2004). A successful DSRM cycle draws on previous literature and lends itself as a solution to a specific problem whose utility, quality, and effectiveness will be rigorously evaluated (Hevner et al., 2004). The development of the artifact should uphold on existing theories and knowledge to a specific problem (Peffers et al., 2007). We followed a nominal process based on previous research involving 6 steps (Peffers et al., 2007) as depicted in Figure 1.

2.1 Problem Identification, Context Characterization, and Motivation

Consistent with the DSRM, problem identification and motivation definition are critical to the sustainability of the artifact. This step was divided into 4 activities, namely context characterization, data analysis, literature review, and semi-structured interview with clinical team.

We obtained an initial description of the context in which the artifact would be used during a meeting with the researchers involved in an earlier research project to develop a telemonitoring service to monitor patients undergoing cardiothoracic surgery (Londral et al., 2022). An additional meeting with the clinical team helped understanding how the follow-up after the telemonitorization period was done and what were the major concerns of the clinical team after the telemonitorization period.

Following the context characterization, data analysis of electronic health records (EHR) was conducted to better understand the demographic characteristics of the study population, such as age, gender, income, education, occupation, and additional medical information on pre-existing conditions to surgery and type of procedure. In addition, patient-reported outcomes (PROMs) collected by nurses during follow-up interviews were also analyzed.

At this point qualitative studies regarding experiences after surgery (Gardner et al., 2005; Pinto et al., 2016; Tadas et al., 2021) where studied to understand what are patient's experiences after surgery. Additionally, risk modifying factors of cardiovascular disease were assessed (Yusuf et al., 2020).

After data analysis and discussion of findings with the research team, semi-structured interviews were conducted with 7 healthcare providers to understand (1) what are risk modifying factors for the population considered important to the clinical team, (2) what is important for patients to have a better quality of life, (3) what are the barriers and facilitators to activities relevant to increasing patient well-being, (4) whether there are personality traits in this population that with better health outcomes, (5) how the follow-up service works, (6) how information is communicated to patients (literacy strategies used), and (7) how this service can be improved. Interviews were performed using LimeSurvey (Schmitz, 2012).

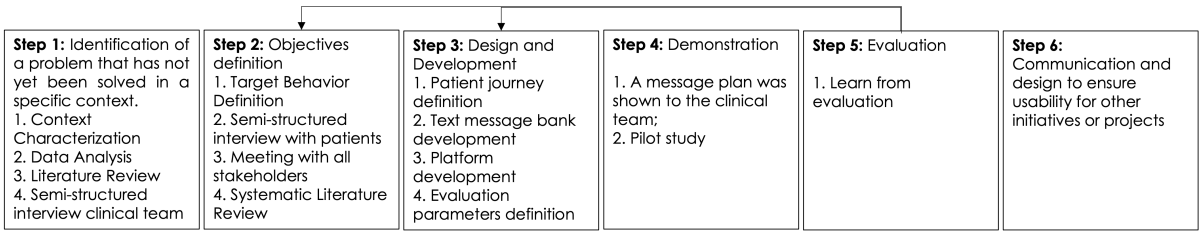

Figure 1: Methodology for developing a valuable artifact for follow-up in the cardiothoracic surgery service.

2.2 Define the Objectives for a Solution

The specification of the target behaviors for the intervention focused on understanding which behaviors can have a broader impact in the modifying risk factors for cardiovascular disease.

Ten patients who had participated in the telemonitoring pilot project mentioned earlier (Londral et al., 2022) were interviewed a year and a half after surgery to collect their experiences during the recovery period. The semi-structured interview consisted of 8 questions, according to the recommendations of the clinical team, who advised us to ask only a few questions, otherwise, the patient would lose interest. In this interview, the COM -B model is used to identify barriers and facilitators to healthy eating and physical activity. So the questions focused on finding out how the surgery changed their lives, what their quality of life is like today, what motivates them to maintain healthy habits and follow the clinical team's recommendations, whether they adhere to diet and physical activity recommendations. We also asked patients if they could recommend changes to the service. In this way, we were able to conduct a behavioral analysis of the patients who participated in the telemonitoring project in accordance with the phase 1 of the BCW framework. The main barriers and motivators for initiating and maintaining a particular behavior were assigned to the intervention function layer of the BCW.

The objectives were set after 2 meetings with the researchers involved in the study (engineers, medical doctors, and nurses) where all the information gathered and a possible objective for a solution were presented. We foresee the need to redefine the objective after each iteration of the study.

A systematic literature review was conducted to determine how to develop conversational agents that deliver personalized and automated content to patients with chronic diseases.

2.3 Design and Development

In designing and developing the solution, we focused on integrating the results of the previously defined target behavior with the intervention functions previously identified by the clinical team and the results of the systematic literature review.

2.4 Demonstration

The first iteration of the DSRM will be completed with a pilot study of 5 patients who agree to participate.

2.5 Evaluation

The evaluation process was defined based on the target behavior previously established in the goal definition phase. Our goal was to define methods currently used in the service to assess patient recovery in order to increase the feasibility of the artifact. We also wanted to measure engagement, acceptance, and satisfaction.

3 RESULTS

3.1 Problem Identification and Motivation

The cardiothoracic surgery service follows patients for one year after surgery. During this time, nurses conduct follow-up visits to assess patients' recovery based on physical activity, pain, diet, body mass index, medications, health monitoring, social support, tobacco use, and quality of life. Regular appointments are also scheduled with the patient's assigned medical doctor. In addition, patients who are willing to participate in the telemonitoring study, if selected for the intervention group, can benefit from the telemonitoring service three months after surgery, as shown in Figure 2.

EHRs provided by the hospital showed that only 1% of patients had no preexisting condition before surgery. Pre-existing conditions or risk factors were arterial hypertension (17.7%), hypercholesterolemia (14.6%), diabetes (6.9%), persistent atrial fibrillation (3.8%), previous myocardial infarction (3.2%), smoking (3.1%), and more. According to the clinical team,

most patients are treated as having a chronic disease after surgery and there is a high risk of readmission 1 year after surgery. Therefore, the service provides specialist appointments, uses various techniques to improve patients' literacy, conducts telemonitoring, does regular follow-up interviews, and distributes brochures on nutrition and physical activity to help patients properly manage their condition.

The semi-structured interviews with the clinical team revealed that risk factors are important to improve health-related outcomes. Managing chronic conditions such as diabetes, hypertension, LDL, a healthy diet, regular physical activity, good mental health, and a social role are factors that positively influence recovery. Barriers to implementing protective behaviors include poor health literacy skills, lack of motivation, lack of support and specialized help, employment, anxiety, fear, pain, and physical capability. The clinical team was unable to identify any unique personality traits in this population. The clinical team suggested developing an automated system that would not increase the workload of the clinical team, predict what the patient's needs would be at home after the telemonitoring period, and send personalized messages to encourage healthy behaviors.

Doctors also say that it is very common for patients to come back to the hospital after 1 year of surgery due to complications. This might be cause by lack of self-management skills and distress at that moment.

For what was said, we hypothesized that a problem could be associated with the lack self-efficacy in self-managing the disease. Thus, the use of pervasive technology could be important to provide support, and valuable information for managing their disease (Halldorsdottir et al., 2020; Akinosun et al., 2021).

3.2 Define the Objectives for a Solution

The target behaviors for the intervention were identified by first analyzing all the modifying risk factors to the target population, which can be split into three types of factors: (1) behavioral factors (ie, tobacco use, alcohol, diet, physical activity, and sodium intake), (2) metabolic factors (ie, lipids, blood pressure, diabetes, obesity), (3) socioeconomic and psychosocial factors (ie, education, symptoms of depression), (3) grip strength, and household and ambient pollution (Yusuf et al., 2020). We chose diet and physical activity as target behaviors for the intervention since they have a great impact in other factors, such as tobacco use, sodium intake, lipids, blood pressure, diabetes, obesity, and symptoms of depression (Warburton and Bredin, 2017; Cena and Calder, 2020).

The semi-structured interviews with patients revealed that personalized advice on physical activity and healthy eating could increase their well-being and help them recover. The main barriers to engaging in these behaviors were occupation, lack of motivation and physical capability, health status, medication, weight, weather, and mental health. The main promoters were social support, health beliefs, identification with the behavior, pets, and the presence of monitoring devices to track activity. We focused in the results of the semi-structured interviews and results from two studies to identify the determinants of having a healthy diet and being physically active (Brug, 2008; Sherwood and Jeffery, 2000). We found that the most important determinants for physical activity are self-efficacy, health-related outcomes, social interaction, stage of change, and social support. While, for having a healthy diet, the most important were monitoring, personal satisfaction, social comparison, stage of change, and social support.

The systematic literature review showed that to carry out a fully-automated BCI it is necessary to set up a data management platform and a communication system, incorporate algorithms that can automate content delivery, specify the intended personalization features, and find proper instruments to evaluate the intervention. Previous studies carried out BCI to improve physical activity, diet, enhance disease monitoring, and self-management (Mayberry et al., 2021; Kelly et al., 2020; Polgreen et al., 2018; Cadilhac et al., 2020; Chokshi et al., 2018; Horner et al., 2017; Thiengwittayaporn et al., 2021). Three of those developed their own data management platforms (Polgreen et al., 2018; Thiengwittayaporn et al., 2021; Cadilhac et al., 2020), while the remaining used commercially available platforms (Mayberry et al., 2021; Kelly et al., 2020; Horner et al., 2017; Chokshi et al., 2018). Every study used rule-based models to automate content delivery. Personalization features included patient-centered goals (Mayberry et al., 2021; Kelly et al., 2020; Cadilhac et al., 2020), barriers to behavior change (Kelly et al., 2020), timing (Mayberry et al., 2021; Kelly et al., 2020; Cadilhac et al., 2020) and frequency (Kelly et al., 2020) of message delivery, functional ability (Cadilhac et al., 2020), disease stage (Thiengwittayaporn et al., 2021), communication channel (Mayberry et al., 2021; Chokshi et al., 2018; Cadilhac et al., 2020), feedback based on activity (Polgreen et al., 2018; Chokshi et al., 2018; Horner et al., 2017), baseline demographic data (Horner et al., 2017), and stage of behavior change (Horner et al., 2017). Nevertheless, personalization algorithms are not well documented and could be enhanced using other approaches that automatically un-

derstand what are the patient's needs and adjust content.

Based on the above, we have the following objectives for the solution:

- The end users are healthcare providers and patients after telemonitoring or surgery who want to receive messages to improve their ability to self-manage their condition.
- There should be no additional burden on healthcare providers.
- A "virtual coach" CA sends text messages to improve self-efficacy and help patients maintain healthy behaviors (diet and physical activity).
- Intervention functions will include education, persuasion, training, and enablement.
- The language used should be encouraging, positive, friendly, polite, and lighthearted.
- Messages should be written using behavior change techniques to allow for replicability.
- Content, communication channel, and dose should be personalized.
- The follow-up questionnaire already used by the clinical team should be used to measure the effectiveness of the artifact.
- Improve self-management skills and prepare patients for the time when they are not supported by the team (1 year after surgery).
- A platform should be developed that allows healthcare professionals to select messages suggested by an automation algorithm.
- This platform should be modular and reusable for evidence-based behavior change interventions.

3.3 Design and Development

The patient journey in cardiothoracic surgery after the integration of this artifact is shown in Figure 2. Typically, patients are admitted to the hospital one day before surgery (preoperative). There, they receive instructions to facilitate their postoperative recovery. After surgery, the patient stays in the hospital for 5-7 days, depending on how the surgical procedure went (hospitalization). After discharge from the hospital, study participants are selected by a risk assessment model to use a remote patient monitoring kit (home telemonitoring). After 3 months of telemonitoring, patients are asked if they would like to receive text messages to help them engage in healthy behaviors (text message intervention).

The text messages were developed using a text message bank that has already been used with patients with diabetes and developed with BCTs (MacPherson et al., 2021). Therefore, we used these messages as a reference to create a text message bank. The text message bank was translated into Portuguese, adapted to the population of the study, and validated by the nurses to ensure the reliability of the content. This database may grow as we determine the need for more messages, which should happen iteratively as the study progresses.

A platform is being developed to automate the conversational agent to be used during the pilot study.

During the pilot study, we will use a fixed-frame dialog to send content to the patient. An example of the weekly dialog flow can be found in Table 1.

Table 1: Example of a weekly dialog flow.

(Monday) Getting rid of old habits is difficult, start with simple things: try to eat fruit when you feel like something sweet or drink water instead of juice.
(Tuesday) The small steps can lead to big changes in your health. Every step you take this week is a step towards a healthier you.
(Wednesday) Think where, when and how you will exercise today!
(Thursday) Try swapping refined carbohydrates (eg white bread) for whole grain equivalents (eg whole wheat bread).

Table 2: Example of a weekly status questionnaire [MoA - mechanisms of action] UX - user experience).

[MoA/UX] Message (expected answer)
[Knowledge] A balanced diet means eating all foods in the same amount. (T/F)
[Attitudes towards behavior] I don't like the taste of healthy food. (T/F)
[Attitudes towards behavior] I would have more energy for my family and friends if I exercised regularly. (T/F)
[Beliefs about consequences] Personally, I exercise to improve my health. (T/F)
[Intention] I intend to eat more fruit. (T/F)
[UX] Do you consider the information sent to you this week to be relevant?
[UX] Would you like to maintain the frequency with which we send you messages? If not, indicate the number of times per week.

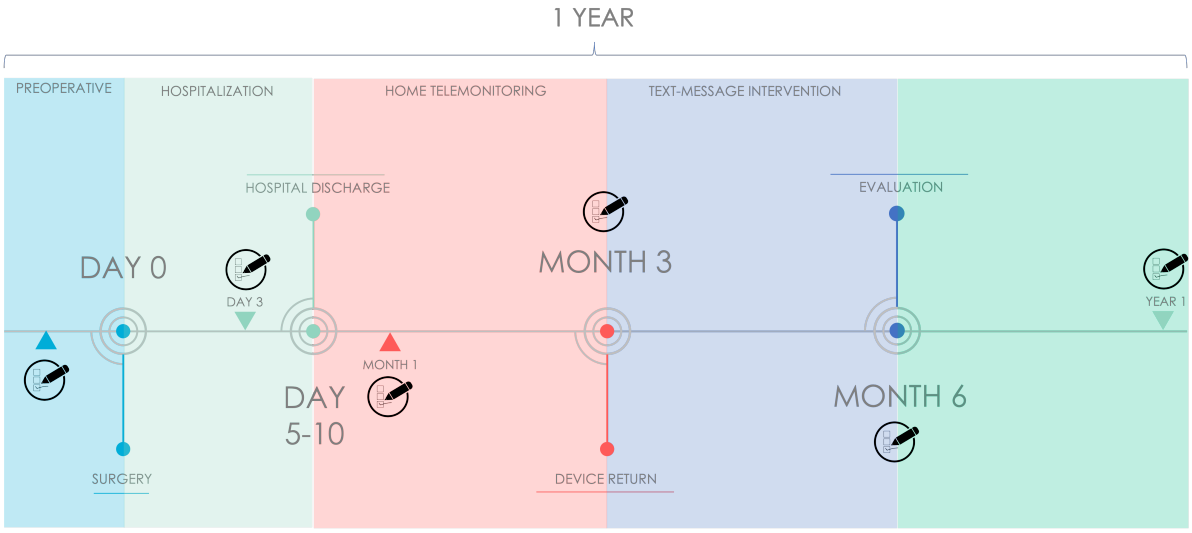

Figure 2: The patient journey at Santa Marta's hospital will comprise 5 stages: (a) preoperative, (b) hospitalization, (c) home telemonitoring, (d) text-message intervention, (e) regular follow-up.

3.4 Demonstration

The demonstration of the solution will be firstly be done with a small pilot study with 5 patients and during a month. The main goal is to understand the usability, the engagement, and the satisfaction with the intervention. The text-intervention diagram is depicted in Figure 3.

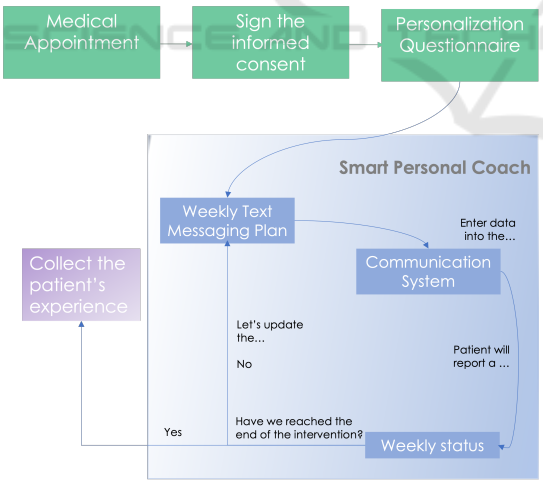

Figure 3: Text-intervention diagram.

3.5 Evaluation

Questionnaires will be used to improve patient experience (dose, timing, and relevance will be assessed weekly). An example of a weekly questionnaire is shown in Table 2. Patient progress will be evaluated using data from the follow-up questionnaire already used by the clinical team to assess the patient's recovery.

4 DISCUSSION AND CONCLUSION

This paper focuses on explaining the methodology that led to the development of a text messaging intervention. DSRM was used to ensure the sustainability and usability of solutions developed to address real-world problems, such as the one we identified: lack of self-efficacy in managing a cardiovascular disease after cardiothoracic surgery. To do this, it is essential to engage with all stakeholders involved. Behavior change theory is used to guide the design of the intervention by guiding a behavior analysis, and help define the target behavior, developing message content, and personalize the intervention.

The goal of this work is to help patients improve their quality of life and well-being and take control of their disease after the follow-up period in the hospital. The platform to be developed will be designed to be reusable for future interventions and ensure usability by paying attention to the user experience. This text messaging intervention has not yet been evaluated and no preliminary results are available.

Currently, we are focusing on developing algorithms to personalize content selection. Unsupervised algorithms will be used to understand patient needs using data from previous patients. The next step will be to develop a modular platform that will allow the clinical team to monitor the diet and physical activity

of patients enrolled in the study and send text messages to patients who are not enrolled in the study.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the cardiothoracic service of the Santa Marta Hospital for their contributions to carry out the study. This research has been supported by the project DSAIPA/AI/0094/2020 from the Fundação para a Ciência e Tecnologia AI 4 COVID-19 Program.

REFERENCES

Akinosun, A. S., Polson, R., Diaz Skeete, Y., De Kock, J. H., Carragher, L., Leslie, S., Grindle, M., and Gorely, T. (2021). Digital technology interventions for risk factor modification in patients with cardiovascular disease: Systematic review and meta-analysis. *JMIR mHealth and uHealth*, 9(3):e21061.

Bauer, U. E., Briss, P. A., Goodman, R. A., and Bowman, B. A. (2014). Prevention of chronic disease in the 21st century: elimination of the leading preventable causes of premature death and disability in the USA. *The Lancet*, 384(9937):45–52.

Brug, J. (2008). Determinants of healthy eating: motivation, abilities and environmental opportunities. *Family Practice*, 25:i50–i55.

Cadilhac, D. A., Andrew, N. E., Busingye, D., Cameron, J., Thrift, A. G., Purvis, T., Li, J. C., Kneebone, I., Thijs, V., Hackett, M. L., Lannin, N. A., Kilkenny, M. F., and on behalf of the ReCAPS investigators (2020). Pilot randomised clinical trial of an eHealth, self-management support intervention (iVERVE) for stroke: feasibility assessment in survivors 12–24 months post-event. *Pilot and Feasibility Studies*, 6(1):172.

Carey, R. N., Connell, L. E., Johnston, M., Rothman, A. J., de Bruin, M., Kelly, M. P., and Michie, S. (2018). Behavior change techniques and their mechanisms of action: A synthesis of links described in published intervention literature. *Annals of Behavioral Medicine*.

Cena, H. and Calder, P. C. (2020). Defining a healthy diet: Evidence for the role of contemporary dietary patterns in health and disease. *Nutrients*, 12(2):334.

Chaix, B., Bibault, J.-E., Pienkowski, A., Delamon, G., Guillemassé, A., Nectoux, P., and Brouard, B. (2019). When chatbots meet patients: One-year prospective study of conversations between patients with breast cancer and a chatbot. *JMIR Cancer*, 5(1):e12856.

Chokshi, N. P., Adusumalli, S., Small, D. S., Morris, A., Feingold, J., Ha, Y. P., Lynch, M. D., Rareshide, C. A. L., Hilbert, V., and Patel, M. S. (2018). Loss-framed financial incentives and personalized goal-setting to increase physical activity among ischemic heart disease patients using wearable devices: The ACTIVE REWARD randomized trial. *Journal of the American Heart Association*, 7(12):e009173.

Fitzpatrick, K. K., Darcy, A., and Vierhile, M. (2017). Delivering cognitive behavior therapy to young adults with symptoms of depression and anxiety using a fully automated conversational agent (woebot): A randomized controlled trial. *JMIR Mental Health*, 4(2):e19.

Gardner, G., Elliott, D., Gill, J., Griffin, M., and Crawford, M. (2005). Patient experiences following cardiothoracic surgery: An interview study. *European Journal of Cardiovascular Nursing*, 4(3):242–250.

Ghandeharioun, A., McDuff, D., Czerwinski, M., and Rowan, K. (2019). EMMA: An emotion-aware wellbeing chatbot. In *2019 8th International Conference on Affective Computing and Intelligent Interaction (ACII)*, pages 1–7. IEEE.

Grimmett, C., Corbett, T., Brunet, J., Shepherd, J., Pinto, B. M., May, C. R., and Foster, C. (2019). Systematic review and meta-analysis of maintenance of physical activity behaviour change in cancer survivors. *International Journal of Behavioral Nutrition and Physical Activity*, 16(1):37.

Halldorsdottir, H., Thoroddsen, A., and Ingadottir, B. (2020). Impact of technology-based patient education on modifiable cardiovascular risk factors of people with coronary heart disease: A systematic review. *Patient Education and Counseling*, 103(10):2018–2028.

Hevner, March, Park, and Ram (2004). Design science in information systems research. *MIS Quarterly*, 28(1):75.

Horner, G. N., Agboola, S., Jethwani, K., Tan-McGrory, A., and Lopez, L. (2017). Designing patient-centered text messaging interventions for increasing physical activity among participants with type 2 diabetes: Qualitative results from the text to move intervention. *JMIR mHealth and uHealth*, 5(4):e54.

Johnston, M., Carey, R. N., Connell Bohlen, L. E., Johnston, D. W., Rothman, A. J., de Bruin, M., Kelly, M. P., Groarke, H., and Michie, S. (2021). Development of an online tool for linking behavior change techniques and mechanisms of action based on triangulation of findings from literature synthesis and expert consensus. *Translational Behavioral Medicine*, 11(5):1049–1065.

Kelly, J. T., Conley, M., Hoffmann, T., Craig, J. C., Tong, A., Reidlinger, D. P., Reeves, M. M., Howard, K., Krishnasamy, R., Kurtkoti, J., Palmer, S. C., Johnson, D. W., and Campbell, K. L. (2020). A coaching program to improve dietary intake of patients with CKD: ENTICE-CKD. *Clinical Journal of the American Society of Nephrology*, 15(3):330–340.

Kontis, V., Mathers, C. D., Rehm, J., Stevens, G. A., Shield, K. D., Bonita, R., Riley, L. M., Poznyak, V., Beaglehole, R., and Ezzati, M. (2014). Contribution of six risk factors to achieving the 25x25 non-communicable disease mortality reduction target: a modelling study. *The Lancet*, 384(9941):427–437.

Londral, A., Azevedo, S., Dias, P., Ramos, C., Santos, J., Martins, F., Silva, R., Semedo, H., Vital, C., Gualdino, A., Falcão, J., Lapão, L. V., Coelho, P., and Fragata,

J. G. (2022). Developing and validating high-value patient digital follow-up services: a pilot study in cardiac surgery. *BMC health services research*, 22(1):680.

MacPherson, M., Cranston, K., Johnston, C., Locke, S., and Jung, M. E. (2021). Evaluation and refinement of a bank of SMS text messages to promote behavior change adherence following a diabetes prevention program: Survey study. *JMIR Formative Research*, 5(8):e28163.

Mayberry, L. S., Berg, C. A., Greevy, R. A., Nelson, L. A., Bergner, E. M., Wallston, K. A., Harper, K. J., and Elasy, T. A. (2021). Mixed-methods randomized evaluation of FAMS: A mobile phone-delivered intervention to improve family/friend involvement in adults' type 2 diabetes self-care. *Annals of Behavioral Medicine*, 55(2):165–178.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W., Eccles, M. P., Cane, J., and Wood, C. E. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine*, 46(1):81–95.

Michie, S., van Stralen, M. M., and West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, 6(1):42.

Peffers, K., Tuunanen, T., Rothenberger, M. A., and Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, 24(3):45–77.

Pinto, A., Faiz, O., Davis, R., Almoudaris, A., and Vincent, C. (2016). Surgical complications and their impact on patients' psychosocial well-being: a systematic review and meta-analysis. *BMJ Open*, 6(2):e007224.

Polgreen, L. A., Anthony, C., Carr, L., Simmering, J. E., Evans, N. J., Foster, E. D., Segre, A. M., Cremer, J. F., and Polgreen, P. M. (2018). The effect of automated text messaging and goal setting on pedometer adherence and physical activity in patients with diabetes: A randomized controlled trial. *PLOS ONE*, 13(5):e0195797.

Schmitz, C. (2012). *LimeSurvey: An Open Source survey tool*. LimeSurvey Project, Hamburg, Germany.

Sherwood, N. E. and Jeffery, R. W. (2000). The behavioral determinants of exercise: implications for physical activity interventions. *Annual Review of Nutrition*, 20:21–44.

Stephens, T. N., Joerin, A., Rauws, M., and Werk, L. N. (2019). Feasibility of pediatric obesity and prediabetes treatment support through tess, the AI behavioral coaching chatbot. *Translational Behavioral Medicine*, 9(3):440–447.

Tadas, S., Pretorius, C., Foster, E. J., Gorely, T., Leslie, S. J., and Coyle, D. (2021). Transitions in technology-mediated cardiac rehabilitation and self-management: Qualitative study using the theoretical domains framework. *JMIR Cardio*, 5(2):e30428.

Thiengwittayaporn, S., Wattanapreechanon, P., Sakon, P., Peethong, A., Ratisoontorn, N., Charoenphandhu, N., and Charoensiriwath, S. (2021). Development of a mobile application to improve exercise accuracy and quality of life in knee osteoarthritis patients: a randomized controlled trial. *Archives of Orthopaedic and Trauma Surgery*.

Tully, P. J. (2013). Quality-of-life measures for cardiac surgery practice and research: a review and primer. *The Journal of Extra-Corporeal Technology*, 45(1):8–15.

Warburton, D. E. and Bredin, S. S. (2017). Health benefits of physical activity: a systematic review of current systematic reviews. *Current Opinion in Cardiology*, 32(5):541–556.

WHO (2021). Cardiovascular diseases (CVDs).

Yusuf, S., Joseph, P., Rangarajan, S., Islam, S., Mente, A., Hystad, P., Brauer, M., Kutty, V. R., Gupta, R., Wielgosz, A., AlHabib, K. F., Dans, A., Lopez-Jaramillo, P., Avezum, A., Lanas, F., Oguz, A., Kruger, I. M., Diaz, R., Yusoff, K., Mony, P., Chifamba, J., Yeates, K., Kelishadi, R., Yusufali, A., Khatib, R., Rahman, O., Zatonska, K., Iqbal, R., Wei, L., Bo, H., Rosengren, A., Kaur, M., Mohan, V., Lear, S. A., Teo, K. K., Leong, D., O'Donnell, M., McKee, M., and Dagenais, G. (2020). Modifiable risk factors, cardiovascular disease, and mortality in 155 722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study. *The Lancet*, 395(10226):795–808.

SCITEPRESS SCIENCE AND TECHNOLOGY PUBLICATIONS