International Journal of Medical Informatics 113 (2018) 26–37

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.elsevier.com/locate/ijmedinf

Feasibility of mobile health game "Fume" in supporting tobacco-related health literacy among early adolescents: A three-armed cluster randomized design

Heidi Parisod[a,*], Anni Pakarinen[a], Anna Axelin[a], Eliisa Löyttyniemi[b], Jouni Smed[c], Sanna Salanterä[a,d]

[a] Department of Nursing Science, University of Turku, Turku, FI-20014, Finland
[b] Department of Biostatistics, University of Turku, Turku, FI-20014, Finland
[c] Department of Future Technologies, University of Turku, Turku, FI-20014, Finland
[d] Turku University Hospital, Turku, FI-20521, Finland

ARTICLE INFO

Keywords:
Tobacco
Health education
Health literacy
Health game
Adolescent
Feasibility studies
Randomized controlled trial

ABSTRACT

Objective: New interventions supporting health literacy and a tobacco-free lifestyle in adolescence are needed to narrow the widening gap in existing health inequalities. Health games offer potential and could be utilized for example in school healthcare, but more research is needed to increase the understanding of the effects of game elements in health interventions. The aim of this feasibility study is to determine the short-term effectiveness of the tobacco-related mobile health game *Fume* and a non-gamified website in comparison with a no-intervention control group, regarding tobacco-related health literacy among 10–13-year-old early adolescents. In addition, we compare the demand for and acceptability of *Fume* to that of the website.

Methods: In total, 151 early adolescents participated in this single-blinded, three-armed cluster randomized trial. The participants from three municipalities in southwest Finland were randomly allocated between a group with access to the health game *Fume* (n = 61), a group with access to the website (n = 47), and a group with no intervention (n = 43). The intervention groups first participated in a 20-min training session with *Fume*/the website, and then had two weeks to use *Fume*/the website based on their own interest. Short-term effectiveness was measured by primary (anti-smoking self-efficacy) and secondary (smoking outcome expectations, attitudes towards tobacco use, tobacco-use motives, motivation to decline tobacco use in the future, and knowledge about tobacco) outcomes derived from the theory-based determinants of tobacco-related health literacy and evaluated with self-assessment questionnaires at baseline and post-intervention (after a two-week follow-up). For evaluating the demand, the actual use of *Fume*/the website was tracked during the two-week period. Regarding acceptability, the raised interest towards *Fume*/the website and opinions about the interventions were evaluated post-intervention. Differences were tested with the McNemar, Fisher exact, and non-parametric tests.

Results: Statistically significant favorable changes during the study period were found for positive ($P = 0.002$) and negative ($P = 0.02$) smoking outcome expectations and attitudes towards cigarette smoking ($P = 0.01$) within the group using *Fume*. No statistically significant changes were detected within the website or control groups. Statistically significant differences were not found for the change in outcome variables among the three groups. The number of visits ($P < 0.001$), number of separate visit days ($P < 0.001$) and total duration of use ($P < 0.001$) were larger for the group using *Fume* than for that using the website. *Fume* sparked more interest in early adolescents than the website did ($P < 0.001$). There were no statistically significant differences in opinions about *Fume* and those regarding the website.

Conclusions: The intervention with embedded game elements, the health game *Fume*, was found to be more feasible as a tobacco-related health education intervention than the non-gamified website among early adolescents in light of demand and acceptability (raised interest). Even though no change in anti-smoking self-efficacy was found, the results of this feasibility study demonstrated favorable short-term changes with *Fume* in some other theory-based determinants of tobacco-related health literacy.

* Corresponding author.
E-mail address: heidi.parisod@utu.fi (H. Parisod).

https://doi.org/10.1016/j.ijmedinf.2018.02.013
Received 19 July 2017; Received in revised form 5 February 2018; Accepted 17 February 2018

1. Introduction

Adolescents' use of non-conventional tobacco products, such as snus (smokeless moist powder tobacco), has increased [1,2]. Also, even though the current trend of cigarette smoking is decreasing, 12% of 15-year-olds still smoke at least once a week [3]. Cigarette smoking is largely associated with a lower socio-economic background [4]. To narrow the widening gap of health inequalities, support of health literacy [5,6] (i.e., motivation and ability to access, understand, and use health information) already among young people [7–9] needs attention. Most commonly, interventions designed to address youngsters' health literacy are targeted at adults, such as parents, and interventions focusing on children and adolescents themselves are still scarce [10].

Developments in digital technology and patterns of adolescents' technology use [11] have encouraged the development of new health education methods to reach adolescents in school healthcare and other settings. The majority of adolescents (92%) report going online daily, and nearly three out of four have access to a smartphone. Other than for information-seeking purposes, adolescents mainly utilize these mobile devices for messaging and sharing visual material in social media and gaming [11].

Interest in gamified interventions has increased during the last decade [12,13]. Game elements (e.g., goals, rules, and opponents) are used in health education interventions to influence motivational, psychological, and behavioral outcomes [13], such as promoting participant engagement and influencing health behaviors. Previous studies have demonstrated the potential of health games in adolescent tobacco prevention [14–17], but more research with experimental study designs is needed to strengthen the understanding of the effects of game elements in the context of health interventions [18,19]. Furthermore, little is known regarding how gamified health interventions are actually being used [19], especially among adolescents.

The aim of this feasibility study is to determine the short-term effectiveness of the tobacco-related mobile health game *Fume* and that of a non-gamified website in comparison with a no-intervention control group regarding tobacco-related health literacy among 10–13-year-old early adolescents. In addition, we compare the demand for and acceptability of *Fume* to that of the website.

2. Methods

2.1. Study design

We conducted a feasibility study using a single-blind, three-armed cluster randomized design in spring 2016 (Fig. 1). The measurement points were at baseline and post-intervention (after a two-week follow-up) with the same participants.

This study was pre-assessed and approved of by the Ethics Committee of the University of Turku (reference number: 11/2016). Permission to conduct the study was received from the participating municipalities in March 2016 before contacting the schools and starting recruitment of the participating early adolescents.

2.2. Recruitment of the municipalities and randomization

Three municipalities meeting the eligibility criteria were randomly chosen for the study. The eligibility criteria required that the municipality: (1) have more than 10,000 inhabitants [20], (2) have at least 11.4% adolescent tobacco prevalence [21], and (3) be located in southwest Finland. Random allocation was done in clusters, dividing the participants between three groups: the health game group (Group A), the website group (Group B), and the no-intervention control group (Group C). This was done at the municipal level using computer-assisted randomization to prevent contamination between participants in different groups.

2.3. Determination of sample size and recruitment of the participating early adolescents

The sample size concerning the participating early adolescents was determined in advance with a power calculation based on previously recognized [22] early adolescents' average anti-smoking self-efficacy scores (mean = 3.57, SD = 0.49). The calculations indicated that having at least 30 participants in each group would give 80% power to detect mean differences of 10% (0.357) in anti-smoking self-efficacy between groups at the end of the study ($\alpha = 0.05$; 2-sided). Since cluster randomized trials require larger sample sizes to achieve the same statistical power as an individually randomized trial [23], we aimed to have sample sizes that were 50% or higher than indicated based on the power calculation.

To be eligible for participation, early adolescents had to: (1) be from 10 to 13 years old, (2) understand and be able to communicate in Finnish, Swedish, or English, and (3) have daily access to either a smartphone or a tablet computer during their free time. They were recruited from eight public schools (medium size and large), and 25 classes (grades 4–6) participated in this study. We started the recruitment with two schools in each of the municipalities. Due to a low recruitment level of early adolescents at the time of the data collection, recruitment for the health game and the website groups was extended, and two additional schools were included in the study at a later phase.

A researcher (HP) introduced the study to the early adolescents in the participating classes during a school day in oral and written form. The early adolescents were blinded to the intervention of interest. Since the randomization was done before the introduction, they were only informed about the kind of intervention they would receive if they participated in the study. They also received detailed information about how to access and use either the health game (Group A) or the website (Group B) and what kind of data would be collected and how it would be collected. Participation was voluntary, and the adolescents had a week to decide to participate. A written informed consent was required from both the participating early adolescent and one guardian.

2.4. Health game intervention (Group A)

The early adolescents in Group A used a mobile health game called *Fume* (version 1.1.0; see Video 1). *Fume* was developed [24] by a multidisciplinary research group that included researchers from nursing science, medicine, and information technology. The health game was first modeled using theoretical and empirical knowledge on tobacco-related health literacy, views of adolescents and other previous research literature. The game was further designed with a game company (NordicEdu) specializing in applied games. Then the game was produced using an iterative process that included four iteration rounds and testing sessions in 2015. During these testing sessions, alpha and beta versions of the game were tested by adolescents 9–16 years old (session 1: n = 16; session 3: n = 10; session 4: n = 44) and health promotion professionals (session 2: n = 3). The design of the game was revised based on observations on the usability of the game and feedback. The version of *Fume* (Version 1.1.0) used in this study contains five minigames, a story, and additional textual information concentrating on the topic of tobacco. The game elements included the